The cognitive and neural basis of suicide: investigating factors that help to identify individuals at risk

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Thesis submitted for the degree of Doctorate of Philosophy in Psychology.

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LIST OF COMMON ABBREVIATIONS

ACC = Response accuracy

ANEW= Affective Norms for English Words

BDI = Beck Depression Inventory

BRI = Behavioural Regulation Index

BRIEF-A = Behaviour Rating Inventory of Executive Function - Adult Version

BRIEF-SR = Behaviour Rating Inventory of Executive Function -Self-Report Version

CBT = Cognitive Behavioural Therapy

CDCP = Centers for Disease Control and Prevention

COPE-R= Revised COPE inventory

CSRP = Centre for Suicide Research and Prevention in Hong Kong

DSM-5= the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition

EEG = Electroencephalography

EPN = Early posterior negativity

ERP = Event-related brain potentials

ERQ = Emotion Regulation Questionnaire

FFT = Fast Fourier Transform

FMRI = Functional Magnetic Resonance Imaging

GEC = Global Executive Composite

HK = Hong Kong

HKJC= Hong Kong Jockey Club

ICA= Independent component analysis

ISI = Interstimulus interval

LH = left hemisphere

LPC = Late positive complex

MEPS = Means-Ends Problem solving

MI = Metacognition Index

MRI = Magnetic Resonance Imaging

MSE= Mean standard error

PET = Positron Emission Tomography

RH = right hemisphere

RT = response time

SAMS = Schematic Appraisal Model of Suicide

SBQ-R = Suicidal Behaviours Questionnaire - Revised

UK = United Kingdom

US = United States

WCST = Wisconsin Card Sorting Task

WHO = World Health Organization

YSPSP = Young Samaritans Peer Support Programme

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ABSTRACT

Suicide is a public health problem and there is serious concern regarding the increase of suicidal acts. The main objective of this thesis was to investigate the relationship between different factors associated with suicide, specifically executive functioning, coping, and emotion regulation. These variables were investigated in accordance with suicide models that explain how different coping and emotion regulation strategies impact suicide, in particular, how cognitive reappraisal may act as a protective mechanism against suicidal behaviour. As the work was conducted in Hong Kong an initial study explored cross-cultural differences in suicide behaviour and the links between self reported executive function, coping, and suicide. It was found that greater use of avoidance coping and reduced use of reappraisal was associated with suicidality. The findings also showed that working memory, inhibition, and emotional control were important predictors for suicidality and this was explored further in an EEG study that measured frontal asymmetry in a series of cognitive tasks. It was postulated that lateralized brain activity may account for the executive function impairments in suicidal individuals as frontal asymmetry has been shown to relate to differential executive functioning. No differences in cognitive performance or asymmetry were found on the basis of reported suicide behaviour, however the sample generally reported low levels of suicide behaviour making any comparisons between high and low risk individuals difficult. A final experiment was completed to measure frontal asymmetry between individuals reporting low and more extreme levels of suicide behavior. Those reporting high levels of suicide behavior performed worse in a Stroop task revealing difficulties with inhibition, and they showed a specific attentional bias towards suicide-related stimuli in an emotional Stroop

task. They also exhibited relatively less leftward frontal asymmetrical activity during the emotional Stroop task revealing difficulties in recruiting the left frontal region to deal with emotional interference. The findings suggest that an attentional bias towards suicide related information may be an indicator of individuals with suicide risk. The current work also provides empirical evidence for suicidal models that predict that reappraisal helps protect against suicide whilst avoidance and information processing biases increase suicidality.

CHAPTER ONE

Introduction

1.1 Problem statement and the prevalence of suicide

On the 5th March 2016, a third-year medical student from a Chinese University took her own life by jumping off the roof of the apartment where she lived (Cheung & Chiu, 2017). She was taken to North District Hospital in Hong Kong (HK) and was pronounced dead shortly after. From the preliminary investigation, police officers did not find any death note at the scene but reported that the student had been unhappy due to academic issues in university. This tragic incident of youth suicide is not rare in HK, and indeed was the sixteenth student suicide reported within a three-month period (Cheung & Chiu, 2017). Notably, just four days following this incident, another 20-year-old male student from a Hong Kong University jumped to his death from his residential block (Chung, 2016). The student was announced dead at the scene. Several suicide notes were recovered from his apartment, one was written to the media and the others were to his family members. It was later revealed in those letters that he was under tremendous pressure in his academic life but had never sought counselling support. This tragic incident made the seventh suicide case in just nine days within the small city of HK.

Suicide is a socially taboo topic that is rarely discussed with others, yet approximately 800,000 people die due to suicide every year, which is one person every 40 seconds (Who.int, 2015). In contrast to suicide being the tenth leading cause of death for all ages (see Centers for Disease Control and Prevention, 2013), suicide is the second leading cause of death for young people aged 15-to-24 years old. The issue of suicide is an even bigger concern in Chinese students. Evidently, suicide is the leading cause of death among adults aged 15 to 34 in China and accounts for 19% of deaths in this age group, which is higher than the rate of death caused by accidents (Phillips, Li, & Zhang, 2002). Nevertheless, these statistics are thought to be only a part of the actual figures with substantial samples unidentified and under reported (Nock et al., 2010). Although the rate of completed suicide is lower among university students than their non-student peers (Mortier et al., 2018a, b), the prevalence of suicide behaviour in university populations is still alarmingly high.

Since the start of the academic year in September 2015, a total of 22 students in HK committed suicide within a 6-month period, 10 of them were university students (Cheung & Chiu, 2017). This is a significant number of suicide cases compared to the previous figures of only two to three university student suicides per year (Figures from the University of Hong Kong's Centre for Suicide Research and Prevention 2010 to 2014). This increase highlights the importance of examining the causes of suicidal behaviour in the student population. The initial conclusion drawn by Yip (2016), the Director of the Centre for Suicide Research and Prevention in Hong Kong (CSRP) is that students today may not be well prepared for university life. More students are currently suffering from high-pressure education, with too much focus on score-oriented assessments (Cheung & Chiu, 2017). Yip (2016) added that universities should increase awareness of this and enhance their counselling support. However, other university academics contend that the issue of youth suicide is complex and that the exact causes for the increasing numbers in suicidality remain largely unknown (Cheung & Chiu, 2017).

In HK, there is increased attention towards suicidality in students and this is reflected by recent media. Newspaper headlines include: “15-year-old hangs himself in ninth student suicide since September” (Hong Kong Free Press, 2016), "More Hong Kong children commit suicide than die in accidents, study reveals" (Hong Kong Free Press, 2016), and "Third student suicide in three weeks raises alarm bells over stress levels” (Hong Kong Free Press, 2015). These headlines have signaled alarming messages to schools and educators to understand why students are making these attempts, and to identify “at risk" students as early as possible. One of the important similarities that the two cases outlined above (Chung, 2016; Cheung & Chiu, 2017) have in common is that both students complained they were unhappy about academic-related issues. These cases highlight the importance for exploring the progression of suicide by understanding what students go through during this period of university life.

When students enter university, it is often reported that they will experience aversive changes that may affect their psychological and physical health (Arslan, Ayranci, Unsal, & Arslantas, 2009; Pedersen & Paves, 2014). This is when students become emotionally distressed and experience stress and self-doubt due to academic and non-academic related matters. According to Ohayon et al. (2014), university life is a time where young adults feel pressurized to develop their own identities, to set life goals, as well as forming intimate relationships with peers. The transition between late adolescence to young adulthood is typically characterized by high levels of stress associated with adjusting to a new social environment and increasing academic demands (Pedersen & Paves, 2014). When a student’s social support networks undergo a radical change during university this may exacerbate levels of anxiety and depression, leading to a higher chance of suicide (Eisenberg et al. 2007; Potter, Silverman, Connorton, & Posner, 2004). Although parents and other family members may still be a part of a student's social support network, the physical separation from them, which may be the first time in the student's life, can be stressful. For some students, leaving home may initially be a fascinating experience, but it can soon become overwhelming when they have to handle issues such as finance, relationships, and independence. This is supported by Yip's study (2007) that the presence of debt was identified as the main risk factor to trigger stressed individuals to contemplate suicide in HK. To add to the dramatic transition to university life, students also experience stressors related to their studies, such as assignments, exams, and meeting different deadlines (Potter et al., 2004). A stressor is any activity, event, or stimulus that causes stress (The Cambridge Dictionary, 2016). It involves both cognitive and behavioural efforts aimed at reducing or controlling a stressor.

1.2 Suicide progression from thoughts to actions

Suicide is usually not an isolated event, but rather it is conceptualized as a continuum of processes (see Figure 1.1) starting with suicide ideation, moving to a suicide plan and preparation, a suicide attempt, and then finally suicide completion (Potter et al., 2004). It should be noted that the term suicidality is used interchangeably with the term suicide behaviour throughout this thesis, both terms refer to any actions, thoughts (also known as suicide ideation), intentions, motivations, plans, and attempts of suicide (Silverman, 2006). To prevent suicidality at an earlier stage, it is vital to focus on the first step of the complete suicide path, suicide ideation. *Suicide ideation* refers to the experience of thoughts, ruminations (repetitive action of focusing on the same feelings and thoughts) or fantasies about committing suicide, and/or verbalizing threats to commit suicide (Reynolds, 1988). It is argued to be the most critical part of the suicide process because it precedes a suicide attempt (Gould & Kramer, 2001; Lee et al., 2009). Understanding the progression from thoughts of suicide to taking action can help to inform early detection and possible prevention of suicidal behaviour (Palmer, 2004; Klonsky & May, 2014).

Figure 1.1 The suicide continuum, from escalation of suicide ideation to the complete act of suicide (Potter et al., 2004)

The figure illustrating the suicide path shows progression as a continuous and hierarchical succession of suicidal behaviours (Potter et al., 2004; Thompson, Dewa, & Phare, 2012). Reynolds (1988) proposed that along the suicide continuum, suicide ideation reflects a milder form of suicidal behaviour, and progresses into more serious suicidal behaviour such as suicide plans and attempts. This proposed progression is supported by researchers such as Glenn and Nock (2014) and Prinstein et al. (2008) who concluded that suicide ideation is a strong predictor of more serious suicidal acts, and that the degree of self-harm is directly proportionate to the degree of suicide ideation experienced. However, May and Klonsky (2016) contended that it must not be assumed that suicidal acts are necessarily starting from suicide ideation and progressing to more life threatening behaviour. Klonsky and May (2014) developed the ideation-to action framework which intends to move the field of suicide research forwards in terms of risk assessment, theory, treatment, and prevention. The ideation-to action framework stipulates that the development of suicidal ideation and the progression from ideation to suicide attempts should be viewed as separate processes with distinct explanations and predictors. In support of this framework, Baca-Garcia et al. (2011) reported that only one-third of individuals with a past suicide attempt reported suicide ideation. Moreover, there were some reports where individuals have committed suicide without any signs of the earlier stages, in these cases, the first suicide attempt has turned out to be a fatal suicide (Schlebusch, 2005).

Recent researchers have conceptualized suicide ideation into two distinguishable features; active and passive suicide ideation. Active suicide ideation consists of active thoughts about self-harm or detailed plans for ending one's own life (Schulberg et al., 2005). Conversely, passive suicide ideation arises when a person feels that life is not worth living for or that they would be better off dead. These thoughts may include but are not limited to feelings of being tired of life and a wish to not wake up from sleep. Compared to active suicide ideation, passive thoughts would include fewer specific intentions or plans for committing suicide (Raue et al., 2007; Schulberg et al., 2005). Szanto et al. (1996) assessed the clinical correlates of active versus passive suicide ideation in patients with recurrent depression. The data challenged the necessity of distinguishing active and passive suicide ideation due to the high overlapping features of both definitions. They also noted that a patient's suicide ideation can change from passive to active during an episode of suicide crisis, making the distinguishing features difficult to define (Schulberg et al., 2005). Whilst it is not the focus of this thesis it is noteworthy that suicide ideation can be active or passive, both are important and interchangeable.

1.3 Current programs for suicide prevention

Over the last 40 years, an increase in mental healthcare resources and major advances in suicide prevention have become more widely available (Klein, Ciotoli, & Chung, 2011; Pedersen & Paves, 2014; Pompeo, 2014). These include cognitive-behavioural therapies and workshops. Alongside the well-established suicide prevention services in HK, the Centre for Suicide Research and Prevention (CSRP) has also set up the Problem solving Skills Training and Mentorship Programme for individuals with emotional, behavioural, or academic difficulties. These programs aim to strengthen the knowledge and skills acquired by students, it also aims to encourage students to solve problems on their own with support from mentors (Centre for Suicide Research and Prevention, 2017). Similarly, the Young Peer Support Programme (YSPSP) organized by the Samaritans aims to train students to provide social support to peers with emotional distress (Samaritans Hong Kong, 2017). Despite a broad range of existing programs offered, the rates of suicide have not decreased appreciably in proportion to the amount of resources spent (Centers for Disease Control and Prevention, 2014). It is suggested that even with considerable effort in prediction and prevention, suicide rates still contribute significantly to the burden of healthcare (Mathers & Loncar, 2006) and are projected to increase worldwide through 2030 (WHO, 2013). Suicide not only causes devastation to families and friends, it also puts a substantial economic burden on society (Shepard, Gurewich, Lwin, Reed & Silverman, 2015).

Recently, Klonsky, May and Saffer (2016) suggest that the key reason for the limited success in reducing suicide is the insufficient knowledge of the hierarchical succession of suicide behaviour from suicide ideation to a suicide attempt. They proposed the study of motivations for suicide attempts could be one way to help understand why individuals commit suicide. It is posited that exploring motivations for suicide can help individuals not only identify what causes the irrational thoughts for suicide, but also to give alternative solutions to their current problems. Common motivations of suicide identified include inability to deal with unbearable emotional pain, desire to escape self, using suicide as a mean to get attention, or to seek help from others (May & Klonsky, 2013). Klonsky et al. (2016) added that understanding the motives for suicide may facilitate development of intervention and prevention programs. To do this, it is essential to get an overview of the most important risk factors associated with suicide behaviour.

1.4 Common factors associated with suicide

Based on the current body of literature, the most common factors associated with suicidality include the presence of recurrent suicide ideation, hopelessness, a history of past suicide attempt(s), cognitive deficits (e.g. poor problem solving), and comorbidity with affective disorders[1] (Baechler, 1979; Baumeister, 1990; Rudd et al., 2006). These factors are studied by a wide variety of disciplines such as sociocultural, environmental, biological, and cognitive perspectives (e.g., Borowsky, Ireland, & Resnick, 2001; Hawton & van Heeringen, 2009; Nierenberg et al., 2012). Among these factors, the established link between a past suicide attempt, recurrent suicide ideation, and depression are regarded as the most important risk factors for predicting future suicide behaviour.

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[1] Affective disorders refer to a set of psychiatric diseases related to disturbance in mood that ranges from mild to severe. The main types of affective disorders include depression, bipolar disorder, and anxiety disorder. An affective disorder is also termed as a mood disorder by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5).

In the past, suicidality has been extensively investigated through the exploration of risk factors. This means that researchers often focus on elucidating psychological vulnerabilities and maladaptive cognitive processes associated with suicide behaviour (Nierenberg, Bentley, Farabaugh, Fava, & Deckersbach, 2012). According to Baumeister (1990), the urge to commit suicide arises when individuals acutely perceive themselves as inadequate, incompetent, and guilty, and this results in the need to escape the aversive feelings using suicide. With a number of psychological factors shown to be highly associated with suicide behaviour, researchers and clinicians have used these variables to aid early identification of individuals at risk (Homaifar, Bahraini, Silverman & Brenner, 2012). This is also referred to as a risk-based approach because research usually focuses on what risk factors link to the disorder.

University life is likely to be the first time for students to leave home and this could be especially challenging for Chinese students (Zhang, Wang, Xia, Liu & Jung, 2012). Support for this is derived from Mooney (2005) who claimed that Chinese students are often the only ‘child’ in the home, and family functioning is particularly crucial for them. In the critical period of entering university, students begin to learn how to cope in the real world independently, which in turn means that coping may serve as a crucial factor. To add to this social and environmental challenge, university students are in a transition from adolescence to adulthood so it is important that their cognitive abilities are well equipped at this stage to provide flexible and adequate ways to cope with different demands for work, relationships, and academic life. If the individual is still undergoing psychological development and he/she experiences aversive life event at this stage, this may hinder adaptive behaviour in this situation and manifest in suicidality. For this reason, investigations into the cognitive, coping, and emotional factors of the student population would help to understand how these risk factors interact with suicide behaviours differently.

1.4.1 The comorbidity of depression and suicide behaviour

Suicide is a preventable cause of death that often coexists with affective disorders such as depression (Arsenault-Lapierre, Kim, & Turecki, 2004; Sokero, Melartin, Rytsala et al., 2005). Depression is characterized by a range of cognitive and physical symptoms including lack of interest and energy, difficulties concentrating, feelings of guilt and sadness, suicide ideation, change in weight and psychomotor abilities, fatigue, and sleep disturbance (CDC, 2013; Depressive Disorders, 2013). Below is a quote from a male suicide completer, 28 years old who expressed the suicide dilemma of having the concurrent feelings of depression as well as suicide thoughts

"*There is a silent line between relief and depression, one that I have yet to master… where is the line? When do I know I have crossed it? I will tell you when… it is when everything is perfect, everything is filled, yet something is empty and I am ready"* (Lester, Wood, Williams, & Haines, 2004).

Bostwick and Pankratz (2000) documented that the risk of suicide is 17 times higher in individuals with affective disorders compared to those without. Consistent statistics also indicated a high degree of comorbidity between suicide and depression, with more than 90% of all suicide completers being diagnosed with at least one form of affective disorder (Arsenault-Lapierre et al., 2004; Mann, 2003). This supports the notion that depression is clearly an important part of the picture in suicide progression and that increased levels of depression is associated with increasing suicide risk (Pompeo, 2014; Potter et al., 2004; Sokero et al., 2005). For this reason, many of the suicide prevention programs often try to identify individuals with a suicide risk via screening for early signs of depression (Wang et al., 2007). The high comorbidity between suicide and affective disorders is one incentive for having research and prevention programs to examine these constructs together rather that separately (Preuss, Schuckit, Smith, Danko & Buckman, 2002; Yen, Shea, Pagno, Sanislow & Grilo, 2003).

Depression affects approximately 6.7% of adults aged 18-65 years in the United States (Adaa.org, 2017), and 8.4% in HK (Lee, Tsang, & Kwok, 2007). The prevalence of depression within a student population is alarmingly high with considerable numbers of students reporting emotional disturbances during their studies (Mackenzie et al., 2011). This is shown by around 12 to 18% of students being diagnosed with at least one form of affective disorder during their time at university (Mowbray, Megivern & Mandiberg, 2006). The prevalence of depression was also explored within Chinese university students (N= 5245). Using the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996), it was found that 11.7% of the respondents reported having clinical levels of depressive symptoms (Chen et al., 2013). Eisenberg et al. (2007) administered a web-based survey in a public university in the United States (US) to compare differences between undergraduate and graduate students. Among 2843 responses, 15.6% of 1181 undergraduates reported having depression or anxiety disorder compared with 13% of 1662 graduate students. The figures indicate that university life could be a critical period where affective disorders are manifested in the student population. Compared to the national prevalence which is approximately 6.7% for depression and 3.1% for general anxiety disorder (Adaa.org, 2017), it is evident that the prevalence of affective disorders among these student samples is alarmingly high. When comparing the prevalence of affective disorder in graduates to undergraduates in Eisenberg et al.'s study (2007), Pereira-Lima and Loureiro (2015) noted that university graduates who have finished their degrees and have integrated into the workforce are generally more capable of maintaining satisfying and longer lasting relationships. Graduates are also more productive and have better mental and physical health, and this may explain why graduates reported lower levels of depression and anxiety levels compared to undergraduates. This again highlights the critical stage students are going through during their university life and the importance of selecting the right sample for studying the suicide process in a research.

Following from the studies of Arsenault-Lapierre et al. (2004) and Mann (2003), rather than reviewing the high percentage of suicide completers who had been depressed, Angst, Angst, Gerber-Werder, and Gamma (2005) explored the percentage of depressed individuals who had made a suicide attempt. They found that 10-15% of the depressed patients have attempted suicide during the course of their disorder. This means that only a small percentage of depressed individuals proceed to suicide whilst over 85% remained in the depressed state without striving for change. Despite the high association between suicide and depression, this has raised questions as to why only a small proportion of depressed individuals proceed to a suicide act whilst others do not. It is reasoned that other factors may have a significant impact as to whether someone decides to commit a suicide act or not.

1.4.2 Executive functions and suicide behaviour

Regarding the suicide continuum outlined in figure 1.1 (Potter et al., 2004), it is noteworthy that from the first point of suicide ideation to the final stage of committing suicide, the suicide progression path requires complex cognitive processes. These may involve but are not limited to solving problems to avoid accumulation of emotional pain, attending to sensitive stimuli relevant to one's own emotional state, inhibition of intrusive thoughts, planning and organizing ways to commit suicide, and decision making about the final attempt (Burton, Vella, Weller & Twamley, 2011). These cognitive processes generally fall under the umbrella term of *executive functions*[2], which are responsible for controlling, organizing and directing cognitive activity, emotional responses, and behaviour (Banich, 2009). It is posited that emotion interacts with cognitive processing and is an important determinant as to whether an individual may progress from one point of the suicide continuum to the next (Cha et al., 2010; Van Heeringen & Marusic, 2003).

Executive functions constitute many components that allow individuals to plan and execute goal- directed behaviours, overcome unanticipated challenges, regulate emotions, exert self-control, work with information held in the mind, shift focus between multiple tasks, and modify behaviour flexibly according to a situation (Burgess, Veitch, de lacy Costello, & Shallice, 2000; Burton et al., 2011; Damasio, 1995; Diamond, 2013; Doty, 2012). It has been suggested that executive functions consist of three core processes, cognitive flexibility, inhibitory control, and working memory, and these are the building blocks for daily life (Diamond, 2013; Miyake et al., 2000). This higher level

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[2] Since the 1980s, the term executive function, executive control, cognitive control, and frontal lobe functioning have been used interchangeably through years of different publications. All of these terms are proposed to be a psychometric construct on the activity occurring within the frontal lobes (Anderson et al., 2011).

of processing is predominant in the prefrontal cortex (PFC) which interacts closely with other brain regions (e.g., the anterior cingulate and the amygdala; Anderson, 2008; Diamond, 2013).

There is an assumption that when the brain approaches complete development in early adulthood, it should be fully equipped with all the cognitive abilities required to cope with different demands of work, relationships, and academic life (Goldstein & Naglieri, 2013). However, similar to other cognitive abilities such as language skills and intelligence, executive functions vary between individuals, some may fail to develop effective executive function and this may have negative psychological impacts (Glenn & Nock, 2014). This is crucial because an individual's executive function abilities may determine whether they will proceed from suicide ideation to planning, or from planning to taking actions in their final suicide attempt (Glenn & Nock, 2014).

Many studies have reported deficits in multiple aspects of executive functions to be associated with increased severity of suicide behavior, including attention, reasoning, problem solving, planning, decision making, and inhibition (Burton et al., 2011; Doty, 2012; von Hecker, Sedek, & Brzezicka, 2013; Imbir & Jarymowicz, 2013; Jollant et al., 2005; Keilp et al., 2012; Loyo, Martínez-Velázquez & Loyo, 2013; Løvstad et al., 2016; Richard-Devantoy & Courtet, 2016).

To explore the possibility that deficits of executive functions may be linked to suicide behaviour and depression, Jollant et al. (2007) conducted a functional Magnetic Resonance Imaging (fMRI) investigation with 317 patients with psychiatric disorders (e.g. bipolar disorder) to explore the neural basis of decision making, a cognitive aspect found to impact suicidality (Jollant et al., 2005). They recruited 69 past suicide attempters with depression, 25 depressed patients with no history of a suicide attempt, and 82 healthy controls to perform Iowa Gambling task. This task measures decision making by asking participants to make a choice between four decks of card, with two advantageous decks for which little money is won but even less is lost (resulting in a net gain) and two disadvantageous decks in which some money is won but even more is lost (resulting in a net loss). The participant is instructed to win as much money as possible in this task. Replicating their earlier findings (Jollant et al., 2005) they found that compared with healthy controls and depressed patients with no suicide behaviour, suicide attempters performed worst in the Iowa Gambling task[3]. Jollant et al. (2007) reasoned this is due to the emotional dysfunctions in suicide attempters which in turn impaired their decision making and increased suicide behaviours. They also added that the cognitive impairment could be accounted for by a decrease activity in brain region crucial for decision making. Followed from this, Jollant et al. (2010) explore the left lateral orbitofrontal and occipital regions that are known to be critical for decision making under risky contexts. With the neurological correlates of 13 depressed suicide attempters, 12 depressed with no history of attempts and 25 healthy controls explored whilst they performed Iowa Gambling task, the fMRI findings replicated previous studies that decreased activation of the lateral orbitofrontal cortex during a decision-making task serves as a neural marker of an increased suicide risk (Wagner et al., 2012; Willeumier et al., 2011). Such convergent findings warrant claims for investigating neurological as well as behavioural traits of suicidal individuals.

[3] Participants could win or lose money with each choice (adopted from Bechara et al. 1999). Some choices are advantageous in the short-term (with high reward), but disadvantageous in the long run (with higher punishment); other choices have lower reward in the short-term but are advantageous in the long run (with lower punishment).

Another experimental study that explored the link between executive functions and suicidality was conducted by Loyo et al. (2013) using self-report measures (Behaviour Rating Inventory of Executive Function - Adult Version; BRIEF-A) together with the colour and emotional Stroop Tests, the Wisconsin Card-sorting task[4] and the Iowa Gambling task that measure attentional control, abstract reasoning ability, and decision making respectively. The BRIEF-A inventory assessed individuals perceived difficulties on different aspects of executive functions. The sample consisted of 25 suicide attempters with depressive symptoms, 25 non-suicide attempters with depressive symptoms, and 24 non-depressed participants. Compared to the non-suicide attempters and non-depressed participants, suicide attempters with depression showed more executive function deficits. It is evident that they took longer to respond and had lower accuracy in the colour Stroop task[5] (indicating poor selective attention and inhibition) compared to the non-depressed participants. Although Loyo et al. (2013) found that suicide attempters also performed worst in the Wisconsin Card-sorting task and the Iowa Gambling task, they showed no improvement in performance the Iowa Gambling task when the first and last blocks of trials were compared. This reflects relatively poor decision making and an inability to improve with practice. This study concluded that individuals with suicidal tendencies may be predisposed to particular problems with selective attention, inhibition, cognitive flexibility, and decision making. It thus implies

[4] This Wisconsin card sorting task (WCST; Loyo et al., 2013) assesses abstract reasoning and set-shifting ability. Participants are required to classify cards according to different criteria As the relevant category switches across trials, task performance is dependent on an individual's flexible thinking and ability to inhibit the previously relevant category.

[5] In a colour Stroop task (Stroop, 1935), participants are asked to name the color of words that possess a congruent (e.g. the word red printed in red) or incongruent semantic meaning (e.g. the word red printed in green). The task requires the inhibition of an automated response (reading the word) in order to name the color therefore it requires selective attention and inhibitory control. Longer response times to incongruent trials reveal difficulties inhibiting an automatic process (known as the Stroop interference effect; Beall & Herbert, 2008; MacLeod, 1991).

that performance in a cognitive task may be one empirical method to identify individuals with dangerous levels of suicidality.

Despite the evidence establishing the association between different executive functioning aspects and suicidality, there are also some contradictory studies that argue executive function deficits are not related to suicidality (King et al., 2000; Marzuk, Hartwell, & Leon, 2005), with some results even showing better executive functions in suicidal individuals (Burton et al., 2011, Nangle et al., 2006). For instance, King et al. (2000) compared the neuropsychological performance of depressed patients with recent incident(s) of attempt to those without. The tasks included the Trail Making Test that measures mental sequencing and flexibility, the California Verbal Learning Test measuring verbal learning and verbal fluency and the Wisconsin Card Sorting Test for set-shifting[6]. Overall, they only found differences between the two groups in the Trail Making Test. In this task participants draw lines as quickly as possible to connect a set of dots that consists of just number/ dots, followed by dots with alternation between numbers and letters. Specifically, patients with a recent incident of attempt were more likely to make more errors and present impairment in cognitive flexibility but not on other aspects of executive functions.

Contrary to the supporting evidence for cognitive deficits in suicidal individuals, there are some studies that have shown measures of executive functions to be outperformed by suicidal individuals. For example, Nangle et al. (2006) found that better problem solving may be associated with better planning and initiation of behaviour (i.e.

[6] Shifting is also sometimes called set shifting, both refer to the cognitive ability of updating or changing attention flexibly in response to changes in the environment. In some neuropsychological tests, shifting is measured by having patients to perform according to some rule but then are asked to switch to a new rule. Successful task performance therefore requires the ability to abort the old rule and start applying to a new rule quickly.

to begin a task independently and generate new ideas and problem solving strategies), which may increase risk of attempting suicide from a state of suicide contemplation only. This postulation is based on the evidence that impairment in these executive functions is associated with difficulties in goal formulation and an inability to plan effectively (Chan et al., 2004). Consistent with their prediction, the comparison in performance on the neuropsychological battery[7] indicated that participants with at least one lifetime suicide attempt performed better than participants with suicide ideation but no history of past attempters on cognitive measures of planning, attention, and verbal fluency. Nangle et al. (2006) explained that the relatively higher executive function measures by suicide attempters may suggest that this group had greater ability to formulate plans and initiate behaviour directed towards a particular goal, including having committing suicide.

Alongside these studies that focus on the interactions between different executive function aspects with suicidality, other studies proposed that executive functions interact closely with emotions (Gross & Thompson, 2007; Gross, 2015). Miyake and Friedman (2012) posit that impaired executive functions increase suicidality because they impede the ability to regulate one's own emotions, thoughts, and actions. For example, when individuals have deficits in set-shifting, they may have more difficulty shifting away from the thoughts of self-harm and to think about solutions to problems. This also affects the way they cope in response to stress because the ability to adapt flexibly in response to changes in the environment and to choose the most effective coping strategy are both related to shift (Miyake & Friedman, 2012). By increasing the current knowledge on the

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[7] A battery is defined as two or more tests that are related by an assessment method. It can give information from combinations and patterns that are derived from the relationships between these tests. Therefore, battery is particularly useful for neuropsychological assessment as it provides information about an individual that cannot be obtained from individual tests used alone (Kane, 1991).

emotion-cognition interaction, it may help to understand how cognitive impairment links to increased emotional disturbance and the recurrence of suicide behaviour.

1.4.2.1 Emotion-cognition interaction

As outlined, emotion interacts with cognitive processing and it is an important determinant in the suicide path (Cha et al., 2010; Van Heeringen & Marusic, 2003). One of the most well-established findings on how emotions impact cognition was explained by *the broaden-and build theory* (Fredrickson, 2001). Proponents of this theory focused on how positive emotions (also termed positive affect) may broaden attention (Derryberry & Tucker, 1994), promote flexible thinking, and increase open-mindedness and acceptance of new opportunities. Two main types of attention are distinguished in the literature namely, top-down (goal-oriented) and bottom-up (stimulus-driven) (Carrasco, 2011; Pinto, van der Leij, Sligte, Lamme, & Scholte, 2013). Top-down attention refers to the voluntary allocation of attention to certain information on the basis of task demands and past experience (Pinto et al., 2013). Bottom-up attention occurs when attention is automatically captured by salient stimuli (Schreij, Owens, & Theeuwes, 2008). Isen, (1999) explained that positive emotions may help to widen long-term physical, intellectual, and social resources, and in turn give individuals access to a broader array of mental faculties that are more efficient, flexible, and creative. In this sense, individuals in a positive emotional state may also enhance the wellbeing of others by engaging in more pro-social behaviour such as donating time and money to charity (Isen, 1999). Opposite to the broadening impact of positive emotion, negative emotion limits the range of responses in terms of thoughts and actions to prepare for self-protective fight or flight behaviours. It is evident that negative emotions have opposite impact by narrowing attention and increasing sensitivity towards information related to negative psychological wellness. For example, increased attentional bias (the tendency to process certain types of information over others) towards negative information is often associated with symptoms such as negative emotional states in depression (Lopes, Viacava & Bizarro, 2015).

Complementing the broaden-and build theory researchers suggest that emotions are vital as they help to facilitate adaptation by readying behavioural responses (Tooby & Cosmides, 2008), enhancing memory for important events, and guiding interpersonal interactions (Phelps, 2006). Fredrickson (2004) contended that being in a positive emotional state may help to improve psychological wellbeing and physical health. Indeed, there is a great deal of evidence to show a beneficial impact of positive emotion on cognitive processing and a detrimental impact of negative emotion. For example, Isen (1999) recruited participants to be induced into a positive emotional state by watching a comedy or receiving a gift or an unexpected reward. Results showed improvements in their memory, learning, problem solving, creativity, and risk-assessment. In contrast, negative mood has been shown to impede performance on problem solving and working memory [8](Mathers & Loncar, 2006). It has been suggested that the poor cognitive performance under negative affect may be attributed to the fact that cognitive resources are being used to process intrusive thoughts and worries and this

[8] Most of the empirical work on working memory is based on a model developed by Baddeley and Hitch (1974; 1992), the Working Memory Model. The working memory system comprises domain specific buffers (also referred to as slave systems) controlled by a central executive. The central executive is responsible for the supervision, control, and coordination of information, activated by the two slave systems; the phonological loop and the visuospatial sketchpad. The central executive component is also related to attentional control as it needs to coordinate within the two slave systems by switching rapidly between tasks, therefore, it is involved in the allocation of attention between different systems (Baddeley, 1996). Following the establishment of these systems, Baddeley (2000) added another slave system, the episodic buffer to the model as a capacity-limited component where representations from different modalities can be integrated.

distracts the individual from the task they are trying to complete (Eysenck & Calvo, 1992).

A more recent study using a dot-probe task Platt et al. (2015) asked participants to focus on a fixation cross at the center of a screen whilst two stimuli (one neutral and one emotional) appeared randomly on either side of this cross. A dot would then be presented in the location of the emotional or neutral stimulus and participants had to respond to this as quickly as possible. Again, results showed that increased levels of depression correlated with faster response times to probes appearing in the location of negative stimuli. This reveals that individuals with depression are more biased towards negative information when compared to neutral or positive information. From the evidence outlined, there is the implication that an individual's negative emotional states have the potential to impede cognitive processing but it is uncertain whether the disruption will be more substantial in individuals with more severe forms of emotional disturbance (e.g. individuals with suicide behaviour).

Across different research, there is a tendency to use the terms *emotion* and *affect* interchangeably rather than to differentiate them (Pressman & Cohen, 2005; Strumpfer, 2006). Affect is a very broad concept that covers a variety of subjective experiences such as emotions and moods (Eysenck & Keane, n.d., Fredrickson, 2001, 2004). It is usually longer lasting than emotions and mood states. Compared to affect, emotion stems from personally meaningful events (receiving a gift or almost getting run over by a car). It is appraised consciously or unconsciously, and is experienced over a brief period (Fredrickson, 2004). Whilst affect is often described as either positive or negative, emotions are categorized into many groups such as anger, disgust, fear, happiness, sadness, and surprise, though they can also be grouped into positive and negative (Ekman, 1999).

Aside from the widely used terms of emotion and affect, other terms such as *mood state* is also used at times to describe relatively low-intensity but more prolonged experiences than emotional states (Fredrickson, 2004). A mood state is typically a long lasting subjective experience, and occupies the background of consciousness (Fredrickson & Losada, 2005). Although both moods and emotions are about some personally meaningful circumstance (i.e. they have an object), emotions are typically short-lived. In practice, researchers often elicit the emotional state of participants through emotion induction techniques. For example, the induction of positive moods and emotions by giving out a surprised gift, money rewards, by watching aversive or pleasant video clips, etc. However, for the ease of expressing standardized terms in this thesis, emotion, affect and mood will be considered as a universal definition without further distinction of their meanings.

1.4.3 The importance of emotional regulation to psychological wellbeing and suicidality

Emotions have an important role in facilitating adaptation and enhancing both cognitive and psychological wellbeing (Phelps, 2006). However, evidence suggests that emotions can sometimes be harmful especially when they emerge at the wrong time or in the wrong intensity in a given situation. In any specific moment, it is crucial to regulate emotion adaptively. For example, an individual may choose to listen to calm music when they feel agitated for being stuck in a traffic congestion, or to talk to a friend and express their sadness after breaking up with a partner. These examples illustrate different attempts to regulate negative emotions by emotion regulation in daily lives. Emotion regulation is defined as “the monitoring, evaluation and modifying of emotional reactions to accomplish goals” (Thompson, 1994, p.27-28). It is a multi-dimensional construct that involves cognitive and behavioural responses to the important information about the environment as well as inhibition of negative emotions (Cole et al., 2004; Thompson 1994). The ability to regulate emotion effectively is essential for psychological health and is also a form of socially adaptive behaviour (Iordan, Dolcos, & Dolcos, 2013). For example, doctors may try to act seemingly calm and empathic for anxious medical patients, teachers may try to show high levels of interest in students (Gross, 2015; Sutton, Altarriba, Gianico, & Basnight-Brown, 2007), or an individual may try to avoid direct confrontation with a grumpy neighbor who is rude and impolite (Gross, 2015).

Campbell-Sills, Barlow, Brown, and Hofmann (2006) investigated two emotion regulation strategies; perceived acceptability and suppression of negative emotion in participants with anxiety and affective disorders. Accepting one’s own emotions is to experience the emotions, thoughts, and bodily sensations fully without trying to change, control, or avoid them (Hayes, Strosahl, & Wilson, 1999). This entails openness to internal experiences and willingness to remain in contact with those emotions (even if they are uncomfortable) and it opposed suppression which is to push these emotional experiences away. To examine the psychological impact of these emotion regulation strategies, participants watched an emotionally provoking film and were asked to either suppress or accept their emotional response. Results revealed that those who accepted their emotions showed less negative affect during the post-film recovery period, whereas those who tried to suppress their negative emotions had increased cardiac arousal and inhibited mood recovery. The fact that when participants used suppression they took longer for their negative mood state to return to baseline (before watching the film) indicate that suppression is maladaptive whereas acceptance is a more adaptive way of regulating emotions. The findings support the supposition by Gross and John (2003) who explained that suppression creates a discrepancy between the inner experience and outer expression, and this could make individuals feel less in touch with themselves and cause disruptions in social situations (Butler et al., 2003; Gross & John, 2003). Indeed, suppression has been repeatedly reported to interfere with and hinder psychological wellbeing and the ability to repair negative mood, therefore it is often classified as maladaptive emotion regulation (Gross & John, 2003; Jollant et al., 2005).

In close relation to suppression, other forms of emotion regulation similar to this are avoidance (the attempt to avoid feelings and emotions by disengagement or dissociation), and rumination have also been classified as maladaptive emotion regulation. These emotion regulation strategies are generally associated with lower life satisfaction, low self-esteem, lack of close social relationships and support, and worse coping abilities (John & Gross, 2004). Importantly, all of these were also found to increase suicide risk and the development of suicidal plans and behaviour (Eisenberg et al., 2007; Potter et al., 2015; Silverman et al., 2004; Yip, 2016). In addition, prior studies have also reported that anxiety and depression often result from excessive use of maladaptive emotion regulation strategies to down-regulate (decrease the intensity or duration) negative emotions (Campbell-Sills et al., 2006; Campbell-Sills & Barlow, 2007; Gross, 1998; Gross & John, 2003;). Studies consistently show that these strategies are not helpful and would only exacerbate to more severe symptoms in the long run.

Apart from examining maladaptive emotion regulation, some researchers have compared different types of emotion regulation strategies (e.g., direct problem solving, reappraisal, rumination, avoidance, or acceptance[9]) and examined how using each of them may exacerbate affective disorders to a different extent (Aldao & Nolen-Hoeksema, 2010; Campbell-Sills, et al., 2006; Campbell-Sills & Barlow, 2007). Problem solving is an active attempt to overcome or prevent a problem (Billings & Moos, 1981), whilst reappraisal is to find positive attributions or interpretations of an event to prevent or reduce negative emotions about the event (Gross, 1998). The convergent findings show that both forms of emotion regulation are generally linked to better mental health, whilst failure to use them adaptively may lead to negative emotions and increase the chance of an individual developing an affective disorder (Campbell-Sills, et al., 2006b; Campbell-Sills & Barlow 2007; Gross & John 2003). For this reason reappraisal and problem solving are also often referred to as adaptive emotion regulation strategies. Moreover, some researchers have further shown that individuals with depression and anxiety reported having more difficulties in using reappraisal, acceptance, problem solving, or attentional deployment than healthy controls (Campbell-Sills et al., 2006; Aldao & Nolen-Hoeksema, 2010). Attentional deployment is the control of the attention towards or away from the stimuli within an emotion generation process (Ochsner, Silvers, & Buhle, 2012). Campbell-Sills and Barlow (2007) posit that the inability to use these adaptive emotion regulation strategies may lead to exacerbation of negative emotions that

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[9] This is defined as a willingness to experience events fully and without defense (Forsyth, Parker, & Finlay, 2003; p. 865). Acceptance also incur having an internal response, to participate in meaningful experiences without judging or avoiding such internal experiences (Roemer & Orsillo, 2007; p. 74).

are more controllable, severe, and chronic. This may explain why disturbance in emotion regulation may be implicated in depression and anxiety disorders since negative emotions will accumulate and not minimize as a consequence of this disturbance. When faced with the difficulties in emotion regulation, these individuals often turn to the use of maladaptive emotion regulation strategies such as rumination and emotional avoidance but these strategies are not effective ways in regulating their negative emotions (Campbell-Sills et al., 2006). Consequently, the negative emotions persist, leaving individuals to be in a prolonged depressed or anxious state.

Other empirical support for the relationship between emotion regulation and psychopathologies is from a meta-analysis conducted by Aldao and Nolen-Hoeksema (2010). The review analyzed how six emotion-regulation strategies (acceptance, avoidance, problem solving, reappraisal, rumination, and suppression) exert different effects on the symptoms of four psychopathologies across 114 studies (anxiety, depression, binge eating, and substance-related disorders). Results indicated a largest effect of rumination on increasing the symptoms of all disorders. There was a medium to large effect size for avoidance, problem solving, and suppression, and only a small to medium effect size for reappraisal and acceptance on reducing the symptoms of each disorder. Although the meta-analysis again confirmed the consistent trend that maladaptive emotion regulations (rumination and avoidance) were associated with increased psychopathologies, it only provided minimal support that adaptive regulations (reappraisal and acceptance) were associated with decreased symptoms of these disorders. Also, the meta-analysis did not specify why individuals would select maladaptive over adaptive emotion regulation strategies, therefore it is worth exploring other factors such as coping behaviours that have been shown to impact one's ability to regulate one's own emotion and behaviour.

1.4.4 The impact of coping on suicide behaviour

Alongside the importance of regulating one's own emotions, having adaptive ways to cope with every upcoming challenge is just as important to better equip individuals to take advantage of any opportunities in life. According to Lazarus and Folkman (1984) coping refers to the "conscious volitional efforts to regulate emotion, cognition, behaviour, physiology, and the environment in response to stressful events or circumstances" (p.89). Through years of extensive research into coping, many other definitions have emerged. For example, Stone, Helder, and Schneider (1988) defined coping as a series of thoughts and actions individuals have in response to a stressor.

Although the disparity in defining coping remains (see Compas, Connor-Smith, Saltzman, Thomsen & Wadsworth, 2001 for a review), most researchers have agreed that coping generally serves to regulate emotions and behaviours under the presence of stressor (Compas et al., 1997; Eisenberg et al., 2007; Skinner, 2007). The effectiveness of a coping strategy depends on how it can reduce immediate distress, and contribute to long-term outcomes such as maintaining positive psychological wellbeing. There are recent findings that support this in that suicidality is dependent on how individuals choose to cope with difficulties (Morris, Evans, Rato, & Garber, 2014; Tang & Qin, 2015). These studies support that the use of broad variety of coping strategies effectively and flexibly can help to reduce depression and associate with lower levels of suicidality. As highlighted by Richard-Devantoy and Courtet (2016), the capacity to utilize adaptive coping strategies is dependent on one's cognitive abilities, in particular, suicidal individuals with impaired executive functions are at greater risk of attempting suicide possibly because they have more difficulty generating alternative coping strategies. This reflects how the different important factors may be interlinked to affect suicide behaviour.

There are many ways of coping listed in the literature, with the most common ones being support-seeking, avoidance/denial, positive restructuring, emotional discharge, logical analysis, self-soothing (e.g. comfort food consumption), social withdrawal and suppression of competing activities (Folkman & Lazarus, 1980, 1984). Suppression can be considered as a form of emotion regulation as well as coping in different literatures. They differ in ways that emotion regulation involves more cognitive effort whereas in coping it involves more behavioural efforts to suppress specific responses to stressors. In addition, whilst for coping, suppression would always target a negative event (stressor), suppression in the perspective of emotion regulation could be positive or negative (e.g. suppressing a laugh or anger). The types of coping strategies individuals adopt and their frequency of use can be measured using a number of methods such as open-ended interviews, observations, and self-report inventories. Using an online health behaviour survey to examine stress levels and coping strategies in 1139 students, Ickes, Brown, Reeves, and Martin (2015) reported that some coping strategies are more commonly used by undergraduates and graduates to cope with stressors in academic life. These include coping by self-soothing such as excessive sleeping (69.6%), doing exercises (66.1%), and comfort food consumption (56.8%). Notably, coping in the form of seeking social support was reported to be the most useful strategy in reducing perceived levels of stress in student life. In a similar study, Görgen, Hiller, and Witthoft, (2013) assessed the use of coping and the anxiety levels among 242 students. It was found that the use of dysfunctional coping such as rumination, that is having persistent and repetitive thoughts regarding the stressors, was associated with increased anxiety levels in students.

Although there is empirical evidence to support the argument that coping is essential for individuals to deal with stressors and in maintaining positive psychological wellbeing, the study of coping is particularly challenging because the concept is so broadly defined and diversely studied across different fields in the literature (Skinner & Gembeck, 2007). Early theorists such as Folkman and Lazarus (1980, 1984) were among the first to propose categorizations of coping strategies related to cognitive processing. They claimed that the selection of coping is highly variable and constantly changing, hence the effectiveness is dependent on the context of situational demands and on the cognitive resources of the individuals. For example, denial may be helpful in alleviating distress for stressors that cannot be changed (e.g. bereavement), but may be considered as maladaptive in situations where direct problem solving is more effective (e.g. for stressors such as being fired from a job and facing academic failure). For this reason, Folkman and Lazarus (1980) claimed that coping is not exclusively defined as either adaptive or maladaptive, nonetheless, through investigation into coping and psychological wellbeing, there is a trend that some coping strategies may be especially useful to deal with some stressors than the others. In particular, Tang and Qin (2015) examined how the use of social support and coping skills may influence suicidal behaviour among 5972 undergraduates from 6 universities in China. All participants completed a series of questionnaires and logistic regression was performed to assess the effect of coping on suicide behaviour. Of the 5972 students, 16.39% reported having recurrent suicide ideation. It was also shown that frequent use of seeking guidance and support, problem solving, and seeking alternative rewards were more effective ways of coping as they were associated with reduced suicide risk. Conversely, poor social support and frequent use of coping in the form of acceptance, emotional discharge, logical analysis, and avoidance were associated with increased suicide ideation. Evidently, failure to implement different coping strategies in response to a stressor, to regulate one's own emotion, cognition, or behaviour may have a negative impact on psychological wellbeing, or in the extreme case, lead to suicide (Görgen et al., 2013; Zhang, Wieczorek, Conwell, & Tu, 2011).

The important effect of coping on suicide behaviour has been extensively studied in recent years (Kirchner, Ferrer, Forns, & Zaninin, 2011; Sung, Puskar, & Sereika, 2006; Tang & Qin, 2015; Uğurlu & Ona, 2009; Zhang et al., 2012). Whilst considering that some coping strategies are more effective than others, researchers may question why suicidal individuals show reduced use of adaptive coping strategies. To determine whether suicidal individuals lack these adaptive coping skills naturally, or whether they choose not to use them despite their availability, Wilson et al. (1995) compared the use of different coping strategies among suicidal and non-suicidal young adults. Interestingly, they found that suicidal participants were just as capable as the healthy control group in generating adaptive coping strategies with comparable support seeking and active coping strategies. However, participants with a high risk of suicide persisted in using more maladaptive coping strategies and fewer adaptive coping strategies than the healthy control group. They were also more focused on emotions, had poorer cognitive abilities and utilized more behavioural avoidance as a way of coping (Wilson et al., 1995). Other studies on university students replicated Wilson et al.'s findings on the relatively greater use of avoidance coping in suicidal participants (Blankstein et al., 2007; Uğurlu & Ona, 2009; Zhang et al., 2012). From this it is evident that suicidal individuals may have the capacity for using the adaptive forms of coping but they tend to use more maladaptive coping strategies to deal with their stressors. As coping ability cannot fully explain suicide behaviour there is the argument that other underlying factors should be considered, such as neurological activity of these behaviours. This has led to the interest for exploring neurological correlates of suicide individuals to see how that may influence the capability to utilize coping strategies and underscore the progression of suicidality.

1.4.5 The neurological basis of suicidality

The determinant of one's executive function ability is traced back to its biological development which begins in infancy, it continues to develop rapidly during adolescence, and does not reach maturity until early adulthood (Goldstein & Naglieri, 2013). This is supported by neuroimaging studies which revealed that the frontal lobes continue white and gray matter development until at least the third decade of life where it reaches the complete stage of development (Johnston et al., 2017). The continued brain maturation is also exhibited by peak executive functions abilities for individuals aged between 20-29 years old (De Luca et al., 2003). Consequently, examining brain activities of young adults will be beneficial in the research of this thesis.

Recent advances in neuroimaging technologies have provided an alternative method for assessing executive functions more objectively and are less reliant on self-report measures. The neurological investigation of executive functions is mainly based on exploring the frontal brain region; as this is the area that has been repeatedly found to correspond to executive functions (Fazakas-DeHoog et al., 2017; Løvstad et al., 2016). The evidence is gained from studies showing significant activation in prefrontal regions while participants perform cognitive tasks that require executive functions. For example, using fMRI can measure increase in brain activation of the dorsolateral PFC (dlPFC) during task that require executive functions. Attentional control is the ability to modulate and control selective attention to relevant information (or sometimes refer to as attentional bias) and inhibition of irrelevant information (Riddle, 2007). This cognitive ability varies between individuals and is influenced by emotion (Bower, 1981, 1991; Brosch, Scherer, Grandjean, & Sander, 2013). Using fMRI and Stroop tasks, Herrington et al. (2010) found increased frontal brain activity when individuals performed a colour Stroop (Stroop, 1935) and emotional Stroop task that measure attentional control. An emotional Stroop task is similar to the colour Stroop task whereby participants are asked to name the colour of words. As emotional and neutral words are used in the emotional Stroop task, researchers can assess how emotional distraction interferes with colour-naming (see Williams, Mathews, & MacLeod, 1996).

A related fMRI study by Hoffmann, Mothes-Lasch, Miltner and Straube (2014) compared brain activation of participants during word processing task with emotional interference whereby participants were presented with neutral and emotional words. Compared to neutral words, Hoffman et al. (2014) found an increased activation of the amygdala, the medial PFC, and language-processing cortical areas when negative or threatening words were presented. The increased activation of these areas was not evident during presentation of neutral words revealing that exposure to emotional words have increased cortical and subcortical neural network processing compared to neutral words. From the findings of Herrington et al. (2010) and Hoffman et al. (2014), it is suggested that processing of different emotions is associated with differential brain activation, and therefore neural imaging data could be an objective measure to reflect emotional processing.

Goldstein and Naglieri (2013) reviewed the theoretical and clinical constructs of executive functioning, and documented that the PFC is well connected to its adjacent brain regions such as the parietal lobes and the midbrain. This connection is central for the regulation and evaluation of behaviour that enables individuals to question, develop strategies, and engage in self-monitoring. Indirect evidence is derived from clinical studies that have reported a variety of executive functioning deficits when the frontal lobe is damaged. These deficits were also previously identified to be associated with suicide behaviour. For example, distractibility, lack of initiation, impulsive control, and disinhibition (Arria et al., 2009; Goldstein & Naglieri, 2013; Jollant, Lawrence, Olié, Guillaume, & Courtet 2011). In a related vein, Johnston et al. (2017) posited that the elucidation of neural systems can help to better understand suicide behaviour and improve suicide prevention. As the frontal-limbic system (the neural connection between the frontal region and the limbic system that regulates emotion and impulses) is still under development at young adulthood, neural imaging of these brains may provide explanation as to how suicidal thoughts and behaviours arise in young adults (Hathaway, 2017). In an MRI investigation, Johnston et al. (2017) explored brain development in young adults who were past suicide attempters (n=26) or individuals with only suicide ideation but not suicide attempt (n=42). Findings revealed that past suicide attempters exhibited relatively lower activity in the frontal-limbic system, and had less white matter volume (the wiring that provides connections between brain areas) compared to healthy controls. The findings also suggested that the frontal cortex of suicide attempters is less functional in regulating the circuitry, which may result in increased emotional pain, difficulties in generating alternate solutions to suicide and greater chance to act on suicidal impulses (Johnston et al., 2017). The neurological findings may serve as a new way to identify those who are most at risk of suicide, they may also help clinicians to develop new strategies to minimize risk factors, and therapies designed to strengthen the vulnerable brain circuits (Johnston et al., 2017). Based on these studies, the current research of this thesis aims to combine neurological and cognitive measures with the variables of coping and emotion regulation to identify risk factors and possible predictors for suicide behaviour.

1.4.6 The association between executive functions, coping, emotion regulation, and suicide

From the scope of existing literature, it is evident that the cognitive and behavioural factors (executive functions and coping) outlined so far not only inform their association with suicidality but they are also closely interlinked with each other. For this reason, some researchers have examined these constructs together rather that separately when investigating suicide. For example, both Richard-Devantoy et al. (2012) and Richard-Devantoy and Courtet (2016) documented that individuals who had attempted suicide showed more cognitive deficits in decision making, problem solving, autobiographical long-term, and working memory compared to non-suicide attempters. Importantly, they also argued that these impaired executive functions apparent in suicidal individuals are coupled with difficulties in generating alternative coping strategies. With problems in both cognitive and behavioural aspects, individuals are at even greater risk of attempting suicide because they are less able to consider the consequences of their behaviour carefully. They may also be less capable to inhibit negative thoughts and using maladaptive emotional and behavioural responses to a greater extent.

Another argument of how executive functions may be linked to other key variables associated with suicide behaviour was put forward by Joormann and Gotlib (2010). It was posited that executive functions play a pivotal role in emotion regulation, especially when some regulations such as attentional deployment are highly related to cognition (Gross, 2003). Similarly, Joormann and Gotlib (2010) suggest that effective emotion regulation such as reappraisal is linked to the flexible control of attention and inhibition that allows individuals to redirect the focus away from irrelevant thoughts and to better manage negative intrusive thoughts. Reappraisal involves reinterpreting the meaning of a stimulus, including one's personal connection, in order to change one's emotional response to the stimulus (Gross, 1998). Reappraisal is generally considered as adaptive because it involves changing a situation's meaning in such a way that there is reinterpretation in a more positive or neutral manner. To test this assumption, Joormann and Gotlib (2010) used self-report measures of rumination, reappraisal, and expressive suppression were collected from currently depressed, formerly depressed, and never-depressed participants before performing a negative affective priming task. This task is used to assess inhibition whereby participants are presented with two stimuli; a target and a distractor. They were told to ignore the distractor and respond to the target stimulus.

Inhibition is essential because on different trials, the to-be-ignored emotional stimulus may become the target. Joormann and Gotlib (2010) found that increased use of maladaptive emotion regulation strategies such as suppression was linked to inhibition (indexed by performance in the negative affective priming task). In particular, difficulties in inhibition of negative stimuli was related to less use of reappraisal and more use of expressive suppression. Within the group of currently depressed participants, reduced inhibition of negative material was associated with greater use of rumination. This finding confirms that given a situation whereby individuals fail to execute adaptive emotion regulation points, they may experience more difficulties in downregulation (inhibition) of negative emotions. This may in turn lead to more emotional distress due to the accumulating emotional disturbance, and may perpetuate different affective disorders (for a full review, see Aldao et al., 2010 & Nolen-Hoeksema, 2012; Campbell-Sills, et al., 2006; Gross, 2015; Joormann & Stanton, 2016; Nolen-Hoeksema et al., 2008).

More recently, Lantrip, Isquith, Koven, Welsh, and Roth (2015) again explored the use of adaptive emotion regulation; reappraisal but this time they examined multiple aspects of executive functions among 70 adolescents. The correlational study involved the use of self-report measures of emotion regulation and perceived difficulties in executive functions (as indexed by scores on the Behaviour Rating Inventory of Executive Function-Self-Report, Guy, Isquith, & Gioia, 2004). It was found that lower scores on the Behaviour Rating Inventory of Executive Function-Self-Report (BRIEF-SR) were linked to increased use of reappraisal. Moreover, less difficulties with executive functions were associated with an increased ability to regulate emotions by facilitating the use of reappraisal. Therefore the findings support the earlier assumption by Miyake and Friedman (2012) that whether someone could select and use adaptive emotion regulation strategy is dependent on one's own cognitive ability.

From the findings of Joormann and Gotlib (2010) and Lantrip et al. (2015), it is reasoned that the decreased use of adaptive emotion regulation and impaired cognitive abilities may exacerbate depressive symptoms. To investigate this relationship, Joormann and Stanton (2016) collated and analyzed previous studies regarding cognitive abilities and emotion regulation in depressed individuals. The review was consistent with the findings of Lantrip et al. (2015) wherein depressed individuals with cognitive deficits reported more difficulties regulating emotions after experiencing negative life events. They also tend to use maladaptive emotion regulation strategies (e.g., rumination, suppression, and avoidance) more frequently and have more difficulties implementing adaptive emotion regulation strategies. Joormann and Stanton (2016) inferred that the ability to use adaptive emotion regulation (e.g. reappraisal) is dependent on one's cognitive abilities such as the ability to remember goals, plan, and anticipate outcomes. Therefore, cognitive deficits may lead to the difficulties in regulating emotion, and this may attribute to the onset of depression and other forms of emotional disturbance.

Joormann and Stanton (2016) further suggest that cognitive ability and emotion regulation interact, and can possibly influence suicidality as well. This may also help to explain why among the high number of individuals reporting depression, some (those who are unable to regulate their emotions and have cognitive deficits) go on to commit suicide whilst others do not. Considering the pivotal role of executive functions in suicide progression and the selection of using adaptive emotion regulation strategies, Fazakas-DeHoog, Rnic and Dozois (2017) have recently turned to non-clinical sample and explored how impairment in executive functions may account for suicide behaviour in university students. The study involved 397 undergraduate students completing measures of cognitive deficits (problem solving deficits, problem solving avoidance, and cognitive rigidity), cognitive distortions (hopelessness and negative evaluations of self and future), and current suicide ideation. They revealed that cognitive distortions have a significant impact even with individuals reporting only milder forms of suicide behaviours (i.e. engaged in suicidal ideation but not attempt), whereas cognitive deficits may exert their effects on suicide ideation via a relation with cognitive distortions. Findings underscore the importance of both cognitive distortions and deficits for understanding suicidality, which may have implications for preventative efforts and treatment. With considerable evidence to support the relationship between executive functions, emotion regulation and suicidality, it is noted that research has not been conducted in a student population in HK.

1.5 Concerns with the existing approach to investigate suicide and suggestions for a new approach

Although the use of risk-based approach within the empirical and epidemiological research has helped to identify important variables to predict suicide progression, there is concern over the approach which often identifies a large number of individuals who may be at risk of suicide. For example, approximately 20% of the young adult population who has experienced suicide ideation and more than 10% reported having depressive symptoms were identified as being at risk of suicide each year (Hawton & van Heeringen, 2009). However, the majority of them will not progress to suicide attempt in the end thereby generating a large number of false positives for suicidality. A second issue regarding the current approach to studying suicidality is that some common risk factors associated with suicide such as hopelessness and having emotional disturbance are not exclusive to suicide, they are also linked to depression and anxiety disorders respectively. Therefore, the existing knowledge of these variables can only provide general information about potential risk factors that may not be specific to suicide, and these have limited utility in predicting suicide behaviour (Brenner & Homaifar, 2009). This leads to the argument that using solely risk factors to identify at-risk individuals may not provide the most effective prediction and prevention of suicide (Hawton & van Heeringen, 2009; Seligman & Csikszentmihalyi, 2000; Seligman, Steen, Park, & Peterson, 2005).

Since recognizing that the study of risk factors alone cannot fully explain suicidal behaviour, some researchers have turned to exploring positive psychological factors that may cultivate psychological wellbeing (Seligman, Rashid, & Parks, 2006; Tarrier, 2010) and protective factors associated with reduced suicidality (Johnson, Gooding, & Tarrier, 2008; Perkins & Jones, 2004). These works have helped to develop some of the theoretical framework reinforcing *resilience.* Resilience refers to factors associated with reduced rates of affective disorders or other negative outcomes (e.g. Bonanno, Galea, Bucciarelli, & Vlahov, 2007). Individuals who are considered to have greater resilience to suicide may hold certain personal features that enable them to adapt to changes in adversity, and recover from negative events (Olsson, Bond, Burns, Vella-Brodrick & Sawyer, 2003). These serve as an important protective factor against the development of suicidality in the face of risk factors or adversity (Perkins & Jones, 2004). Examples include having high self-esteem, social and emotional competence (Flemming, Merry & Robinson, 2007) and using more self-appraisal (Johnson et al., 2008).

Another issue that has challenged the study of suicide was put forward by Klonsky et al. (2016). For example, although most researchers are clear about the different terms and definitions of suicidality, many have struggled to establish a set of agreed terms, with differences in terminology and variations used between subfields (e.g., by psychologists, mental health professionals, researchers, school systems, and coroners). Such diversity impedes the ability to combine knowledge from disparate suicide studies and limits their comparison regarding different factors attributed to suicidality (Posner et al., 2014). The dissociation also hampers the ability to integrate findings across the various studies published. In addition to this, Klonsky et al. (2016) also raised concern over the existing approach in investigating suicidality due to the measures of suicidality. In particular, the divergent aims and different methods used in prior studies to measure suicide behaviour, which range from the simplest form to the more complex forms of assessments on suicide behaviour. The simplest form of screening consists of only one or two items such as “Did you ever seriously consider suicide?” or, “Have you ever attempted suicide?” Both questions would be followed by a yes or no answer (CDC, 2015). Alternatively, more comprehensive forms of assessments may include a series of multiple choice and open-ended questions. The inventories cover many aspects of suicide behaviour such as frequency, severity, planning, communication, and intent of suicide at the present time as well as in the future (Nock et al., 2007).

Due to these variations in assessing suicidality, the sample populations differ across studies in terms of the degree of suicide severity, stage of suicide, the measures used to assess suicidality, and the comorbidity of other affective disorders. Though versatility in measurement approaches allows for assessments in different settings and time frames, it also creates issues in literature reviews (Klonsky et al., 2016). For example, the presence of suicide ideation is at times operationalized as fleeting thoughts about suicide but at other times requires heightened intensity, duration or frequency. Such diverse approaches in assessing suicidality have made comparison of empirical findings and integration of knowledge across literatures especially problematic. In light of the divergence of suicide measures and the mixed definitions on suicidality (Burton et al., 2011; Nangle et al., 2006), the current knowledge on the underlying causes of suicidality remains unclear and inconclusive.

Although there has been a wealth of research in the study of suicide behaviour, prediction and prevention of suicide is challenging because suicide is an extremely personal and sensitive topic (Nock et al., 2010). Those who experience suicide behaviour may avoid discussing this with others and sharing feelings and thoughts often trigger feelings of stigmatization. This can also lead to difficulties in predicting suicidality because assessments are largely based on clinical interviews and self-report measures (Wilson, 2009). This means clinicians have to rely on an individual self-disclosing information regarding their current suicide ideation, suicide plans and any history of past suicide attempts. Such disclosure may be unreliable (Mann & Currier, 2007) if an individual is unwilling to report their intentions and they may also deliberately deny or conceal their suicide tendency to avoid intervention or hospitalization (Nock et al., 2010).

1.6 Aims and objectives of the research in this thesis

In light of the challenges in measuring and predicting suicidality, it is argued that the use of neurological and cognitive measures could provide potential indicators for characterizing suicide behaviour. From the wide range of supporting studies, it is now clear that cognitive and neurological impairments, emotion regulation, and coping are important factors associated with suicide behaviour. The current research sought to extend this work by examining their relationship and how they influence suicide behaviour. Importantly, it is noteworthy that the existing literature investigating suicide behaviours are largely based on past suicide attempters or clinical populations, with only few studies investigating non-clinical populations with lower severity of suicidality (Zhang et al., 2012). The non-clinical population should not be ignored given the percentage of students with recurrent suicide ideation and the alarming increase of suicide behaviour (Cheung & Chiu, 2017; Yip, 2016). For this reason, the focus of the current research will be non-clinical populations and this also gives wider application to the preventive and identification measures in predicting suicidality at an early stage of suicide behaviour.

In summary, the main theme of the research of this thesis was to explore cognitive and neurological factors that could serve as valid indicators for characterizing suicide risk in a non-clinical sample. The first study (Study 1) was preliminary investigation to explore self-report measures of executive functions and coping strategies in relation to suicide behaviour and to determine whether these differ in a HK sample. This study was based on the issue that much of the past research has been conducted in the West with little understanding of how the findings extrapolate to Chinese sample (Wong et al., 2006). The findings of Study 1 have helped to determine which of the executive function components and coping strategies confer the most important predictors for suicidality. Since the first study focused on elucidating risk factors associated with increased suicide risk, it is of comparable importance to study how resilience factor is associated with suicidality. The use of cognitive reappraisal was investigated as a possible resilience factor against suicide in Study 2 and this was based on the Schematic Appraisal Model of Suicide (SAMS; Johnson et al., 2008). The exploration of depression variable was also added to this study due to its high comorbidity with suicidality (Bostwick & Pankratz, 2000; Wang et al., 2007). The study sought to establish whether the separate constructs of cognitive reappraisal and avoidance coping would differentially impact suicidal behaviour and depression.

Due to the limitation of using self-report questionnaires in both Study 1 and 2, Study 3 aimed to take a different approach to studying the key executive functions in relation to suicide behaviour. Based on the findings of Study 1 and suicide models outlined in Study 2, suicide behaviour arises when there is an attentional bias to particular life events, difficulty in inhibiting irrelevant emotional distractions, and insufficient working memory capacity to solve problems. Therefore, executive functions such as attentional, inhibition and working memory were investigated experimentally using cognitive tasks in Study 3. In addition to this, EEG measures were also taken to examine whether there was any neurological difference between individuals with high and low levels of suicidality.

Considering the distinctiveness of the sample in this research who were all Chinese bilinguals, it was recognized that the standard stimuli used in well-established cognitive tasks may not be applicable to this population. This raised the necessity to carefully select the stimuli for the final experiment. Two pilot studies (Study 4a and 4b) were conducted to select the type (faces or words) and the language (Chinese or English) of stimuli used for the final Stroop task (Study 5). Building upon the work from Study 3, Study 5 investigated how frontal asymmetry is associated with suicidality again but in a sample with higher levels of suicidality. Additionally, the study examined how frontal asymmetry is related to inhibition of different emotions through the use of an emotional Stroop task. In terms of the investigation of difference in attentional control between individuals with high and low levels of suicidality, the emotional Stroop task was improved from Study 3 so that attentional bias towards suicide-related stimuli could be investigated.

CHAPTER TWO

Exploring the links between suicide, executive functions, and coping

2.1 Specific executive functions associated with different stages of suicide progression

A great deal of research has highlighted the use of executive function deficits in assessing suicide risk, as outlined in Chapter 1 (Elliott, 2003; Jollant et al. 2011; Keilp et al., 2008; Loyo et al., 2013). These studies revealed that deficits of specific executive function such as attention, memory, decision making, planning, and problem solving were associated with suicidality. Keilp et al. (2001) conducted a series of experiments assessing executive functions via neuropsychological batteries among patients with varying degrees of suicidality. The sample included depressed patients without history of suicide attempts, depressed patients with a past history of high lethality suicide attempts, depressed patients with a past history of low lethality suicide attempts, and a non-depressed group. Those who experienced mild physical injury from the attempt were categorized as low lethality and those who experienced serious injuries that required medical intervention were categorized as high lethality. Batteries for assessing executive functions included measures of attention, memory, motor functioning, general intellectual functioning, and general executive functioning. Findings revealed no significant group differences on the majority of measures with the exception of attention and memory, individuals with a past history of suicide attempt had poorer attention than the control group and those without a history of attempt. Deficits of working memory were apparent in individuals who had made a high lethality suicide attempt in the past compared to the healthy control group. However, this difference was not found in attempters with low lethality or depressed non-attempters. This indicates that suicidality may impact executive functions but this is limited to those who have dangerous levels of suicidality only.

There is ample research that investigated a range of different executive function deficits corresponding to various stages of the suicide continuum (Davis & Nolen-Hoeksema, 2000; see Wedig & Weinstock, 2012, and Wenzel, Brown, & Beck, 2009 for discussions). Some studies found that deficits in shifting and ruminative thinking were associated with the initial stage of suicide, suicide ideation, while others documented deficits in inhibition (Burton et al., 2011) and impulse control (Jollant et al., 2005) were associated with more severe form of suicidality such as suicide attempts. In an experimental investigation by Burton et al. (2011), demographic, clinical, and executive function measures of 77 patients with psychiatric disorders were examined. It was predicted that past suicide attempters (n=37) would demonstrate poorer executive functions as indexed by cognitive tasks that assess attention, inhibition, and problem solving when compared to those without history of attempt (n=40). However, contrary to predictions, past suicide attempters exhibited higher problem solving skills but poorer inhibition than participants with suicide ideation but past no history of attempts (n=40). The findings add support to the results of Nangle et al. (2006) and suggest that the risk of suicide attempt is associated with better problem solving skills but worse inhibitory control. It is reasoned that better problem solving is associated with initiation of behaviour and better planning including plans for suicide attempt. Similar results were documented by other studies who reported impaired decision making and inhibitory control (lower accuracy and faster response time in cognitive tasks) among past suicide attempters (Jollant et al., 2005; Malloy-Diniz, Neves, Abrantes, Fuentes & Corrêa, 2009; Richard-Devantoy & Courtet, 2016).

Jollant et al. (2005) contended that decision making as well as impulsivity (the increased likelihood to engage in an action without planning or consideration of the outcomes) are crucial in the suicide progression as they may limit the ability to formulate plans and initiate goal-directed behaviour such as suicide attempt. From this perspective, impulsivity and impaired decision-making may increase the degree of suicide ideation but not the risk of completed suicide because the success of a suicide attempt also depends on careful planning (e.g. the lethality of tool used and the way to carry out the attempt without being discovered beforehand). This dissociable pattern of executive function deficits between suicide ideation and suicide attempts seem to suggest that individuals at different stages of suicidality might present with different cognitive disturbances. Nonetheless, the majority of research has provided comprehensive evidence that intact executive functions are fundamental to healthy mental functioning in everyday life and it is important to explore these executive function components in more detail.

Building on the scope of findings, some researchers queried whether suicidality is linked to multiple aspects of executive function rather than to specific executive function components (Alvarez & Emory, 2006; Jurado & Rosselli, 2007; Miyake et al., 2000). Indeed, many aspects of executive function are at times intertwined in such a way that it is difficult to determine which executive function is causing an effect (Jollant et al., 2011). For example, updating[10] is one executive function that enables individuals to oversee actions and behaviour and to ensure that an action is being completed according to the plan (Joormann & Tanovic, 2015), yet it has been found that deficits in updating may impact other cognitive abilities such as the retrieval of autobiographical memories from the past (e.g. Williams, 2006). This may obstruct the ability to generate solution based on past experience, imagine possible outcomes in the future and thereby impede problem solving (see Williams et al., 1996).

Among the long list of executive function outlined, it is notable that certain cognitive processes focus on emotions and others focus on behavioural actions (Anderson, Jacobs & Anderson, 2011). Their distinguished cognitive and emotional features have led to the subdivisions of different executive systems, one majoring in metacognition[11] and the other corresponding to emotions (Goldstein & Naglieri, 2013).

2.1.1 Categories of executive functions

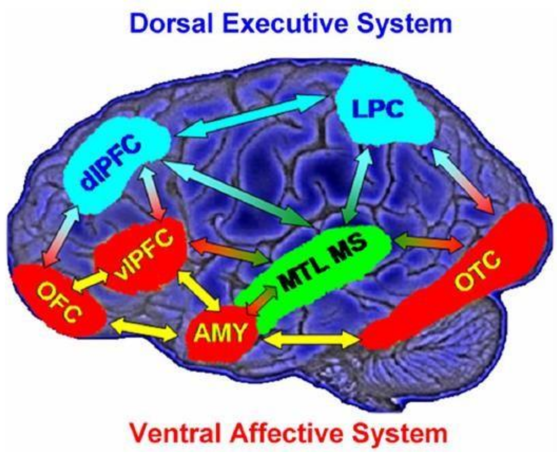
Due to the wide range of cognitive processes involved, executive functions are best explained using two systems based on their dissociate functions, the *Dorsal (cold) Executive System* and the *Ventral (hot) Affective System* (Mayberg, 1997). These two systems are distinct by their predominance in different brain regions (Figure 2.1). As the name suggests, the cold executive system includes mechanistic and logically based

[10] Updating requires monitoring and coding of incoming information and appropriately revising the items held in working memory by replacing no-longer-relevant information with new, more relevant information (e.g., Morris & Jones, 1990). Some journals would use the term updating whilst others would use working memory.

[11] According to an early definition by Flavell (1979), Metacognition refers to the processes to think and to learn. It involves higher order of active control over the cognitive processes engaged in learning. Examples are to plan, monitor, and assess one's understanding and performance.

cognitive processes such as attention, planning, and problem solving (Grafman & Litvan, 1999). Conversely, the hot affective system deals with the emotional aspects (e.g. emotional response and regulation) and it may interfere with the cold executive system. Individuals will respond to emotions differently depending on the use of the hot affective system and the cold executive system (Iordan et al., 2013).

Figure 2.1 Dorsal (Cold) Executive System and Ventral (Hot) Affective System



Adapted from the figure courtesy of Dr. Aysenil Belger (2016). The figure illustrates that the Dorsal (Cold) executive system includes the dorsolateral prefrontal cortex (dlPFC) and the lateral parietal cortex. The Ventral (Hot) affective system includes the amygdala, the ventrolateral PFC (vlPFC), and the Orbito-frontal cortex (OFC). Other brain regions in which both systems interact with include the medial temporal lobe memory system and the occipito-temporal cortex. Monochromatic arrows represent connections within the same system, whereas bichromatic arrows represent connections across both systems.

The two systems exhibit dissociable effects on cognitive control whereby increased activity of the cold executive system (but not hot affective system) is generally associated with increased performance in tasks that recruit attention and working memory (Rottschy et al., 2012). Working memory can be conceptualized as a system that temporarily stores and manipulates information held in mind across time (Baddeley, 1974, 1992). For example, when an individual is asked to remember a phone number, he or she will repeatedly rehearse the number until the next recall where the number is dialed. Therefore working memory is also essential to other executive functions such as learning and language processing.

According to Drevets (1998), decreased activation of the cold executive system and increased activation of the hot affective system may result in impaired executive control and increased emotional disturbance respectively. However, opposed to Rottschy's postulation for the importance of the cold executive system, Jollant at al. (2011) proposed that the hot affective system is comparably important for tasks that require critical executive functions. This is supported by neuroimaging evidence outlined earlier that patients with deficits in the hot affective system (e.g. the lateral orbitofrontal cortex) substantially impeded executing task performance featuring decision making thus regulating their emotions (Chung, Weyandt, & Swentosky, 2014; Jollant et al., 2010). Therefore, the convergent evidence reflects that the emotion-cognition interaction may not be as simple to define as it seems. Aside from this interaction, the supporting evidence so far substantiated the link between suicidality and executive functions, yet limited research has examined how coping behaviour plays a role in this relationship.

2.2 Executive functions and coping

Regarding the cognitive and behavioural features of coping in response to situational demands, Lazarus and Folkman (1984) have emphasized the importance of managing stressors effectively through the means of emotion, behaviour, and cognitive functions. Similar to how cognitive abilities can impact emotion regulation, Lazarus and Folkman (1984, 1986) stipulate that an individual's cognitive ability can affect the type of coping strategies adopted and this can impact subsequent suicide behaviour.

The literature generally supports the argument that individuals with functional cognitive abilities in the form of good working memory, planning, cognitive flexibility, and inhibition are better able to cope effectively with a stressor (Richard-Devantoy et al., 2014; Richard-Devantoy & Courtet, 2016). For example, individuals need to recollect instances of similar stressors experienced previously, and this requires information retrieval by long-term memory and also to assess the situation and link to long-term memory via working memory. They would also need to seek alternative cognitive or behavioural responses that incorporate cognitive flexibility and problem solving. This means that effective planning, larger working memory capacity (which could help to recollect more strategies to cope), and improved cognitive control (i.e. flexible, goal-directed behaviour that requires allocation of mental resources and prioritizing information) would all be crucial in implementing coping strategies and potentially resulting in less susceptibility to suicidality. It should be noted that students at university may still be developing their cognitive abilities and have inflexible approaches to coping strategies (Banich & Compton, 2011). Such malleability may be important in the study of how executive functions and coping strategies can impact upon suicidality.

The study of how executive functions and coping link with suicide behaviour could help to develop and improve suicide prevention programmes. For instance, one of the common suicide prevention activities[12] offered by the suicide prevention program in HK includes safety management techniques (Centre for Suicide Research and Prevention, 2017). It incorporates the use of crisis management cards for suicidal individuals. These cards contain a list of resources, tools, and activities that provide coping strategies that serve as a reminder that there are many ways to manage distress and to get through a crisis. For example, given a hypothetical situation of receiving a poor mark in the final exam, there are list of cards to remind students that they could either turn to peer support, watch a funny movie or reflect on how to improve their marks in the future. However, some studies reported that not everyone has positive outcomes through these types of educational programs (Jobes, 2006; Rudd, 2006). One possible explanation is that individuals with cognitive impairments such as impulse problems are less likely to make use of these safety management techniques. They also added that managing impulsive thoughts, considering the consequences of one's own actions before acting, and deriving alternative strategies to effectively deal with challenges and problems were all associated with increased suicide risk (Jobes, 2006; Rudd, 2006). This highlights that the effectiveness of suicide programs is also partly determined by cognitive ability, and therefore executive functions would be seen as having a critical role in shaping behavioural responses such as coping and suicide behaviour.

[12] In HK, the most well-established suicide prevention programs are run by the Hong Kong Jockey Club Centre for Suicide Research and Prevention and The Samaritan Befrienders Hong Kong. Their programs offered mainly aim to enhance training for teachers and subsidies for schools to better identify at risk students, and to promote mental health education. In recent years, many interactive group activities have been designed to enhance students' ability to learn to cope with difficult situations in life.

2.3 Different forms of coping

In a comprehensive review, Skinner, Edge, Altman and Sherwood (2003) identified over 400 different ways of coping together with 100 coping assessment tools for measuring the frequency of these coping methods have been identified. Some theorists have attempted to differentiate this broad and diverse range of coping strategies and have proposed their own categorizations of the types of coping (see Skinner et al., 2003; Charles, Carver & Connor-Smith, 2010). For example, Folkman and Lazarus (1980, 1984) state that coping has two main purposes, either to target a stressor directly with the aim of resolving a problem, or to manage negative emotional reactions with the aim of reducing tension and the psychological and physiological responses elicited by the stressor. Based on these two purposes, Lazarus and Folkman (1980, 1986) proposed two major divisions of coping; problem-focused coping and emotion-focused coping respectively.

Problem-focused coping aims to alter the stressor directly, taking steps to remove or to avoid it, or to diminish its impact if it cannot be avoided (Carver & Smith, 2010). Therefore, this coping aims to actively solve a problem by managing or changing a situation. For example, if students perform badly in an exam, they may reflect on what aspects they did badly, and think of ways to improve in the next exam. Some examples from the long list of existing coping strategies include planning, logical analysis, problem solving, and seeking instrumental support. In comparison, emotion-focused coping aims to relieve emotional distress caused by or associated with the stressor. It attempts to minimize or to adapt to one’s own emotions by altering thoughts or behaviour (Carver & Smith, 2010; Folkman & Lazarus, 1980, 1984). In the example above, rather than actively thinking about how to improve in the next exam, student may tell themselves that they have already tried their best and accept this as a reality, or they may prefer to discuss their feelings with their friends to express their disappointment. To name a few of the relevant coping strategies that fall under this category are seeking guidance, positive acceptance, religious coping (praying), and social support.

Though the distinction between problem-focused and emotion-focused coping is an important dimension in coping research, Carver et al. (1989) argued that it was over-simplistic and had a lack of comprehensive coverage on the multi-dimensional nature of coping strategies. As Carver et al. (1989) proposed that more differentiation in coping was needed, they developed the COPE inventory with 15 different coping strategies divided into three groups; *problem-focused coping*, *emotion-focused coping*, and *avoidance-focused coping* (see Figure 2.2). Avoidance-focused coping involves both thinking and having purposeful actions to avoid stressful situations (Carver et al., 1989; Endler, 1997). It reflects cognitive and behavioural attempts to avoid thinking about a stressor. This strategy is different to both emotion-focused and problem-focused coping in that it does not directly deal with the problem or the emotions induced by the stressor. Examples include sleeping, venting of emotion, or in extreme forms, disengaging one's own self from the distressing situation via alcohol or drug abuse to achieve a momentarily avoidance from reality.

Figure 2.2 Different categories of coping proposed by Carver et al. (1989)

problem-focused coping	emotion-focused coping	avoidance-focused coping
• Active coping • Planning • Seeking social support for instrumental reasons • Suppression of competing activities • Restraint coping	• Seeking social support for emotional reasons • Turning to religion • Positive reinterpretation and growth • Acceptance • Denial	• Focus on and venting of emotion • Mental disengagement • Alcohol-drug disengagement • Behavioural disengagement • Sense of humor

Through years of investigating the different methods of coping, hundreds of different coping strategies have been listed (Skinner et al., 2003). The preference to use one strategy over the other is dependent on what resources are available (friends, family support, one's own cognitive abilities), the situational demands, and the different purposes they serve. These purposes may include solving problems and dealing with one's emotions (Lazarus & Folkman, 1984) to change or accommodate the stressor (Brandtstadter & Renner, 1990; Rudolph et al., 1995) and engaging in stressful interactions or disengaging from them (Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000). At times, the difference in purpose a coping strategy aims to serve may result in it being categorized into different coping sub-groups. For instance, seeking social support can be categorized as emotion-focused coping if the goal is to obtain emotional support and reassurance, but if the goal is to obtain advice or instrumental help, it will be categorized as problem-focused coping instead (see Figure 2.2). This suggests that categorization of coping is dependent on the goals behind its use.

Despite the established categories of different coping strategies identified by Carver et al. (1989), there remains controversy regarding how best to categorize coping because some coping strategies may feature both problem-focused and emotion-focused strategies (Horwitz, Hill, & King, 2011; Tang & Qin, 2015). For example, walking away from a fight may be considered as emotion-focused coping (to calm down) as well as a problem-focused coping (to modify the setting of a conflict). Therefore, having three categories of coping may be too broad and sometimes be confounded (Tang & Qin, 2015). The next section will focus on some of the most widely established coping strategies in relation to psychological wellbeing.

2.3.1 The psychological impact of adaptive and maladaptive coping

With the general acceptance that coping strategies are important for an individual's psychological wellbeing, considerable research has focused on examining whether some coping strategies are more adaptive than others (Görgen et al., 2013; Gustems-Carnicer & Calderón, 2013; Syed & Seiffge-Krenke, 2015; Zuckerman & Gagne, 2003). Pienaar et al. (2007) conducted a study to examine the relationship between the use of adaptive coping (indexed by COPE inventory; Carver et al., 1989) and the extent of suicide ideation (indexed by Adult Suicide Ideation Questionnaire; Reynolds, 1991) among 1794 uniformed police officers. Results showed that greater use of approach coping and turning to religion were associated with lower levels of suicide ideation. Pienaar et al. (2007) also suggested that police officers who actively engage and confront their work stressors by exploring meanings for the events especially within a religious framework could effectively help them to reduce suicide ideation and negative feelings. Conversely, an increased use of avoidance coping was associated with more suicide ideation indicating that disengaging from negative work events by cognitively or behaviourally avoiding the events were not effective in dealing with the stressor. The avoidance would only predispose the officer to increased suicide ideation. However, it is noteworthy that the sample in the study (police officer) is very different from the student population in the research of this thesis. The stressors university students go through are likely to differ from those of police officers too. Therefore, the findings of adaptive and maladaptive ways to cope in Pienaar et al. study (2007) may not be transferable to a student population in the current investigation.

As students undergo the transition to university life they may often experience multiple major life challenges and this may affect their ability to adapt effectively using different coping strategies (Compas et al., 2013). From a cognitive perspective, suicide urges may arise when individuals are unable to identify and solve the problems they face (Fortinash, Holody & Patricia., 2004) and when coping strategies to deal with their immediate stressors are lacking (Bazrafshan et al., 2014; Esmaeilnia, Faramarzi, Mousavi, & Shamsi., 2005). Building on the early investigations which have compared different coping strategies such as problem solving, social support, and avoidance (Lazarus & Folkman, 1984). Wodka and Barakat (2007) have compared the use of different categories of coping strategies to see if a certain group (rather than a certain strategy) may be more effective than the others. It was revealed that problem-focused coping is generally linked to positive psychological wellbeing, whereas avoidance-focused coping (e.g. passive coping) showed the opposite effects where they were associated with poor psychological wellbeing. Wodka and Barakat (2007) explained that problem-focused coping could be more effective because it not only diminishes the stressor, but also ameliorates the distress generated by that stressor. Emotion-focused coping may help to diminish distress, making it possible to consider the problem more calmly, and this may result in better problem-focused coping. The relationship between problem-focused and emotion-focused coping makes it more useful to think of the two as complementary coping functions rather than as two fully distinct and independent coping categories (Wodka & Barakat, 2007).

Regarding the effectiveness of different coping strategies among the student population, Sadaghiani and Sorkhab (2013) compared problem-focused, emotion-focused, and avoidance-focused coping and examined their impacts on depression in university students. With 252 students recruited to complete self-report measures for coping, depression, anxiety and stress, the results revealed that those who were more depressed and stressed used avoidance-focused coping to a greater extent than the other forms of coping strategies. It was explained that being passive in coping by using avoidance would only lead to more emotional disturbance. Following from this, Gustems-Carnicer and Calderón (2013) found that psychological wellbeing (indexed by the Brief Symptom Inventory; Derogatis, 1993) in 98 undergraduates was positively correlated with greater use of approach coping as indexed by Coping Responses Inventory-Adult form (Moos, 1993). The approach coping is similar to the problem-focused coping in Sadaghiani and Sorkhab (2013) and includes logical analysis, positive reappraisal, seeking guidance and support, and problem solving. The avoidant coping in that study included cognitive avoidance, acceptance, seeking alternative rewards, and emotional discharge. Consistent with Sadaghiani and Sorkhab (2013), the use of avoidant coping is regarded as a maladaptive way of coping as it is linked to lower levels of psychological wellbeing. The results confirm this as psychological distress was positively associated with greater use of avoidance coping, in particular, increased emotional discharge (i.e. the attempt to reduce tension by expressing negative feelings). This also suggest that coping that aims to directly resolve the stressor is more adaptive for students than trying to avoid the distress or emotions caused by the stressors. Therefore, this study draws similar conclusion to Pienaar et al. (2007) despite the use of different samples in both studies (police officers and students).

More recently, Freire, Ferradás, Valle, Núñez, and Vallejo (2016) explored coping in university population again but have extensively examined psychological wellbeing in 1072 Spanish university students. Coping strategies and four indices of psychological wellbeing (self-acceptance, environmental mastery, purpose in life, and personal growth) were assessed via self-report inventories. Results found that higher levels of psychological wellbeing were associated with greater use of coping strategies such as positive reappraisal, support-seeking, and planning. These results complement other studies that psychological wellbeing is positively linked to the use of appraisal and planning (e.g. Gustems-Carnicer & Calderón, 2013). The negative impact of avoidance coping was once again confirmed whereby being mentally estranged from a problem, hiding a problem, self-blame, rumination, and projecting the responsibility for all negative matters onto others constitute dysfunctional strategies for students. These coping strategies are suggested to hinder a student's ability to complete a task and to increase emotional distress. Notably, the result of Freire et al. (2016) differs from the speculations of Gustems-Carnicer and Calderón (2013) because emotion-focused coping such as support seeking was documented as an adaptive way of coping rather than maladaptive. This divergent finding indicates that the most adaptive form of coping in a student population may vary across different studies that explore different subscales of a coping category. For example, whilst Gustems-Carnicer and Calderón (2013) investigated emotion-focused coping in the form of emotional discharge, Freire et al. (2016) examined it in the form of support seeking.

Further to the impact of coping strategies on suicide behaviour, it should be noted that the effectiveness of a coping strategy varies depending of the type of stressor it is being used to deal with. For example, whilst emotion-focused coping is generally considered as a maladaptive form of coping due to its association with poor psychological wellbeing (Blankstein et al., 2007; Morris et al., 2014), some researchers contended that it can at times be an adaptive way for dealing with an unsolvable problem, such as turning to religion or acceptance when facing the death of a significant others (Compas, Malcarne, & Fondacaro, 1988). These emotion-focused strategies may be most appropriate for dealing with bereavement or incidents that cannot be changed, nevertheless the role of cognitive abilities on coping is crucial.

2.3.2 Manifestation of maladaptive coping and executive function deficits in suicide and depression

Based on a systematic review of executive functions and suicidality, Bredemeier and Miller (2015) argue that individuals with deficits in executive functions, particularly shifting, may have more difficulty controlling thoughts about self-harm or switching to more positive or adaptive forms of coping in response to stress. They also explained that when an individual is suicidal, they may lack the cognitive flexibility needed to identify new solutions or coping strategies to deal with the stressors. This contributes to the feeling of entrapment, a psychological state that resembles the state of being "trapped" (Baumeister, 1990). This entrapment is usually paired with feelings of hopelessness thus limiting the ability to utilize a broad range of coping alternatives. Consequently, this may underlie the desire for suicide as the individual feels that there is no other choice but suicide. One of the most common ways to measure the state of hopelessness and feelings of entrapment is via measures of depression, a clinical disorder that is characterized by feelings of worthlessness and helplessness (CDC, 2013).

Support for the link between the state of entrapment, inflexible thinking and maladaptive coping strategies is derived from Morris et al. (2014). The study involved the use of the colour Stroop task and the Wisconsin Card Sorting Task to assess inhibition and cognitive flexibility in 32 depressed and 36 healthy control young adults. All participants completed self-report measures for depression and coping. Morris et al. (2014) postulated that effective coping strategies require appropriate selection and incorporation of different executive function components and both factors may exacerbate depression. The use of primary and secondary control coping (Connor-Smith et al., 2000) was compared in the study. According to Rudolph, Dennig and Weisz (1995) primary control engagement coping is characterized by attempts to change the stressor or one’s emotional responses to it (i.e., problem solving, emotional expression, emotional modulation). Conversely, secondary control coping allows adaptation to a stressful situation either by regulating attention (e.g., cognitive restructuring, acceptance, positive thinking, distraction) or by disengagement coping with the aim to withdraw from the stressor (e.g., avoidance, denial, wishful thinking). Participants were re-assessed regarding the timing and severity of depressive symptoms that had occurred during the interval period of 35 weeks. It was found that severity of depression was correlated with poorer performance on both cognitive tasks. The moderator of this relationship was secondary control coping. Notably, less frequent use of disengagement coping and more frequent use of secondary control coping (e.g. acceptance) predicted decreases in depressive symptoms over a follow up period of 35 weeks later. In terms of cognitive measures, better ability in inhibition as indexed by the colour Stroop task predicted less progression in depression for individuals reporting less primary control coping or more disengagement coping. Similarly, higher cognitive flexibility (as indexed by Wisconsin Card Sorting Task performance) predicted less progression in depression among individuals reporting less secondary control coping. It was concluded that individuals with concrete, inflexible thinking may favor the use of maladaptive coping strategies. Inhibitory control deficits, particularly in the capacity to disengage attention from negative stimuli, have been found to interfere with recovery from negative affect and may be a risk for depression. Morris et al. (2014) concluded that individuals with poorer inhibitory control may be particularly unsuccessful in managing their automatic behavioural responses to stress. In contrast, among individuals who were better able to suppress automatic, or prepotent responses in the colour Stroop task, greater use of maladaptive coping strategies such as avoidance, denial, and wishful thinking did not predict increases in depressive symptoms. Overall, these findings are consistent with evidence that cognitive dysfunction is associated with elevated depressive symptoms and more disengagement or avoidance coping (Arnett, Higginson, Voss, Randolph, & Grandey, 2002).

Contrary to the supporting findings regarding the link between executive function deficits and suicidality (Burton et al., 2011, King et al., 2000; Marzuk et al., 2005), Morris et al. (2014) found that remitted depressed individuals did not have impaired inhibition or cognitive flexibility relative to the healthy controls. However, it is worth noting that these executive function components significantly interacted with coping to predict increases in depressive symptoms during the 35-week follow-up interval. This highlights the possibility that the impairment of executive functions alone may not have a significant impact, but when they interact with coping strategies it may have a robust effect in exacerbating depression. As cognitive task performance and the use of maladaptive coping has been used to better predict depression, this has raised the possibility that they could similarly be used to predict severity of suicidality.

2.4 Investigating suicidality and coping from a cross cultural perspective

As it stands, the current challenges for preventing suicide in HK is how to identify at risk individuals at earlier stages. Based on the existing literature which is heavily based on findings conducted in European or American countries, it is hard to determine if the established link between coping, executive functions and suicide can be replicated in Chinese culture[13]. With a lack of cross-cultural comparison on the prevalence of suicide and coping behaviours across Eastern and Western cultures, it is important to explore these variables further as this would help to determine whether the existing suicide prevention programs in the West are suitable for a place where suicide rate is rising at an alarmingly rate (i.e. Chinese population in HK).

[13] Culture is a term used to describe a particular racial or ethnic group who have shared set of social beliefs and values, assumptions about life, and goal-directed activities (Wong, Wong, & Scott, 2006).

2.4.1 Cross-cultural comparison on suicide behaviour

Suicide behaviour exists in all demographics (among different countries, age groups, family backgrounds, and financial status). Although documentation is collated each year to report the prevalence of suicide worldwide (WHO, 2015; HKJC Centre for Suicide Research and Prevention, 2015), empirical efforts to articulate the relationship between culture and suicidal behaviour are scarce (Colucci, 2006). Further, there are also few studies comparing the prevalence and epidemiology of suicide in different countries (Yasgur, 2017; Lester, 2008). It is noteworthy that knowledge gained on the global trend for suicide may help to clarify the impact of culture on suicide behaviour. This may help to develop culturally sensitive services in suicide prevention.

Although suicide is a global public health problem causing approximately 1 million cases of death each year (World Health Organization, 2010, 2015), the suicide figures are unevenly distributed over different countries (see Table 2.1). Evidently, more than 60% of suicides occur in Asia (Beautrais, 2006; Yip, 2008) and 25% of total suicide deaths occur in China (Yip, Liu, & Law, 2008). Given the disparity on how each country develops their own cultural and socioeconomic values, beliefs, and behaviours, countries within the same region may yield considerable differences in suicidality (De Leo, Milner & Wang, 2009). Take Asia as an example, suicide rates vary from 5.8 per 100,000 in Malaysia to 10 per 100,000 in China, and 32 per 100 000 in Korea (see Table 2.1; World Health Organization, 2015). To account for the alarming statistics of suicidality in China, one reason for it would be that Chinese students are overprotected by their parents compared to students in Western cultures (Zhang et al., 2012). With such considerable variation, suicide research conducted in one country may not be representative of another and draws the necessity of investigating such cultural difference.

Table 2.1- Global Health Observatory data repository on suicide rates by WHO across 4-years

		Suicide rates (per 100 000 population)			
		2015	**2010**	**2005**	**2000**
Singapore	Total	9.9	10.6	11.6	11.9
	Male	13.6	13.8	15.7	15.4
	Female	6.4	7.5	7.6	8.4
Japan	Total	19.7	24.3	24.7	24.4
	Male	27.3	35.2	36.6	35.5
	Female	12.4	13.9	13.4	13.8
Malaysia	Total	5.8	5.4	5.3	5.9
	Male	8.6	7.8	7.4	8.3
	Female	2.9	2.9	3.2	3.4
Korea	Total	32.0	34.1	27.2	14.8
	Male	46.0	45.5	36.4	20.3
	Female	18.1	22.9	18.0	9.3
China	Total	10.0	9.8	9.9	11.0
	Male	8.7	8.4	8.6	9.6
	Female	11.5	11.2	11.4	12.5
Hong Kong [14]	Total	12.6	13.8	14.6	13.5
	Male	17.4	18.4	18.8	16.7
	Female	8.5	9.8	10.8	10.5
United Kingdom	Total	8.5	7.7	8.0	8.8
	Male	13.3	11.9	12.1	13.5
	Female	3.8	3.7	4.1	4.3
United States of America	Total	14.3	13.0	11.7	10.8
	Male	22.1	20.3	18.4	17.3
	Female	6.6	5.7	5.1	4.5

Regarding the prevalence of suicide in HK, there is even less research conducted and those studies that have been conducted often have not included university students as

[14] There is no comparable WHO statistics for Hong Kong and therefore, this statistic is provided by a different source: HKJC Centre for Suicide Research and Prevention, HKU ("Suicide Rate - Centre for Suicide Research and Prevention", 2017, and the University of Hong Kong's Centre for Suicide Research and Prevention 2010 to 2015)

a target population. For example, Yip et al. (2004) reported that 10.8% of 2586 HK young adults (not specifically university students) aged 15-24 have considered suicide in a given year. Additionally, there are figures reporting the prevalence of suicide in university samples but these were based in China not HK (Tang & Qin, 2015; Zhao et al., 2012). This suggests there is insufficient data representing the prevalence of suicide in HK university students despite the rise of suicide behaviour reported in the media in recent years.

In terms of gender differences in suicidality, Table 2.1 indicates that suicide rates are generally higher in males than in females for all countries except China. The gender ratios in every 100,000 vary from approximately 3-4 males to 1 female in European countries to 1-2 males to 1 female in Asian countries. This reflects a higher rate of suicides among males in Europe compared to Asia (Yip, 2009). However, China has a unique gender ratio compared to the rest of the world; with more female suicides than male suicides (see Table 2.1). Interestingly, this distinctive gender ratio for China is not the same in HK (Phillips et al., 2002; Yip, Callanan, & Yuen, 2000). It is evident from the table that the gender ratio for suicide in HK is similar to the statistics presented in European countries that is approximately 2 males to 1 female. This may be due to the fact that HK is a former British colony but is now part of China, therefore it may share some common behaviours (including suicide behaviours) as the UK. Due to the alarming suicide rates in HK it is essential to explore suicide behaviour in this sample. However, acknowledging that cultural factor may impact suicide differently, it is important to examine whether there are any differences in suicidality between two cultures and this will determine whether it is suitable to continue investigations on solely HK sample in preceding studies of this thesis.

Comparing the rates and trends of suicide between Asian and Western countries, some important patterns have been identified. Firstly, the World Health Organization (2010) reported that suicide is the leading cause of death in Asian countries (such as China) but it is reported to be the third or fourth cause of death in Western countries (such as the UK). Liu, Chen, Cheung, and Yip (2009) explained this based on the difference in lethality of methods used by suicide attempters in the East and the West. For example, individuals from Asian countries tend to attempt suicide using higher lethality methods, such as jumping, pesticide-related poisoning, and charcoal burning. In Western countries, such as the UK, the most common means of suicide include hanging and drug-related poisoning, which are less effective in causing death (Suicide method statistics in the UK, 2017). The lower lethality used may decrease the likelihood of suicide completion but not the actual desire, therefore it is still essential to study the UK population despite this difference in lethality.

2.4.2 Perception of suicidality across different cultures

When describing cultural behaviour, the terms individualism and collectivism are often used. According to Hofstede (1994), individualism refers to a culture whereby individuals prefer to act independently rather than as members of a group. Self-actualization and individual decisions are valued more highly than group decisions in this culture, and the individuals favor personal time, freedom, and challenge more than people from collectivist cultures (Hofstede, 2008). Contrary to Asians, Westerners are considered to be high on individualism and low in collectivism (Varnum, Grossmann, Kitayama, & Nisbett, 2010). This is partly because Western culture puts emphasis on independence with less consideration of group behaviour (Yasgur, 2017).

Collectivism is directly opposite to individualism whereby individuals respect and like to interdepend on the *group* they belong to (usually a family group or an association). For this reason, collectivists would differentiate themselves to others as *in-group* and *out-group* members. Compared to Westerners, Asians generally consider themselves as belonging to a collectivism-oriented, interdependent, or low individualism culture (Hofstede, 1994; Kuo, 2011; Nisbett et al., 2001). Hofstede (2008) measured the level of individualism across 65 countries including the UK and HK, to provide an indication as to which cultures are more individualistic than others. Using the 'Individualism Index', which ranges from 0 for high collectivist to 100 for high individualist, Hofstede (2008) reported the UK to be ranked third in terms of individualism (with a score of 65) compared to HK which was ranked 46 (with a score of 25).

When it comes to suicide, Asians may also apply this collectivist view in that they may find ways to escape intolerable situations that would elicit remorse in their group or elicit interpersonal conflict (Yasgur, 2017). For example, having a marriage failure or adolescent pregnancy may bring shame to the *group* (the family or school), and this may lead to a higher chance of them contemplating suicide. To some extent, more Asians than Westerners may accept suicide as a legitimate act to deal with the perceived disgrace brought to their *group.* Supporting claims arise from suicide reports whereby Asian parents of suicide completers expressed that the suicide act was an understandable option since the family would be dishonored by the undignified act (e.g. adolescent pregnancy) of the suicide completer (Yasgur, 2017). One of the main explanations for how individualism is linked to suicide behaviour is that experiencing emotional disturbance (e.g., crying or feeling hopeless) is often regarded as a personal weakness. This suggests that individualists may be less likely to seek professional help and would rather try to resolve the psychological problem on their own than discussing it with others. In terms of the comparison of suicide prevention programmes between HK and the UK, some of these cross-cultural differences are reflected in their suicide programs. Suicide prevention services are launched by internationally-known providers such as the Samaritans. The Samaritans is well established in offering services for young people in both HK and the UK. It launched the 9th Young Samaritans Peer Support Programme in HK (YSPSP) that is centered around group enhancement by training students to provide peer support to those with emotional distress ("Youth Programme" – Samaritans Hong Kong, 2017). Conversely, the Samaritans in the UK ("How our service helps", 2017) offers services in person or via the phone on an individual basis that provides a one-to-one opportunity to express a concern. By talking and active listening the service aims to let an individual find solutions for their problems, a method that is consistent with an individualist view.

With a close look into cultural differences in the upbringing of children, it is noteworthy to highlight that many Chinese students today are the only *child* in the home, and family functioning plays an important part of their life. Moreover, Mooney (2005) posited that Chinese children are often overprotected by their parents and the family often solves problems for their children. When these students enter university, they are ill-prepared to deal with stressful demands in university life. This may explain the rise of suicide risk and inadequate coping skills in this younger generations compared to students from other cultures. For many Chinese students, entering university is the first time for them to leave home and they have begun to learn how to cope adaptively without their parents. Compared to the Western cultures, Chinese students are also faced with additional sources of stress, including a crowded living space, strict regulations (Mooney, 2005), and high academic expectations from parents (Schneider & Lee, 1990). Furthermore, rapid social and economic changes also cause significant levels of stress in this young population. For example, the fast pace of life, the unrealistically high housing prices, high unemployment, relatively low wages after graduation, and social unfairness.

Despite the cultural differences, the suicide intervention and prevention programmes in HK are largely developed from findings in Western countries (Wong et al., 2006). With the scarcity of studies comparing prevalence of suicide behaviour between the East and the West, a conclusion cannot be drawn regarding how these two cultures compare in terms of suicidality and the way young people cope during the academic life of higher education. This raises questions as to whether the past findings can be replicated in Chinese cultures such as HK.

2.4.3 Cross-cultural comparison of coping

Although coping with a stressor is a universal experience shared by individuals across all cultures, the mechanisms with which stressors are appraised and evaluated, and how coping strategies are selected vary significantly between cultures (Lam & Zane, 2004; Lazarus & Folkman, 1984). The current scope of studies and theories so far have raised the argument that because the empirical evidence for coping is largely based on Western cultures such as Europe and America (Wong et al., 2006), the findings often place emphasis on the strengthening of individuals to be more independent and to hold a more directed approach (i.e. use more problem-focused coping strategies). This has led to the question of whether the findings are adequate in capturing the diversity of coping strategies from a collectivistic culture such as China (Webster et al., 2006).

Along with these concerns, a study was conducted by Webster et al. (2006) who examined how cultures may impact on the extent of using collective coping versus other coping strategies such as avoidance and engagement in 179 Chinese Canadian adolescents (Chinese descents residing in Canada). Collective coping refers to obtaining guidance and strategies that are group-directed and culturally value-based. This is usually gained via support from family or another group, with consideration of culture norms and group needs (Webster et al., 2006). Avoidance coping in this study refers to the handling of the stressor by behavioural or emotional avoidance, and engagement coping refers to direct actions and personal adjustment in the face of a stressor. It was found that Chinese individuals cope with stressors by using collective coping to a greater extent than engagement or avoidance. This shows that they prefer to take the course of action that seems most acceptable to Chinese values, and they like to engage the assistance of others and approach problems by considering them with the guidance of others.

In a related study that explored the use of coping between adolescents of different cultural backgrounds in Australia (Neill & Proeve, 2000), it was found that Southeast Asians tend to endorse reference to others (i.e., families, friends, experts, and God) as a coping resource more frequently than their European counterparts. Yeh and Wang (2000) compliment this as they also found that Asian American undergraduate and graduate students often cope with psychological problems by keeping the issues within the family, seeking help from family, friends, and social groups, and engaging in social and familial activities. These students were less likely to solve problems by themselves or to seek professional advice compared to their Western classmates. Together, the findings point to the common predispositions among Asians of the greater use of collective and nondirective coping (e.g. avoidance) compared with Westerners.

In comparison to Asian cultures, some studies also reported that individuals from a Western culture often preferred individualistic coping with more orientation towards an individualistic rather than a collective view. For example, Deasy, Coughlan, Pironom, Jourdan and Mannix-McNamara (2014) found that the most common coping strategies used among university students in Australia were escape avoidance and self-controlling. These students reported that choosing coping strategies that are directed towards relieving their psychological distress and their cognitive demands are most important to them. From the findings there is evidence that although the preference of coping used among cultures may vary, there is still an indication that avoidance coping is universally considered to be maladaptive regardless of culture (Blankstein et al., 2007; Tang & Qin, 2015; Uğurlu & Ona, 2009; Zhang et al., 2012). Overall avoidance coping was regarded as maladaptive and confer the most important variable in the prediction of increased suicide risk (Freire et al., 2016; Gustems-Carnicer & Calderón, 2013; Tang & Qin, 2015).

2.4 Study 1: Suicide, executive function, and coping in a cross-cultural sample

2.5.1 Aims and intentions of Study 1

The current scope of evidence has established some link between suicide behaviour and executive functions though most studies did not take account of how individuals apply these cognitive skills to coping (e.g., Miranda, et al., 2011; Morris et al., 2014). Within the empirical evidence describing how some of these executive functions may associate with suicidality, it is also uncertain which one in particular has the most significant impact on suicide behaviour. To fill the research gap in the existing literature, it is vital to investigate the link between executive functions, suicidality, and coping strategies. The primary aim of the first study was to identify which executive functions confer the strongest predictor for suicide behaviour. It also examines how executive functions difficulties and maladaptive coping strategies interact with suicide behaviour. It is predicted that the use of problem-focused coping will be associated with reduced suicidality, while emotion-focused and avoidance-focused coping will be associated with increased suicidality. Addition to this, it was also predicted that individuals with perceived difficulties in executive functions would be associated with difficulty in utilizing adaptive coping strategies (i.e. problem-focused coping) due to the demands of recruiting cognitive abilities for the strategies. In turn, individuals would turn to other maladaptive ways of coping (i.e., emotional-focused and avoidance-focused coping) instead.

Given the scarcity of studies comparing suicidality between cultures, it is important to assess the overall differences in the prevalence of suicidality and the use of coping strategies between HK and the UK. To date, it is uncertain whether the same coping strategies that are adaptive or maladaptive in Western cultures can be applied to a distinctively different culture such as HK. Any difference will help to determine whether the current suicide prevention programmes will be effective for all cultures or if they need to be more specific for HK sample. The research of this thesis intends to focus on a HK sample due to high prevalence of suicide, but the first step is to determine how suicide behaviour and coping differ from a Western sample. Therefore, a secondary aim of Study 1 was to explore the correlation between suicidality, executive functions, and coping between HK and the UK sample. It is predicted that HK and the UK participants will differ in suicidality and the type of coping strategies used.

2.5.2 The measures of executive functions for Study 1

As outlined in the Chapter 1, the continuous development of executive function throughout the lifespan underscores the importance of how complex cognitive abilities (e.g., inhibiting impulse reactions, planning, and setting goals) can affect suicide behaviour. In clinical practice, formal assessment of executive functioning can be conducted through a series of classical neuropsychological batteries, cognition interviews, and self-report inventories. All of these measures provide valid assessments of executive function deficits (Heaton, Chelune, Talley, Kay, & Curtiss, 1993). Although neuropsychological batteries are useful in providing objective evaluation of selective executive function components, they are very time consuming and are not suitable when dealing with large numbers of participants. For this reason, self-report inventories may sometimes be considered as a better option in providing a time efficient assessment.

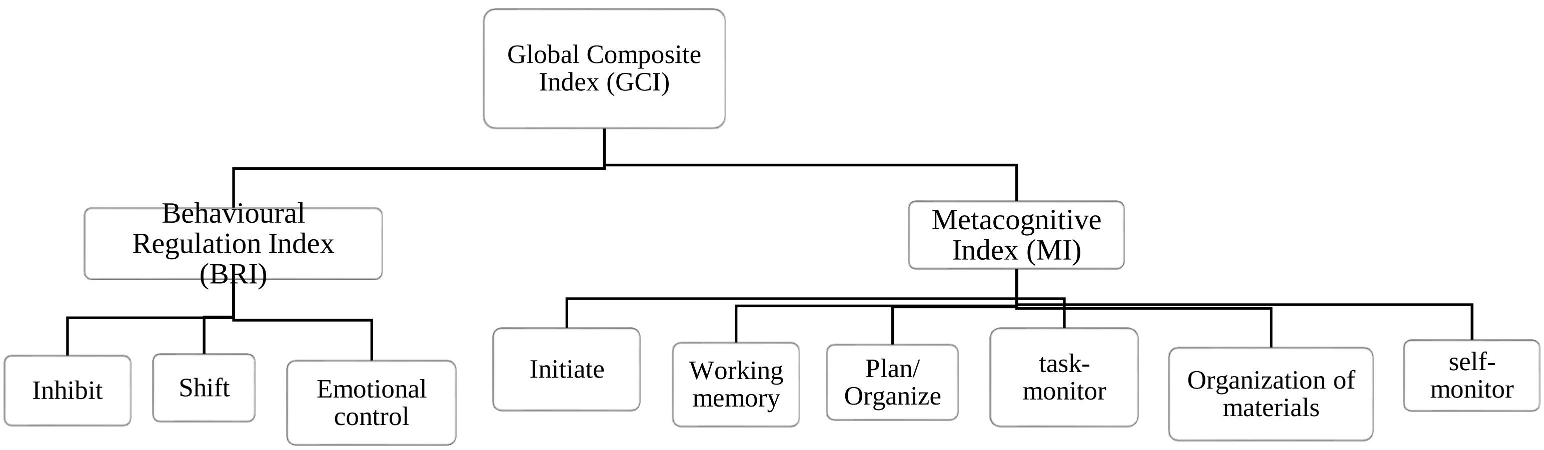
Bulzacka, Vilain, Schürhoff, Méary, Leboyer and Szöke, (2013) suggest that self-report inventories provide ecological measurements and may better reflect everyday situations than lab-based neuropsychological batteries for multiple executive function measures. There are often cases where individuals may have the necessary cognitive skills (also referred to as cognitive potential), but are unable to use these skills in real-life situations (Goldstein, Bernard & Fenwick., 1993). Therefore, the use of self-report inventories may be beneficial as they not only assesses the potential ability of participants, but also the way they use their cognitive capacities in everyday life.

Currently, the most commonly used measure for assessing multiple executive functions is a self-report inventory named the Behavioural Rating Inventory of Executive Functions (BRIEF; Malloy & Grace, 2005). The different versions of this inventory allow the measures to be assessed in many different populations (e.g., adolescents, parents, teacher, or adult version; Malloy & Grace, 2005). The inventory contains nine theoretically and empirically derived clinical scales that measure components of executive functions detailed by Isquith, Roth, Gioia, and PAR Staff (2006). The components include *Inhibit* (the ability to resist impulses and stop one's own behaviour); *Shift* (the ability to update or change attention flexibly from one situation or behaviour to another); *Emotional Control* (modulation and control of one's own emotional response); *Self-monitor* (awareness of personal strengths and weaknesses, and how they impact on one's own behaviour and on others); *Initiate* (to begin a task independently and generate new ideas and problem solving strategies); *Working Memory* (actively retrieve and hold information in the mind in order to manipulate and process it); *Plan/Organize* (anticipation of future events/consequences, using goals or instructions to guide behaviour, planning, and strategizing); *Organization of Materials* (orderliness of work and organization of possessions and task materials); and *Task Monitor* (keeping track of one's own problem solving progress and correct mistakes when needed).

Isquith et al. (2006) defined the Metacognition Index (MI) as one's ability to plan, organize, self-monitor, initiate activity, generate problem solving ideas, and to sustain working memory. Therefore, this scale comprises of individual scoring for Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials scales (see Figure 2.3). These measures are similar to the Dorsal (Cold) executive system as described in Chapter 2. The Behavioural Regulation Index (BRI) is the ability to maintain appropriate regulatory control of one's own behaviour and emotional responses. This includes inhibition of thoughts and actions, flexibility in shifting set, modulation of emotional response, and monitoring of one's own actions. The Behavioural Regulation Index enables the processes that fall within the MI to successfully guide active and systematic problem solving, as well as more generally supporting appropriate self-regulation. These measures are similar to the Ventral (Hot) affective system.

The Behaviour Rating Inventory of Executive Functions, adult version (BRIEF-A) was chosen for this study because university students are classified as adults. This inventory is a clinical assessment with well-established normative data. Many past studies support the construct validity of the BRIEF inventory for both non-clinical (Hauser, Lukomski & Samar, 2012) and clinical samples (Ciszewski, Francis, Mendella, Bissada & Tasca, 2014). Reports indicate that the BRIEF inventory is sensitive to early executive deficits, before they might typically present on objective measures of cognitive function (Rabin et al., 2006). This matches with the aim of the current research, which is to provide early identification of individuals at risk of suicide before they reach a dangerous level. It has been demonstrated that the BRIEF-A is a quick diagnostic tool used for screening deficits in executive function, and it has high internal consistency (Cronbach's alpha α = .96) for the Metacognition Index (MI), the Behavioural Regulation Index (BRI), and the Global Executive Composite (GEC; Ciszewski et al., 2014).

Figure 2.3. Different categories of executive function as identified by the behavioural report of executive function (BRIEF-A; Malloy & Grace, 2005)



2.5.3 METHOD

2.5.3.1 Design

The first variable was suicide behaviour, which distinguishes participants as having high or low levels of suicidality. The second variable was executive function, and this consisted of measures for nine components of executive function categorized into two groups of processes; the Behavioural Regulation Index (BRI) and the Metacognitive Index (MI). There was a separate scoring for BRI, for MI and for a total score on the overall executive function (GEC). The third variable was coping, which incorporated three separate scores for problem-focused coping, emotion-focused coping, and avoidance-focused coping. Cultural background (HK or the UK) was a between-participant variable. All the studies in this thesis have obtained ethical approval from the Ethics Committee of the School of Health Sciences at the University of Salford and informed consents were always obtained from all participants.

2.5.3.2 Participants

One hundred and thirty-three undergraduate Psychology students were recruited in this study. Sixty-four participants (7 males, 57 females) were studying at the University of Salford in the UK. Their ages ranged from 18 to 40 years, with a mean of 23.14 years (SD = 5.51). Sixty-nine participants (25 males, 44 females) were from The Open University in HK. Their ages ranged from 18 to 36 years, with a mean of 21.06 years (SD= 2.97).

2.5.3.3 Materials

A total of 3 questionnaires (Appendix 1.1-1.3) were used for this study in order to measure each of the dependent variables. Suicide behaviour was measured using the Suicidal Behaviour Questionnaire - Revised (SBQ-R; Osman, Bagge, Gutierrez, Konick, Kopper, & Barrios, 2001). This is a 4-item inventory that explores different dimensions of suicidality. Item 1 measures lifetime suicide ideation and/or suicide attempts, item 2 assesses the frequency of suicidal ideation in the previous 12 months, item 3 quantifies the threat of a suicide attempt, and item 4 is the self-reported likelihood of future suicide behaviour. Each question was answered using a Likert scale and each scale differed slightly. The scales ranged from a minimum of 0 to a maximum of 6, with lower numbers indicating a relatively low level of suicidality. Total scores range from 3 to 18 and represent overall severity of suicide behaviour whereby higher scores represent higher levels of suicidality.

Executive functions were measured using the Behaviour Rating Inventory of Executive Functions - Adult Version (BRIEF-A; Malloy & Grace, 2005). This is a 75-item questionnaire to assess executive functions in daily life by capturing an individual's purposeful, goal-directed, problem solving behaviour. The questions are answered on a 3-point Likert Scale (1= Never, 2= Sometimes, 3= Often). High scores on the BRIEF-A indicate a "disorder of executive functions" in a specific domain. Executive functions are divided into a Metacognitive Index (MI) that includes self-monitoring, initiate, working memory, planning, task monitoring, and organization of materials, and a BRI which includes inhibition, shifting, and emotional control. The BRIEF-A inventory also provides a GEC that is the sum of the BRI and the MI. Raw scores are collected from the BRIEF-A and are then transformed into different *T* scores according to the age of the participant. Higher GEC represents deficits in executive functions (Isquith, et al., 2006).

Coping was measured using the COPE inventory (Carver, Scheier, & Weintraub, 1989). This is a 60-item inventory that assesses different behavioural responses to stress. This inventory divides coping into 15 subscales: active coping, planning, suppression of competing activities, restraint coping, and seeking of instrumental social support are all categorized as problem-focused coping; seeking emotional social support, positive reinterpretation, acceptance, denial, and turning to religion are related to emotion-focused coping; and focus on and venting of emotions, behavioural disengagement, and mental disengagement fall under the category of avoidance-focused coping. Each question is answered using a four-point scale (1 = I usually don't do this at all, 2 = I usually do this a little bit, 3 = I usually do this a medium amount, and 4 = I usually do this a lot). Each subscale of coping is measured using 4 questions, giving a minimum score of 4 and a maximum of 16. There are a total of 5 coping subscales under each of the following coping categories: problem-focused, emotion-focused, and avoidance-focused coping, therefore each category has a minimum score of 20 and a maximum of 90. A higher score indicates the use of a particular coping strategy to a greater extent.

2.5.3.4 Procedure

All participants were given an information sheet (Appendix 1.1- 1.3) and consent form (see Appendix 3) together with the questionnaires. They were asked to read the instructions and then complete each questionnaire at their own pace. The completion of the questionnaires took approximately 30 minutes and following completion participants were debriefed by the researcher (Appendix 4.1).

2.5.4 RESULTS

Responses of all three questionnaires for each participant were collated. The median and range of all variables are presented in Table 2.2. A total of 30 participants (22.6%) scored higher than 7 on the SBQ-R (median = 10.00, range = 7-15) which indicates a relatively high suicide risk. There were 10 of them (i.e. 7.63% of the total sample) reporting a history of at least one suicide attempt, there were 103 participants reporting lower risk of suicidality as they scored below 7 on the SBQ-R (median = 3.00, range = 3-6). A cross-cultural comparison was made illustrating that 14 out of 69 HK participants (20.29%) reported a suicide risk compared to 16 out of 64 in the UK group (23.19%). To compare suicidality according to cultural background a Mann Whitney test was used as the data did not conform to parametric assumptions (see Appendix 6.1.1). The result showed no significant difference in suicidality between the UK and HK (U =1868, z = -1.601, p = .109).

Table 2.2. **Descriptive statistics of the suicide, coping, and executive functions for the UK and HK participants.**

	UK n=64		***HK*** n=67	
	Median	***Range***	***Median***	***Range***
Global Executive Composite	123	84-157	121	91-156
Behavioural Regulation	47	37-64	47	37-60
Meta-cognitive Index	71	41-106	71	45-104
Problem-focused coping	53	34-69	54	35-70
Emotion-focused coping	49.5	25-65	47	30-69
Avoidance-focused coping	33.5	19-50	31	20-53
Suicidality	4.5	3-15	3	3-15

Regarding the cross-cultural difference in coping strategies adopted between HK and the UK participants (Table 2.3), a Mann Whitney test was used to compare the use of different coping strategies by individuals in the UK and HK group. As there were 15 comparisons, a Bonferroni adjustment was applied and the alpha was adjusted to 0.003. Results showed significant differences between the UK and HK in that HK participants used certain coping strategies to a greater extent (Appendix 6.1.2). These were denial (U = 1460.5, z = -3.399, p = .001), behavioural disengagement (U = 1468.5, z = -3.356, p = .001) and restraint (U = 1560, z = -2.95, p = .003)

***Table 2.3*: Descriptive statistics of the 15 coping strategies for the UK and HK participants.**

	UK		HK	
	Median	***Range***	***Median***	***Range***
Positive growth	11.50	0-16	13.00	6-16
Mental disengagement	10.00	0-16	10.00	5-16
Focus of emotion	11.00	0-16	9.00	4-16
Instrumental social support	11.00	0-16	11.00	5-16
Active coping	11.00	0-15	11.00	7-16
Denial	6.00	0-11	7.00	4-14
Religious coping	4.00	0-16	6.00	4-16
Humour	8.00	0-16	10.00	5-16
Behavioral disengagement	7.00	0-14	8.00	4-14
Restraint	9.00	0-14	10.00	6-13
Emotional social support	12.00	0-16	11.00	4-16
Substance use	4.00	0-16	4.00	4-13
Acceptance	11.00	0-16	11.00	8-16
Suppression	9.50	0-15	10.00	7-16
Planning	11.00	0-16	11.00	7-16

2.5.4.1 Suicidality and executive functions

Given that there was no difference in suicidality between the two groups, when assessing the relationship between the study variables, all participants were merged into a single group and the variable of culture was not considered in further analysis. A series of Spearman's correlations were conducted as the data did not conform to parametric assumptions. Correlational analyses (Appendix 6.1.3) were conducted to assess the relationship between suicidality and executive functions. Higher levels of suicidality were significantly correlated with greater deficits of executive functions. Increased suicidality was related to higher scores for GEC (r (131) = .41, p = .001), MI (r (131) = .32, p = .001, and BRI (r (131) = .47, p = .001). Deficits in all components of the BRI were significantly, positively correlated with suicidality: emotional control, r (131) = .42, p = .001, inhibit, r (131) = .30, p = .001, and shift, r (131) = .31, p = .001. Therefore, poor emotional control, difficulty with inhibition and shifting were all related to increased suicidality. Similarly, deficits in almost all components of the MI were significantly and positively correlated with suicidality: working memory, *r* (131) = .26, *p* = .001, initiate, *r* (131) = .36, *p* = .001, organization of material, *r* (131) = .36, *p* = .001, plan/organization, *r* (131) = .25, *p* = .001, task monitor, *r* (131) = .20, *p* = .001. The only aspect of MI that did not correlate with suicidality was self-monitor, *r* (131) = .17, *p* = .053.

As most of the executive functioning components were significantly associated with suicidality, a multiple regression analysis was further performed with suicidality as the dependent variable to see which of the specific executive function components confer the most predictive variable for suicidality. Using the enter method, a significant model emerged (*F* (8, 124) = 5.424, *p* = .001) Adjusted R square = 0.21 (Appendix 6.1.4). Significant executive function variables that increased suicidality were difficulties with emotional control (Beta = 0.276, *p* = .018), organization (Beta = -0.299, *p* = .013), and initiate (Beta = 0.345, *p* = .02).

2.5.4.2 Suicidality and coping

Correlational analyses were conducted to assess the relationship between each coping strategy and suicidality (Appendix 6.1.6). The only emotion-focused coping that was significantly correlated with suicidality was religious coping, and this showed a negative correlation, *r* (131) = -.21, *p* = .013. Higher scores on avoidance-focused coping were associated with increased suicidality such as mental disengagement, *r* (131) = .32, *p* = .001, venting of emotion, *r* (131) = .30, *p* = .001, and alcohol-drug disengagement, *r* (131) = .41, *p* = .001. In contrast to the hypothesis, problem-focused coping was not associated with reduced suicidality (active coping, *r* (131) = .03, *p* >.05, planning, *r* (131)

= -.04, p >.05, seeking social support for instrumental reasons, r (131) = .07, p >.05, suppression of competing activities, r (131) = .17, p >.05, and restraint coping r (131) = .12, p >.05).

To further explore which specific coping strategies confer the most predictive variable for suicidality, a multiple regression analysis was performed with suicidality as the dependent variable and different coping strategies as predictor variables. Using the enter method (Appendix 6.1.6), a significant model emerged (F (9,117) = 5.133, p = .001, adjusted R square = 0.32) Significant variables that reduced suicidality were related to greater use of emotion-focused coping: positive growth (Beta = -0.337, p = .034), turning to religion (Beta = -0.183, p = .031), and acceptance (Beta = -0.317, p = .016). Greater use of two coping strategies was associated with increased suicidality and these came under the category of avoidance-focused coping: venting of emotion (Beta = -0.285, p = .008) and alcohol-drug disengagement (Beta = -0.33, p = .001).

2.5.4.3 Coping and executive functions

Correlational analyses were conducted to assess the relationship between each coping strategy and executive functions. In terms of the relationship between coping strategies and difficulties in executive functions (as indexed by BRIEF-A), analysis indicated that difficulties in executive function were significantly associated with increased use of all avoidance coping strategies. These include venting of emotion, r (131) = .25, p < .005, mental disengagement, r (131) = .35, p < .001, alcohol-drug disengagement, r (131) = .23, p <*.05*, behavioural disengagement, r (131) = .33, p <.001, and humor, r (131) = .18,

$p < .05$. In contrast, deficits in behavioural regulation were inversely correlated with planning, r (131) = -.172, $p < .05$.

2.5.4.4 The relationship between suicidality, coping, and executive functions

To assess the impact of executive functions and coping on suicide behaviour, suicidality was entered into a linear regression with those variables that correlated most highly. Emotional control (an aspect of executive functions) and alcohol-drug disengagement (avoidance coping) were entered into step 1 of the regression. Both variables were identified as the strongest predictors of suicidality, accounting for 24.6% of the variance. In step 2 of the regression, an additional variable, organization (an aspect of executive functions) was entered, allowing for a total of 32% of the variance to be explained (see Appendix 6.1.4).

2.5.5 DISCUSSION

The primary aim of this study was to investigate the association between executive functions and suicidality, as well as exploring how deficits in executive functioning would affect the way an individual cope with stressors. This would aid in identifying critical behavioural and cognitive predictors for suicidality. To date, there is limited suicide research within the HK population with the majority of findings based on Western cultures (Wong et al., 2006). With the unknown impact of cultural factors on suicide and the uncertainty of whether prior research on coping and suicidality can be replicated in a Chinese culture such as HK, it is difficult to ascertain whether the current suicide prevention methods that center around an individualistic view may have comparable effectiveness in cultures that emphasize collectivism. On the basis of this, a secondary aim of this study was to compare suicidality and the use of different coping strategies by individuals from the UK and HK.

2.5.5.1 Executive functioning and suicidality

Consistent with the literature that has highlighted the importance of executive functioning in promoting healthy psychological functioning (Becker et al., 2011; Keilp et al., 2008, 2013), the current findings add support to the existing literature and reveals how difficulties in executive function link to suicidality. In particular, difficulties in emotional control, inhibition, shifting, working memory, initiate, organization of material, plan/organization, and task monitor were all found to be linked to increased suicidality. The only executive functioning component that did not correlate with suicidality was self-monitor. This suggest that the awareness of personal strengths and weaknesses, and how they influence others do not have a significant impact on suicide behaviour.

The significant correlation between executive function difficulties and suicidality complements a recent study conducted by Bredemeier and Miller (2015) who explained why deficits in specific executive functions might contribute to suicide risk. It is reasoned that executive function deficits can lead to a wide range of difficulties such as regulating one’s own emotions, thoughts, and actions, which in turn increases the risk of suicide attempt. For instance, individuals with deficits in shifting may have more difficulty diverting attention away from thoughts about self-harm, and they may struggle in switching to more positive or adaptive forms of coping in response to stress. Similarly, individuals with inhibition deficits might have difficulty resisting the urge to self-harm when the suicidal thoughts become overwhelming. Similar to this postulation, Dougherty et al. (2004) have previously documented that those with a history of suicidal behaviour show deficits in inhibition compared to healthy controls. The ability to inhibit becomes crucial during suicide crisis where the urge of carrying out the suicide attempt may occur within 10 minutes of having had suicide ideation (Deisenhammer et al., 2009). Therefore, impairment in multiple aspects of executive function, especially inhibitory deficits, may exacerbate the problems in regulating emotions, thoughts, and actions, which ultimately increases suicidality (Ballenger, 2009; Miyake & Friedman, 2012). The current results support that individuals with inhibition deficits might have difficulty resisting the urge to act on thoughts about self-harm when they occur. These impaired executive functions, together with impulsivity may manifest to suicidality (Ballenger, 2009).

2.5.5.2 Executive functions and coping

Aside from the main investigation of how different executive functions impact suicide behaviour, the current findings revealed important links between executive functions and coping strategies. With the prediction that problem-focused coping strategies (e.g., active coping and positive growth) require cognitive abilities and good problem solving skills to directly resolve a stressor, therefore, utilizing these coping strategies may be especially problematic for those who have difficulties with executive functions. Under these circumstances, individuals may turn to other ways to cope rather than the use of problem-focused coping strategies. In support of this assumption, it is evident that executive function difficulties (as indexed by increased scores on BRIEF-A) were significantly correlated with increased use of avoidance-focused coping. These include venting of emotion, mental disengagement, alcohol-drug disengagement, behavioural disengagement, and humor. In contrast, difficulties in executive functions (indicated by the GEC scores) were not associated with any problem-focused coping and emotion-focused coping except for increased use of denial. However, perceived difficulties in behavioural regulation was found to be associated with decreased use of planning (coping strategy). From these results, it is inferred that the use of planning requires adequate cognitive resources and is associated with better abilities in regulating one's own behaviour. When individuals have more difficulties with behavioural regulation they may turn to use more of the strategies that are generally considered as maladaptive. This may be partly because the alternative coping strategies require fewer cognitive demands. Examples include denial, disengagement, and avoidance. The result also supports the assumption that effective coping strategies require appropriate selection and incorporation of different executive function components. Nonetheless, the present findings are consistent with past literature that has reported that cognitive dysfunction is associated with greater use of disengagement or avoidance coping (Arnett et al., 2002). It also compliments earlier findings that individuals with good working memory, planning, cognitive flexibility, and inhibition are better able to cope effectively with a stressor (Morris et al., 2014).

In Study 1, regression analyses were conducted on numerous coping and executive functions in predicting suicidality. As emotional control, organization, and initiate were identified as the most significant predictors, this suggests that individuals who have difficulty in regulating their emotions, problems with initiation, and issues in organizing tasks are critical in the recurrence of suicide behaviour. Consistent with the findings, Williams et al. (1996) posited that deficits in updating and organizing were associated with difficulty retrieving past memories. This in turn leads to difficulty imagining possible future outcomes when faced with stressors in the form of life adversities. Subsequently, such cognitive difficulties are also shown to impede the ways individuals flexibly deal with stressors because they have difficulty in organizing their thoughts. Aside from the impact of initiation and organization, which are aspects of meta-cognition, difficulties in behavioural regulation such as emotion control is another important aspect of executive functions identified in this study. It was not only a key predictor for suicidality, but was also significantly associated with greater use of avoidance-focused coping (i.e., mental disengagement, behavioural disengagement, and venting of emotion). This suggests that difficulty in emotion control may lead to difficulty in selecting adaptive coping strategies and implementing these coping strategies. The lack of effective coping strategies, especially emotion-focused coping because it was found to reduce suicidality, may subsequently lead to more suicidal thoughts.

2.5.5.3 Coping and suicide behaviour

Another objective of the current study was to examine the relationship between coping and suicide behaviour. Based on the findings (Kirchner et al., 2011; Morris et al., 2014; Sadaghiani & Sorkhab; 2013; Pienaar, Rothmann, & Van De Vijver., 2007; Tang & Qin, 2015), the current study predicted that the use of emotion-focused and avoidant-focused coping are associated with higher levels of suicidality, whereas the use of problem-focused coping would be associated with lower suicidality. However, some results contradicted the main stream of findings regarding the adaptive use of coping strategies.

One important finding was that the use of emotion-focused coping strategies in the form of positive reinterpretation and growth, religious coping, and acceptance were associated with lower levels of suicidality. Stanton et al. (2000) argued that emotion-focused coping could be an effective coping strategy that allows more emotional expression, thus promoting a positive social response. They further posited that the use of emotional coping is more effective for dealing with uncontrollable stressors versus controllable ones. This assumption was supported by their findings that female patients undergoing breast cancer treatment reported significantly lower levels of distress when they frequently used emotional coping compared to problem-focused coping. Similarly, the multiple major life challenges students go through during their academic life may be perceived as uncontrollable, and the use of emotion-focused coping strategies may be adaptive for them to cope with the stressors. This is because dealing with the problem directly through the use of problem-focused coping may not always be effective in resolving the problem and the emotions elicited by the stressor. Examples include difficulties meeting new friends, dealing with homesickness and managing workload associated with meeting multiple assignment deadlines.

Similar to emotion-focused coping, there was also an unexpected relationship between problem-focused coping and suicidality. Contrary to expectations, increased use of problem-focused coping was not associated with reduced suicidality. This supports prior literature which have found that there are circumstances whereby active coping strategies may be less effective (Compas, 2009; Compas et al., 2001). For example, in dealing with stressors that are uncontrollable such as parental divorce and poverty-related stress (D'Imperio, Dubow & Ippolito, 2000). Compas (2009) argued that active coping that directly deals with the stressor may not help to change an uncontrollable stressful event, therefore, other forms of coping such as reinterpreting the situation and learning to positively accept a situation may be a better way out. In the current sample, students may think in a similar way, that is, they may accept that having no friends rather than actively seeking to change the situation (e.g. trying to go out and join clubs to make friends) would be a more feasible coping strategy in their current academic lives. It is also an easier coping strategy to just accept rather than thriving to change the situation which may be seen as uncontrollable. Consequently, the coping strategies considered by undergraduates as effective may be different to those sample populations in previous studies.

The current findings may also be interpreted from a cognitive perspective due to the distinctive characteristics of university students sampled in this study. Firstly, the majority of the participants were young adults (the UK participants mean age of 23.14 years and HK participants mean age of 21.06 years), and as executive functions continue to develop beyond young adulthood (Goldstein & Naglieri, 2013), it may be the case that because this population is yet to fully develop their executive functions, they have not mastered their problem-focused coping strategies in order to tackle challenging stressors. Therefore, it is possible that increased problem-focused coping did not correlate with reduced suicidality because participants may not be able to use this strategy of coping effectively and therefore disregard it as an option. This assumption is supported by the finding that the only coping style that was significantly associated with lower levels of suicidality was religious coping which is an emotion-focused coping strategy that does not directly address a problem (Carver, 1989).

Consistent with past literature (Blankstein et al., 2007; Uğurlu and Ona, 2009, Zhang et al., 2012), increased use of avoidance-focused coping strategies was associated with increased risk of suicide in this study. This confirms the proposal that coping that avoids rather than directly addresses a stressor is regarded as maladaptive and harmful to one's psychological health. Therefore, avoidance-focused coping is mainly maladaptive and utilizing it to a large extent could increase suicide behaviour. Moreover, apart from suicide behaviour, past research suggests that whilst individuals may avoid confrontation of intense emotions during periods of increased stress or pain, excessive use of avoidance can ultimately lead to poor psychological health (Amstadter, 2008).

Lambert et al. (2004) explained that avoidance coping is maladaptive as it only temporarily reduces the experience of stress and physiological arousal and it has minimal value as a stress management technique for physical or mental health. In comparison, coping in the form of seeking social support involves elements of problem solving and encourages emotional expression to others. The experience of seeking advice from others for further information, emotional support, disclosure, rationalization, or justification for one's perceptions and actions, may help individuals to find ways to express and ameliorate their negative emotions rather than to deal with the stressors alone.

Due to the heterogeneity in the existing coping research which undermines the disparity of participants' age groups, backgrounds, and the different types of stressors and coping measures used across different studies, there are unanswered questions as to which type of coping is most effective (Aldwin, Sutton, Chiara & Spiro, 1996; Stanton et al., 2000). The current study raises the argument that the terminology "maladaptive" implies negative connotations when, in practical terms, it is possible that some coping styles that may often be considered as “maladaptive” may be beneficial in dealing with some situations (Zuckerman & Gagne, 2003).

2.5.5.4 Cultural differences in suicidality and coping strategies

Adding to the current scope of research, the current study also predicted that the relationship between coping and suicidality would be significantly impacted by culture, therefore the past findings conducted in Western countries may not be replicated in the student population in HK. In light of the limited research investigating prevalence of suicide in a student population, the current finding indicates that 18.4% of the HK students reported recurrent suicidality. The reported figure is higher than the figure reported in HK previously (10.8% of HK students aged 15-24 reported having suicide ideation over a 12-month period; Yip et al., 2004). It also supports the claims that the prevalence of suicidality within a university student population in HK is especially alarming compared to the general prevalence of suicidality in HK reported in Table 2.1 (12.6% in 2015 and 13.8% in 2010). However, the result is consistent with those reported in China that 19.3% of Chinese University students reported recurrent suicide ideation (Zhao et al., 2012), and 16.39% out of 5972 university students reported the presence of suicide ideation (Tang & Qin, 2015).

Based on the suicide statistics across different countries illustrated in Table 2.1 (World Health Organization, 2015, the University of Hong Kong’s Centre for Suicide Research and Prevention 2010 to 2014), the prevalence of suicide in HK is higher than the UK across 4-year comparisons (2000, 2005, 2010 and 2015). Opposite to the trend from the WHO statistics, the current study revealed lower levels of suicidality in HK

(18.4%) relative to the UK participants (25%). Whilst higher rates of suicide were reported in the UK sample compared to past research there was no difference in SBQ-R scores between the HK and the UK groups.

For the cross-cultural investigation of coping strategies in HK and the UK participants, results showed that HK participants reported using all 15 types of coping strategies more extensively than the UK participants. This is revealed by the higher scoring on COPE inventory for each of the 15 subscales, and this may in part explain the relatively lower levels of suicidality reported by HK relative to the UK participants. Specifically, HK participants used significantly more denial, humour, behavioural disengagement, religious coping, and suppression compared with the UK participants. Among these five strategies, four of them are emotion-focused or avoidance-focused coping. This suggests that Chinese participants tend to use more emotion-focused or avoidance-focused coping than their Western counterparts, but there are no significant differences in the use of problem-focused coping strategies (except for suppression which has been consistently documented as a form of maladaptive form of coping).

In support of the prior studies, the results have found that emotion-focused and avoidance coping are more common in Asian (e.g. Selmer, 2011) compared to Western cultures (e.g. Oláh, 1995). Focusing on emotions and avoiding the problem may be regarded as maladaptive coping in Western cultures that emphasize personal responsibility and egalitarianism (a trend of thought that favors equality for every individual). However, for Chinese culture that places less emphasis on taking personal responsibility, these coping methods may be perceived as more legitimate and appropriate (Varnum et al., 2010). Moreover, the use of emotion-focused and avoidant coping may alleviate distress temporarily without violating norms, which is crucial in Chinese culture (Matsumoto, Yoo, & Nakagawa 200). In support of this, Park, Armeli, and Tennen (2004) found that perception of low controllability, which is one of the characteristics of a collective culture, was found to be associated with using emotion-focused coping and avoidance (Menon, Morris, Chiu, & Hong, 1999).

In a related study, Lam and Zane (2004) examined how Asian and American students cope differently with interpersonal stressors in university via measures of primary and secondary control coping. Both forms of coping are regarded as engagement coping that directly manages a stressor, in particular primary control coping is similar to problem-focused coping as it aims to alter the stressors via active coping (Gloria, Castellanos, & Orozco, 2005). Conversely, secondary control shares some common characteristics with emotion-focused coping as it focuses on adapting one's mindset to be more equipped to handle a stressful situation (Rothbaum et al., 1982). An example of this would be the use of acceptance coping. When the use of these coping strategies was compared between Asian and American students, Asians were oriented toward the use of acceptance coping but with relatively less use of active coping. The current study supports this finding whereby HK students also reported greater use of acceptance coping when compared to the UK students. In sum, Asian cultures may prefer to cope with interpersonal stressors by changing themselves to adjust to others. This is evident in the increased use of acceptance and denial strategies in HK participants.

The COPE inventory used in the present study serves as a good starting point to explore how different coping strategies correlate with executive functions and suicide behaviour. From the results, it is evident that whilst some coping strategies are highly related to both executive functions and suicidality, others are not significantly linked to them. Therefore, it may be worth exploring other coping measures that are more focused around the theme of this research that is, exploring factors that may relate to suicide, specifically cognitive, neurological, and coping strategies. While the present findings provide insight about the association between coping, executive functions, and suicidality, one constraint of this study is that it is solely based on self-report measures. Whilst the use of self-report measures (BRIEF-A and COPE) provides a useful indication about the extent of how each executive functions and coping strategy relates to suicidality, it is uncertain how individuals will behave under certain emotional contexts. Therefore, other measures of executive functions could be implemented to better inform the process of emotion-cognitive interactions. Future investigations aimed at a more comprehensive assessment of executive functions might further substantiate the current findings.

2.5.5.5 Summary of key findings from Study 1

This first study has achieved the goals of investigating the relationship between executive functions, coping, and suicidality. Building upon the existing literature, the current findings provide more evidence that difficulties in emotional control and use of avoidance-focused coping are important predictors for suicide behaviour. Some unexpected findings emerged whereby emotion-focused coping seems to be a useful strategy for young adults entering a new period in their life (i.e. the transition to university), this would be a useful way to cope with stressors for university students. As there was no significant difference in suicidality between the UK and HK samples, the results set important indications for future directions in that the proceeding studies could investigate suicidality without the concern of cultural impact.

CHAPTER THREE

Exploring suicide in relation to coping, emotion regulation and depression

3.1 Development from Study 1 and Overview of Study 2

Consistent with some past findings study 1 revealed that difficulties in emotional control and the use of avoidance coping are critical suicide predictors (Blankstein et al., 2007; Uğurlu & Ona, 2009, Zhang et al., 2012). As the first study focused on elucidating risk factors and maladaptive psychological processes associated with increased suicide risk (e.g. maladaptive coping strategies and difficulties with executive functioning aspects), it is also important to consider how resilience factor interacts with risk factors in relation to suicide, this factor will be examined in relation to several key models of suicide in this study. With the importance of emotional control and emotion-focused coping on suicidality identified in Study 1, there is indication that emotion plays a critical role in suicide behaviour. Consistent with this, Richard-Devantoy and Courtet (2016) stipulate the importance of exploring coping, emotion regulation, and suicidality and revealed that individuals are at greater risk of attempting suicide when they lack adaptive coping skills and are less able to regulate their emotions and emotional responses. Therefore, the present study will incorporate emotional variable in the form of emotion regulation and this will be investigated in relation to suicidality and coping. With the high degree of comorbidity between suicide and depression raised in past literature (Arsenault-Lapierre et al., 2004; Bostwick & Pankratz, 2000; Mann, 2003; Wang et al., 2007). The variable depression was also added to this study to examine its relationship with suicidality.

3.1.1: Common and distinguishable features of coping and emotion regulation

Based on the review of literature in Chapter 1, the constructs of coping and emotion regulation are similar in many ways, and the study of each variable can be difficult. The majority of the literature describes that both coping and emotion regulation are conceptualized as processes of regulation that involve conscious and controlled cognitive processing (Compas at al., 2014; Gross & Thompson, 2007; Lazarus & Folkman, 1987). However, the early definition of emotion regulation by Gross (1998) reflects some important differences that may help to distinguish it from coping. According to the definition, emotion regulation is referred to as the ability to change the trajectory (i.e., magnitude, latency, and duration) of any emotional response. This suggests that emotion regulation includes the management of both positive and negative emotions that arises under a wide range of situations including non-stressful circumstances (Compas et al., 2001; Koole, 2010).

Although coping is sometimes conceived as a special case of emotion regulation under the presence of a stressor (e.g. Eisenberg et al., 2007), coping is directed primarily at decreasing negative affect to a stressor (Compas et al., 2014; Lazarus & Folkman, 1987). As such, emotion regulation can be applied to a wider range of circumstances (stressful and non-stressful) whereas coping only applies to stressful circumstances (e.g., Gross & Thompson, 2007). For example, emotion regulation involves responses such as suppressing a laugh when seeing someone trip over on the street whereas coping is exclusively limited to responses to stressors only (Compas et al., 2014). However, some researchers (Carver et al., 1989; Gross & John, 2003) dispute this view and argue that coping can be applied to a broader scenario than emotion regulation as it includes both emotional and non-emotional (e.g. behavioural) responses to stress, whereas emotion regulation only includes processes that elicit emotions. Coping is generally considered to be longer lasting and often applied to stressors such as bereavement or diagnoses with a chronic condition. Emotion regulation usually occurs over a relatively short timeframe and varies considerably with different goals and strategies. With these opposing and distinguishing features, both may have a different impact on suicidality. To explore these variables further, it is vital to discuss relevant studies in this field with key psychological models that explain how suicide behaviour is formed and develops.

3.2 Key models of suicide behaviour and emotion regulation

The origins of the recent models of suicide can be traced back to Baechler (1979). In the early theoretical framework, Baechler (1979) was among the first researcher in the field of suicide to propose suicide as a learned problem solving technique, in that individuals may try to alleviate painful internal states such as feelings of sadness, guilt, or loss via a suicide act. Baechler further suggested that the main motivating factor behind suicide is the urge to escape such unbearable situations. As such, suicide was considered as an escape from the emotional distress and aversive state. Shneidman (1983, 1984) later added that suicide occurs when an individual's threshold for tolerating emotional or psychological pain is exceeded, and this threshold varies between individuals. Therefore, if someone has a low threshold they are more likely to contemplate suicide compared to someone with a high threshold. Although Baechler did not conduct research to verify his ideas of escape, his proposals have prompted other researchers to continue positing suicide as an attempt to escape (Baumeister, 1990; Williams, 1997, 2001; Williams &

Pollock, 2000, 2001). Building from Baechler's ideas, Baumeister (1990) put forward the proposal that when an individual's sense of self is inferior to their expectations (i.e. an outcome to a situation/stressor falls below the standards the individual has set for themself) this triggers the desire to escape from the aversive emotional state and from self-awareness.

3.2.1 Escape theory

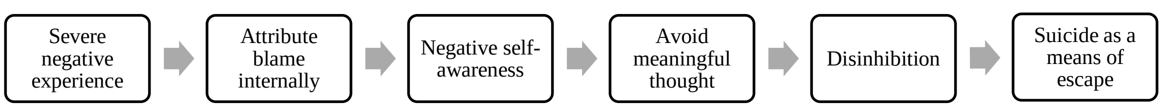
As the name suggests the *Escape theory* (Baumeister, 1990) focuses on the potential to escape a distressing situation, such that the more individuals feel they are unable to escape, the more likely they will attempt suicide. There are six main steps proposed to be involved in the progression of suicide attempt (Figure 3.1). Firstly, there needs to be a severe interpersonal experience that falls short of an individual's expectations resulting from an unrealistic expectation or a major setback. Then, the individual may attribute the blame internally thinking that they were the cause of that failure or setback. Next, the individual will have an increasing sense of negative self-awareness (see figure 3.1) with more feelings of inadequacy, incompetence, or low self-esteem. At this point the increased negative self-awareness may slowly lead to negative affect.

Individuals will then try to escape the resultant negative affect by avoiding meaningful thought and may engage in cognitive deconstruction[15]. This is evident in pre-suicidal individuals (individuals with milder forms of suicidality such as suicide ideation,

[15] Cognitive deconstruction is described by Baumeister (1990) as a cognitive response to a psychologically aversive state whereby individuals experience a subjective shift to less meaningful, less integrative forms of thought and awareness. This would subsequently allow the individual to escape from aversive self-awareness and emotional distress that may arise. This state "involves focusing on physical sensations, one's surroundings, and immediate, proximal goals, thus avoiding any higher level of thoughts" (Baumeister, 1990 p.92).

but have not attempted suicide) who may try to suppress their emotions by hiding their emotions (Baumeister 1990; Gross & John, 2003). Since they refuse to confront their true inner emotions, they are also less likely to see the need to restore any thoughts in response to the emotional disturbance. The next step is cognitive disinhibition, which characterizes difficulty in inhibiting or filtering out certain information such as suicide thoughts (Baumeister 1990). At this point individuals will have a strong desire to escape their own experience of negative affect by entering into a relatively numb and deconstructed state that immediately precedes a suicide attempt (Baumeister, 1990; Kaplow et al., 2014). The final stage is when individuals are overwhelmed by an acute and aversive state of negative affect that is perceived as uncontrollable. If individuals are still unable to generate strategies to deal with their intolerable emotional state, the desire to die emerges and they may view suicide as a mean of escape (Baumeister, 1990).

Figure 3.1. The six main steps proposed in the progression of a suicide attempt by the Escape theory (Baumeister, 1990)



Although the Escape theory has become widely accepted, empirical evidence is rather limited as insufficient studies have attempted to test the theory. In an early study, Reich, Newson and Zautra (1996) attempted to examine how the development of suicide progression fits with the Escape theory. Their study involved older adults who were experiencing stresses due to rapid deterioration of their physical health, the health downturn was associated with an increased level of suicide ideation. Although they found a significant path from which health declines to low self-esteem, then helplessness to increased suicide ideation, most of which fit well with the constructs proposed by Baumeister (1990). However, some of the constructs featured within the Escape theory are not entirely convincing. For example, the measures of confused thinking which is mainly due to physical illness and ageing in older adults seem theoretically inappropriate to represent the construct of cognitive deconstruction of the model which specifies less meaningful and integrative forms of thought (not due to ageing).

Whilst the model states that individuals are unable to generate alternative strategies to deal with their emotions, the findings of Reich et al. (1996) have not addressed why an individual would choose suicide as a mean of escape versus other options such as running away from home or disengaging via drug abuse. Based on the evidence for this model as it stands, Baumeister's (1990) explanation that suicide is a means of escape does not seem to be fully justifiable.

3.2.2 The Cry of Pain model

To further expand on the psychological mechanisms underlying the Escape theory, Williams and colleagues (Williams, 1997, 2001; Williams & Pollock, 2000, 2001) developed the *Cry of Pain model*. Williams and Pollock (2001) proposed that the desire to escape must have two specific aspects; defeat and entrapment (see figure 3.2). Defeat is characterized by perceptions of a failed struggle related to the loss of status or identity, whereas entrapment is an inability to move forward due to a limited ability to generate solutions to stress or a threat (Taylor, Wood, Gooding, Johnson, & Tarrier, 2011). For instance, stress may take the form of environmental factors (e.g. exams and assignments) or negative life experiences (e.g. pressure from family). When coupled with continuous feelings of loss and failure the individual becomes vulnerable to feelings of defeat. Unsuccessful attempts at solving their problems (e.g. repeated attempts at an exam without success) can then lead an individual to feel powerless in escaping from that situation (entrapment). O'Connor (2003) tested the Cry of Pain model by investigating both defeat and entrapment in relation to suicide behaviour. This is achieved by using self-report measures assessing defeat, escape potential, and social support. The study recruited adult sample of 30 previous suicide attempters (i.e. they were recruited the day after admission to a hospital due to a suicide attempt) and 30 matched hospital controls. Results support the proposal of the Cry of Pain model and indicated that previous attempters were significantly more likely to report higher levels of defeat, and lower levels of escape potential and social support, compared to the matched controls.

To put the entrapment and defeat elements into context, Williams, Barnhofer, Crane and Beck (2005) conducted a study with 56 participants categorized into 3 groups; 19 depressed individuals with a past history of suicide behaviour, 15 depressed individuals without any history of suicide, and 22 controls. The model proposes that when an individual fails to find alternative ways to solve their problems this can lead to suicidal behaviour. To investigate this, interpersonal problem solving performance was assessed using the Means-Ends Problem solving (MEPS) task before and after a negative mood-induction procedure. In a typical MEPS task, participants are given the beginnings and ends of ten vignettes that each describe a problem. For each problem, participants are asked to provide the steps necessary to solve the problem, therefore they are required to generate ideal solutions that can effectively connect the problem to the solution (Goddard et al., 1996). Results showed that compared to the other two groups, the past suicide attempters generated significantly fewer effective problem solutions in the task following negative mood induction. Evidently, this insufficient problem solving and perceived absence of rescue factors [16]may represent the state of entrapment within the Cry of Pain model, that is, the inability to move forward due to limited ability to generate solutions (Taylor et al., 2011).

Another study that tested the constructs of defeat and entrapment of the Cry of Pain model was conducted by Rasmussen et al. (2009). There were 113 patients with history of self-harm (36 first-time, 67 repeated incidents) and 37 controls. All individuals completed self-report measures of defeat, entrapment, rescue factors (the measures of perceived social support and positive future thinking), as well as depression, anxiety, and suicidal ideation. Analyses highlighted differences between the three groups on key variables related to the Cry of Pain model. For example, patients with history of self-harm reported more severe degrees of depression, anxiety, and suicidal ideation, they also reported experiencing higher levels of defeat and entrapment, with less rescue factors. Importantly, the results indicated that entrapment mediated the relationship between defeat and suicidal ideation, whilst impaired ability to think positively about the future (but not social support) moderated the relationship between total and internal entrapment and suicidal ideation. Therefore, the findings provided further empirical support for the Cry of Pain model.

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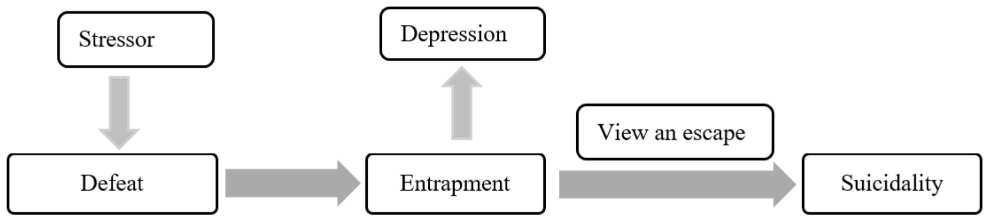
[16] The term rescue factor is a term used in the Cry of Pain model to describe a situation whereby individual perceives that he/she will not receive any external help and feel pessimistic in finding any escape opportunities to an unbearable situation.

Figure 3.2 showing defeat and entrapment in the progression of suicidality



According to the Cry of Pain model in figure 3.2, following from the feelings of entrapment is the desire to die, an urge that is more pronounced when individuals perceive an absence of rescue factors. At this point individuals may lack the necessary skills for managing negative emotions (Rajappa, Gallagher & Miranda, 2011) and to redirect the flow of one's own emotions by spontaneous regulation (Miranda et al., 2011). When they are in this state for long without being able to generate alternative solutions, this may increase suicide urges as a mean to overcome this situation they find no way out to.

With the empirical evidence to support the Cry of Pain model, it is posited that both defeat and entrapment may arise when individuals cannot generate suitable strategies to resolve problems (see figure 3.3) and this may ultimately lead them to consider suicide as the only possible escape route from their distressing circumstances (Chat et al., 2010). Consequently, any negative bias about a stressor may also impair an individual's ability to solve the problems relating to the stressor because they may feel negative about their ability and feel pessimistic about the outcome (Pollock & Williams, 2001). This increases negative perceptions of self, others, and the stressor may worsen the feelings of entrapment because individuals may perceive that there is no way out to the problem and any attempt to try will repeatedly lead to failure like before. In this entrap situation an individual is likely to view suicide as the only escape route (O'Connor, 2003; Williams, 1997).

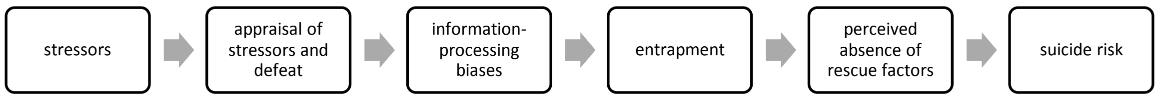
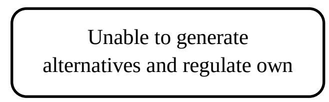


Figure 3.3. Revised path of suicide by Cha et al. (2010)



Rajappa et al. (2011) measured six-dimensions of emotion regulation (awareness, clarity, non-acceptance, impulse, goals, and strategies) among young adults with varying previous experience of suicidal behaviour. The sample included 17 adults who reported current suicide ideation, 20 with one past suicide attempt, seventeen with multiple suicide attempts, and 42 healthy controls. Similar to the proposal of the Cry of Pain model, results showed that concurrent suicide ideation was associated with perceived limited access to effective emotion regulation strategies. Specifically, it was the non-acceptance of emotional responses as measured by the Difficulties in Emotion Regulation Scale; Gratz & Roemer (2004) that significantly predicted suicide risk. Notably, the between-group comparisons revealed that non-acceptance differed significantly only between controls and individuals with multiple suicide attempts but not with the other two groups (with only one attempt). Additionally, Rajappa et al. (2011) suggest that suicidal behaviours are attempts to escape negative emotions when individuals have a lack of rescue factors as proposed by the Cry of Pain model. This is evident in the findings whereby a perceived lack of access to effective regulatory strategies (i.e., lower scoring on ‘Strategies’ in the Difficulties in Emotion Regulation Scale; Gratz & Roemer 2004) was associated with increased level of suicidality. It was suggested that the lack of regulatory strategies may lead an individual to experience emotions as unwanted or behaving impulsively in response to distress, which in turn increases the risk of an actual suicide attempt.

Cha et al. (2010) have offered an explanation for how the feeling of defeat is formed from a cognitive perspective. It is thought that when individuals experience repeated failures and struggles, they may feel hopeless about future outcomes. At this point, information-processing biases are likely to develop (see figure 3.3). This is when information is being processed in an illogical or irrational manner. For instance, suicidal individuals could be selectively attending to, encoding, and retrieving negative information pertaining to suicide (Cha et al., 2010). Therefore, individuals may focus more on their own loses and failures rather than thinking actively about the solution to these failures. Based on the *schema theory* (Beck & Clark, 1988) it is suggested that if suicidal thought is being rehearsed frequently, the information is activated continuously forming a stronger memory trace (Baddeley & Hitch, 1992; Baddeley, 2000). This makes the negative information easier to activate and retrieve. In the long term, when the information is expanded, elaborated, and becomes easily accessible, a suicide schema is formed. This is a semantic network comprising interconnecting stimuli, possible responses, and emotional stored information related to suicide (Johnson et al., 2008; Panagioti, Gooding, Pratt, & Tarrier, 2014). As suicide schema affects what information an individual pays attention to and how they relate to each other, this may influence individuals by placing greater importance on processing negative rather than positive information. Subsequently, this may increase information processing of emotionally congruent and retrieval of more mood-congruent memories related to suicide. The suicide schema is present in varying degrees of strength among individuals and can be initiated by distressing or innocuous events that appear to be unrelated to suicide behaviour (Beck & Clark, 1988). While the schema theory places emphasis on the role of schemas in creating a processing bias, it is noteworthy that the suicide schema would only be active and influence processing when an individual feels overwhelmingly distressed. In the given situation, the activated schema will trigger suicide thoughts as an escape strategy and this may increase the chance of suicide act (Johnson et al., 2008, p.65).

Past findings have tried to identify a range of risk factors associated with suicide including depression, hopelessness, impulsivity, cognitive rigidity, difficulty regulating emotions, a lack of rescue factors, and information processing bias (Cuijpers et al., 2012; O'Connor & Nock, 2014; Rajappa et al., 2011). However, the current problem is that many of these factors have not been successful in predicting and preventing suicide. For instance, not all depressed patients are suicidal (i.e. only 12% to 18% of students report having at least one form of affective disorder were suicidal; Mowbray et al., 2006) and many individuals who are often exposed to a number of risk factors show no suicidal tendencies. A review on the psychological treatment for reducing depression and suicide behaviour by Cuijpers et al. (2012) evaluated studies from 1966 to 2012, with 52 studies regarding psychological treatment (e.g., psychotherapy, medication or a combination of both). Among the 616 participants included in the review that were analyzed on the effects of treatment on suicide ideation and suicide risk, and levels of hopelessness, depression was assessed by diagnostic interview or an elevated level of depressive symptoms (such as using the Beck Depression Inventory; BDI; Beck, Steer, & Brown, 1996). It was concluded that there was insufficient evidence to establish whether suicidality in depressed patients could be reduced by reducing depressive symptoms through the use of psychotherapy. The conclusion also reflected the limited ability to reduce suicide behaviour by reducing depressive symptoms and hopelessness. Despite the fact that the target of reducing depression alone may not be an effective way to prevent suicide, more researchers have turned to explore resilience factors instead. This has led to the emergence of a relatively recent model that focuses on the resilient factors for suicide is named the Schematic Appraisal Model of Suicide (Seligman et al., 2006; Tarrier, 2010).

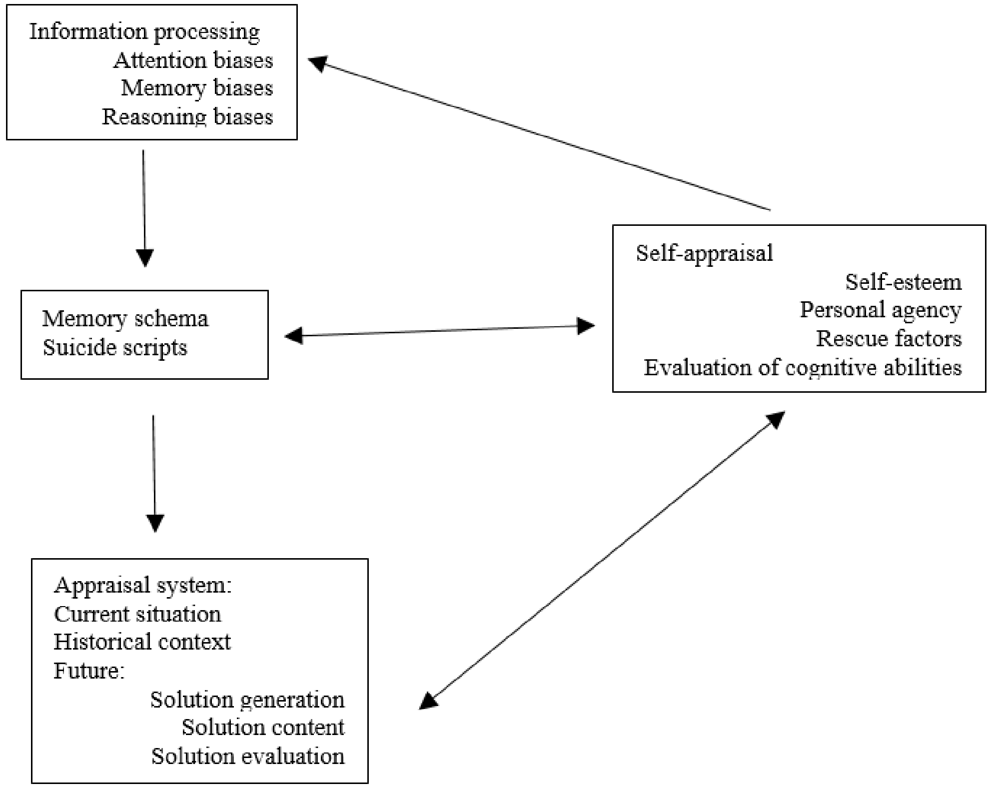
3.2.3 The Schematic Appraisal Model of Suicide

As the Cry of Pain model merely focuses on suicide risk and does not address any factors that may help individuals to be resilient against suicide behaviour, the Schematic Appraisal Model of Suicide (SAMS) was proposed as an extension to the Cry of Pain model (Johnson et al., 2008). Both models acknowledge that pre-suicidal individuals may have information processing biases. Examples of such biases are misattribution, incorrect inference, catastrophizing, and misperception of threat. The SAMS (Johnston et al., 2008) is a relatively new approach that attempts to identify the specific processes underlying resilience to suicide. In an extension to the Cry of Pain model, the SAMS explains the role of defeat and entrapment in relation to protective factors rather than risk factors. It consists of three interacting components; negative information processing biases, the presence of suicide schema, and an appraisal system (see figure 3.4).

Similar to the suicide continuum (Potter et al., 2004) outlined in Chapter 1, suicide behaviour is conceptualized to occur in a series of events from ideation, to planning, and intention to act (Johnson et al., 2008). It is posited that suicide ideation occurs when a suicide schema becomes activated. This may occur in varying degrees of intensity and each time it is activated it will illicit more thoughts of suicide as an escape strategy. It becomes elaborated and associated with a wider range of contexts and affective states (Tarrier et al., 2007). The suicide schema is strengthened by distressing events and information-processing bias whereby the engaged suicide ideation becomes well established and turn each thought into a more detailed plan of suicide. The critical factor at this point regarding whether individuals proceed to a suicide act or not is dependent on the third component, the appraisal system.

Appraisal involves evaluative judgements that can influence how an event or experience is perceived (Lazarus & Folkman, 1984). Two types of appraisal relevant to suicidality (situation and self-appraisal) were proposed by Johnson et al. (2008). Situation appraisal determines whether an individual considers a particular situation to be a threat and whether they think they have possible solutions that may help rescue them, or they feel that there is no escape from the situation. Self-appraisal characterizes an individual's feelings of self-worth. Suicidal individuals often have lower self-esteem and negative views of the self, and such negative self-appraisal can lead to negative situation appraisal (Johnson et al., 2008). For instance, an individual may appraise an exam as being something they find easy or difficult to deal with and this situation appraisal is also dependent on the appraisal of self as being a competent student or not.

Figure 3.4. A diagrammatic illustration of the components of the SAMS as described in Johnston et al. (2008)



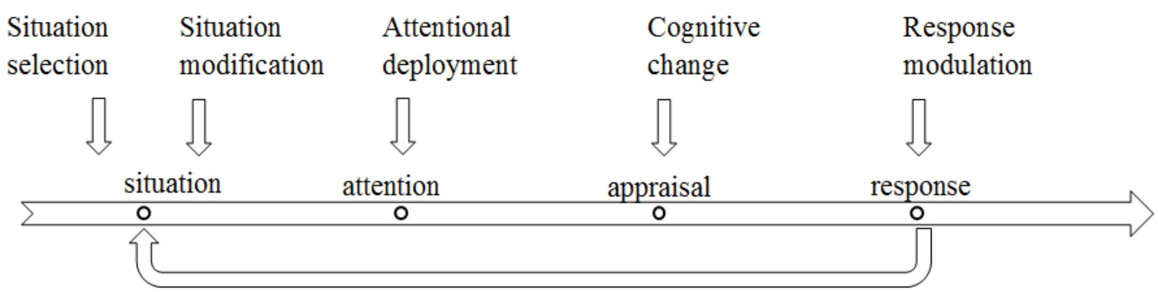
The importance of self-appraisal is demonstrated in a study by Johnson et al. (2010) who investigated levels of suicidality (as indexed by the SBQ-R) in students who were experiencing stressful life events. Those who reported low levels of positive self-appraisal showed increased suicide ideation in response to the stressor. In contrast, those reporting moderate or high levels of positive self-appraisal showed no increase in suicidality under the context of stressful events. This suggests that positive self-appraisal may act as a buffer against suicidality in the presence of environmental risk factors. Johnson et al. (2010) suggest that positive self-appraisers are more able to adopt an optimistic perspective and are able reinterpret a stressful situation. Individuals who make active efforts may provide resilience to suicidal behaviour compared to those with low levels of positive self-appraisal.

It is noteworthy that all of the suicide models discussed so far acknowledge that information processing bias and a motivation to escape are crucial in explaining why an individual may proceed to more suicide behaviour. Importantly, some of the study variables in this current research are aligned with these elements. For example, the avoidance coping identified as the key predictor for suicidality in Study 1 is similar to the escape factor whereby the act to avoid confronting the stressor (rather than directly deal with it) is associated with increased suicidality. This avoidance behaviour may be regarded as a form of escape from the stressor. To explore risk factors and resilience of suicidality, the key element in the suicide models such as the use of appraisal should be examined to see how it interacts with coping and suicide behaviour. As outlined in Chapter 1, adaptive emotion regulation (e.g. appraisal) requires both flexible emotional and cognitive responses in a given situation (Joormann & Gotlib, 2010; Sheppes et al., 2014), the importance of these responses are outlined by a well-established model, namely *the process model of emotion regulation* (Gross, 1998; Gross & Thompson, 2007).

3.2.4 The process model of emotion regulation

According to *the process model of emotion regulation* (Gross, 1998; Gross & Thompson, 2007), there is a sequence of four stages involved in emotion generation, namely, situation, attention, appraisal, and response (figure 3.5). Each stage of emotion is a potential target where emotion regulation may take place. There is a total of five points where emotions can be altered or regulated namely; situation selection, situation modification, attentional deployment, cognitive change, and response modulation (Gross, 2001).

Figure 3.5 The process model of emotion regulation with feedback arrow indicating that an emotional response may change one's own interpretation to the situation and the responding emotions. Figures adapted with permission from Gross (2014)



The first two points of emotional regulation involve changing the nature of the stimulus at the first stage (situation) of the emotion generation cycle (Ochsner et al., 2012). In situation selection, individuals will try to keep themselves away from stimuli that elicit unwanted emotions and put themselves in the presence of stimuli that elicit desired emotions. Based on the previous example mentioned regarding the grumpy neighbor, situation selection would be to remember that the neighbor gets out of the house every morning at 9am and so one may deliberately avoid leaving the house at this time in order to avoid the neighbor. However, imagine if the individual bumps into the grumpy neighbor by chance and this leads to an undesirable emotional response. In that instance, situation modification is a state when that individual may try to change something about the situation to alter its emotional impact. For example, to pretend to take a phone call.

The remaining three strategies (attentional deployment, cognitive change, and response modulation) are more related to cognitive ability (Ochsner et al., 2012). Attentional deployment controls which stimuli to be filtered out of the emotion generation process. The two most studied examples are selective attention, which involves moving the focus of attention towards or away from stimuli (e.g. not attending to the facial expression of the grumpy neighbor), and active distraction, which involves limiting attention to an external stimulus by focusing internally on information maintained in working memory (Gross & Thompson, 2007). An example would be for the individual to start thinking about their day ahead rather than listening too closely to what the neighbor is saying. These types of strategies differ from situation selection as they do not involve physically altering the relationship with the emotional stimulus. Instead they manipulate attention in order to alter one's own emotional response, for example, by taking a phone call or diverting attention inwardly that changes the emotional response. Some researchers explain that when individuals are unable to regulate negative emotions via attentional deployment they may exhibit more negative bias as they are unable to execute attention selection effectively (see Joormann & Tanovic, 2015; Lau et al., 2004). This means that individuals may spend more time processing negative information and engage more in sad mood, thereby leading to more negative thoughts and feelings. Ultimately, this may predispose individuals to greater emotional disturbance and increase the chance of developing depression (e.g. Joormann & Tanovic, 2015). The proposed postulation of how the emotion-cognitive interaction may exacerbate to depressive symptoms fit well with the body of literature who also found sustained negative affect and attentional bias towards negative information are the core features of depression (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008).

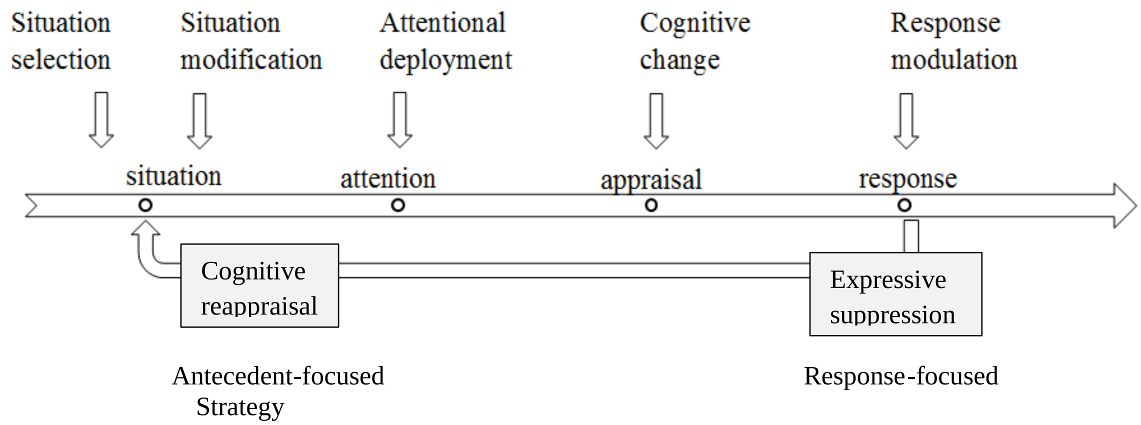
Following the possibility of attentional deployment, cognitive change is the next plausible emotion regulation strategy that involves changing the way one appraises the meaning of a stimulus. It is one of the most cognitively complex strategies insofar as it draws on cognitive processes to support changes in stimulus meaning. This includes but is not limited to language, memory, attention, and response selection. R*eappraisal*, is one typical example of this form of emotional regulation, it involves reinterpreting the meaning of a stimulus, including one's personal connection to it, in order to change one's emotional response (Gross, 1998). Referring back to the previous example, the individual may be confronted with the neighbor who is ignorant or extremely grumpy, reappraisal means that the individual may try to reinterpret this negative response in a more positive way. This could be to reappraise such rude behaviour by thinking that perhaps the neighbor is preoccupied with some distressing problems. Such an interpretation, which may be correct or not, can affect the current emotion of the individual as well as the emotional response to it (Ochsner et al., 2012).

The last point along the emotion-generative process where emotion regulation could occur and impact emotion-expressive behaviour is called response modulation. This occurs late in the emotion-generative process after the emotional response has been initiated. Expressive suppression is the most widely researched example, which entails inhibition of external cues that express one’s own true emotions. Example of these external cues in a distressing situation include to disguise facial expression of anger and body gesture expressing disgust. Inhibiting these cues would also mean that one’s true emotions will not be expressed and what others view of that person who uses suppression may contradict with his/her own internal emotional state (Gross, 1998). For example, smiling at a neighbor whilst feeling angry internally. From the process model of emotion regulation described, it is inferred that having the ability to gain flexible control of attention and inhibition may help to redirect the focus away from irrelevant thoughts effectively, and to better manage negative intrusive thoughts. When individuals can recognize the emotional significance of perceived stimuli and appreciate the need for regulation, they are able to select appropriate strategies based on past memories which are all considered essential (Gross & Thompson, 2007). Conversely, the use of expressive suppression has been shown to have a negative impact on psychological wellbeing (Gross & John, 2003) and could contribute to increased suicidality.

3.2.4.1 Cognitive reappraisal versus expressive suppression

According to the process model of emotion regulation (Gross, 1998; Gross & Thompson, 2007), emotion regulation processes vary along a continuum from automatic, implicit regulation processes (divert attention away from aversive stimuli) that occur without intention, through to highly effortful, intentional attempts to alter the emotional response to a given situation (Gyurak, Gross & Etkin, 2011). Based on the description of four stages of emotion generation in the process model of emotion regulation (see figure 3.6), two of the most studied emotion regulation strategies are cognitive reappraisal and expressive suppression.

Figure 3.6. The process model of emotion regulation indicating cognitive reappraisal and expressive suppression. Figures adapted with permission from Gross (2014)



The process model of emotion regulation describes appraisal as a form of adaptive emotion regulation and the ability to appraise information in a stressful situation may be a protective factor against suicidality (Gross & Thompson, 2007). *Cognitive reappraisal* is defined as the attempt to reinterpret an emotion-eliciting situation in a way that alters the meaning and changes the emotional impact (Gross & John, 2003). It aims to reduce negative emotions by changing one's own interpretation or appraisal of affective stimuli. In contrast, expressive suppression is an attempt to hide, inhibit, or reduce an outward expression of emotion. According to the description of how emotions unfold over time, the process model of emotion regulation argues that cognitive reappraisal and expressive suppression have an impact at different points in the emotion-generative process. Cognitive reappraisal is categorized as an antecedent-focused strategy as it usually intervenes early and focuses on altering the effect of emotion-generating cues (see Figure 3.6). An antecedent-focused strategy aims to initiate and modify an emotional response spontaneously without explicit intentions (Koole, 2010). This strategy is employed before the emotional response has been fully generated or activated (Gross & Thompson, 2007; Ochsner et al., 2004). This form of emotional regulation changes the perception of the situation at the beginning and can therefore modify the entire trajectory of the emotional response before an emotional response (i.e., anxiety, disappointment, panicking, and agitation) is produced. For example, an individual experiencing anxiety (the emotion-generating cue) at a job interview may try to reframe the stressful situation as a valuable opportunity to get to know the potential working environment in more detail.

Another form of emotion regulation stated by the process model of emotion regulation is expressive suppression, which entails inhibiting the outward expression of emotions once they have been generated (Gross & John, 1998). Expressive suppression is a response-focused strategy that aims to monitor and modify emotional responses with conscious effort in order to respond to the emotion-eliciting stimuli. They usually occur at a later stage of the emotion regulatory process and is termed a *response-focused strategy* (Gyurak et al., 2011) as it is employed after the emotion has been generated and experienced (see Figure 3.6). Therefore this strategy can only modify the behavioural expression of the emotion after the emotion has been fully experienced (Gross, 2002; Gross & John, 2003). For example, an individual may try to disguise their anxiety at an interview by breathing slowly and trying to appear confident. Expressive suppression involves the individual managing the emotional responses as they occur, the more effort they put into expressive suppression, the more this will have a negative impact on performance. Therefore, this will affect their cognitive resources in the long-term (Cutuli, 2014; Garnefski et al., 2001; Ochsner et al. 2012).

3.2.4.2 The association of cognitive reappraisal and expressive suppression with psychological wellbeing and suicidality

Although the process model of emotion regulation has specified a general sequence of emotion-generative process, individuals may differ substantially in their ability to use different emotion regulation strategies at each point. Some do it very well whilst others may experience more difficulty regulating their own emotions effectively. In a series of five studies, Gross and John (2003) have investigated individual differences in the use of suppression and reappraisal among undergraduate samples (N=1483). All participants were asked to fill in self-report measures of depression (indexed by the Beck Depression Inventory), positive wellbeing (Ryff & Keyes, 1995), and measures of emotion regulation strategies using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Considering how different emotion regulation strategies unfold over various points of the emotion expression continuum (i.e. antecedent-focused versus response-focused strategy). They found that the use of expressive suppression was associated with lower levels of positive emotional experience and behaviours. It was suggested that when participants try to suppress their negative emotions, they deal with stressful situations by masking their inner feelings and hiding away their outward displays of emotion. Consequently, these individuals are less clear about what they are feeling, are less effective in regulating their negative emotions, and view their emotions in a less favorable or accepting way (as indicated by the scoring of subscale 'self-acceptance' in the wellbeing measures).

As individuals were less likely to express feelings to others and felt even more negative about a distressing event, this suppressive behaviour in turn impacted their social relationships as they were more reluctant to disclose their feelings and they also reported avoiding close relationships (as reflected by the scoring on the subscale 'positive relations with others' in the wellbeing measure). Conversely, the use of reappraisal showed a trend in the opposite way, participants showed that the greater use of cognitive reappraisal (as reflected by scoring on the ERQ) was associated with more positive emotions and greater expressive behaviour. It was suggested that individuals with greater use of reappraisal negotiate stressful situations by taking an optimistic view and reinterpreting it in a positive way to repair their negative emotional states. In addition, as cognitive reappraisal occurs before the complete activation of emotion response tendencies has taken place, regulating emotion in this way does not create a discrepancy between inner experience and outer expression that is experienced in expressive suppression. As such, Gross and John (2003) stated that reduced use of cognitive reappraisal or more frequent use of expressive suppression is linked to lower wellbeing and worse social functioning.

From the findings of Gross and John (2003), individuals who frequently use expressive suppression may be less aware of their own feelings and often experience disruptions in social relationships. This may lead to a negative self-perception and may alienate the individual not only from the self but also from others since they tend to avoid their feelings rather than confront them. As expressive suppression comes late in the emotion-generative process, it requires the individual to manage emotional responses as they constantly occur. In agreement with Gross and John (2003), Cutuli (2014) also contend that repeated efforts to use suppression may deplete cognitive resources to the detriment of social behaviour and create a sense of discrepancy between inner experience and outer expression in the individual. In their review Cutuli (2014) compared the use of cognitive reappraisal and expressive suppression. Participants were exposed to emotion-eliciting situations (i.e. they were presented with negative affective pictures) and were randomly assigned to use cognitive reappraisal or expressive suppression strategies or to act naturally (control condition). It was found that using cognitive reappraisal was associated with more positive emotions experienced, better social functioning, and better wellbeing than the use of expressive suppression. Moreover, Ochsner et al. (2012) reviewed a series of functional imaging research including the analysis of event-related brain potentials (ERP) whilst using different emotion regulation strategies. An ERP is a powerful and sensitive physiological measure of brain activity within milliseconds (Chen, Lin, Chen, Lu, & Guo, 2015). It is one way to directly contrast brain activity when one is using cognitive reappraisal or expressive suppressive. The ERP showed that the use of cognitive reappraisal occurred earlier than the use of expressive suppression with higher and more extensive neural activation during regulation of emotion than using cognitive reappraisal. As greater brain activity reflects greater cognitive processing, this confirms Cutuli's (2014) proposal that the use of expressive suppression requires more cognitive and physiological resources compared to cognitive reappraisal.

In terms of how expressive suppression is linked to suicidality, John and Gross (2004) explained that the use of this maladaptive emotion regulation is often accompanied by a resistance to seek and receive help. Consequently, individuals who engage in expressive suppression tend to have less social support, poor coping abilities, higher avoidance in interacting with others, and a lack of close social relationships. All of these factors deplete the available resources one needs to seek rescue factors in a distressing situation. This would ultimately increase the risk of suicidal behaviour. In contrast to the negative impact of expressive suppression, Gross and John (2003) have found that those who primarily engage in cognitive reappraisal are more likely to share their emotions (both positive and negative) with others and maintain close relationships with friends. They also use more self-regulation strategies in the form of coping and have a stronger social network compared to expressive suppressors. Consequently, individuals who use cognitive reappraisal often experience more positive emotions (as indicated by the higher scoring of positive wellbeing; Gross & John, 2003) and fewer negative emotions than those who reappraised less frequently. Following from this, the benefits of using cognitive reappraisal have been repeatedly found in more recent studies in a student population (Forkmann et al., 2014; Richmond, Hasking & Meaney, 2017). Using self-report measures of the ERQ again, it was found that whilst depression, anxiety, and stress each exerted a direct effect on non-suicidal self-injury among 1586 university students (Richmond et al. 2017), the positive association was mediated by the increased use of cognitive reappraisal. Similarly, Forkmann et al. (2014) revealed that greater use of expressive suppression and reduced use of cognitive reappraisal significantly predicted increased suicidal ideation. The results highlighted possible interventions for students with psychological distress by having more workshops or training on the use of adaptive emotion regulation strategies.

3.3 Study 2: The importance of coping, emotional regulation, and depression in the occurrence of suicidal behaviour

Based on the empirical evidence and explanations from the SAMS and the process model of emotion regulation, it is clear that appraisal in stressful events and the ability to regulate one’s own emotions are among the core aspects in promoting positive psychological health and may serve as a resilience to suicidality. It is also clear that both emotion regulation and coping strategies have considerable impact on psychological wellbeing and suicide behaviour.

3.3.1 Aims and intentions of the current study

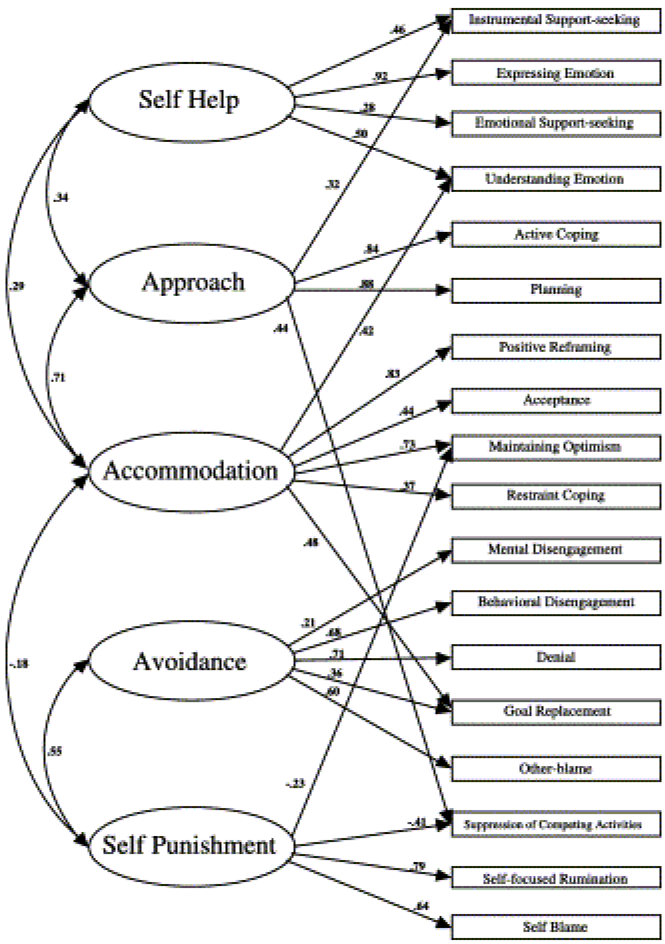
Although different executive functions and coping factors were investigated in relation to suicidality in Study 1, the first study did not address how emotional regulation and depression may be associated with suicide behaviour. Therefore, based on the key models of suicide and the process model of emotion regulation the present study aims to examine suicide in relation to these variables. In accordance to the Cry of Pain model that motivation to escape leads to increased suicidality, the current study predicted that the greater use of avoidance coping will be associated with increased levels of suicidality and depression. Moreover, based on the process model of emotion regulation, it is predicted that the use of expressive suppression and reduced use of cognitive reappraisal are associated with increased suicidality.

3.3.2 Reconsideration of coping measures

In Study 1, coping strategies were previously measured using Carver’s coping inventory (COPE; Carver et al., 1989), which categorizes coping into problem-focused, emotion-focused, and avoidance-focused coping. This COPE inventory contains 15 subdivisions of coping, and serves as a good starting point to understand how different coping strategies correlate with executive functions and suicide behaviour. However, some related studies have examined coping more concisely by excluding less relevant factors to executive functions such as religious coping. As the main theme of this research is emotion and cognitive aspects of suicide behaviour, it is more effective to avoid examining too many subdivisions of coping that may divert away from studying the main factors of this research focus. Therefore, it is vital to select coping and emotional regulation constructs that have more relevance to executive functions and suicide behaviour. Considering the COPE inventory contains subdivisions such as humour and religious coping and they are not the main research focus, it would be best to replace the COPE with another coping measure that has more focus on cognition and emotion. A replacement without having a profound change in the research focus is the revised COPE (R-COPE) developed by Zuckerman and Gagne (2003). This 40-item inventory is similar to the original COPE used in Study 1 but has placed more emphasis on the emotional aspects of coping. For example, expressing emotion, emotion support-seeking, understanding emotions etc. This is important considering the results of Study 1 that Chinese participants tend to use more emotion-focused or avoidance-focused coping than their Western counterparts, and Study 2 uses Chinese participants. Therefore, the emotional aspects of coping can be investigated in more depth through the use of this new inventory.

The R-COPE is derived from 18 different subscales. It shares a high proportion of similarity with the COPE inventory whereby 11 of the subscales remain the same. These include: *active coping, planning, suppression of competing activities, restraint coping, instrumental support-seeking, emotional support-seeking, positive reframing, acceptance, denial, behavioural disengagement, and mental disengagement.* This means that some of the key factors such as acceptance, denial, behavioural disengagement, and mental disengagement that have correlated with suicidality in Study 1 remain. The remaining seven are new subscales. These are *self-blame, self-focused rumination, other blame, goal replacement, maintaining optimism, understanding emotion,* and *expressing emotion.* Compared to the 15 subscales of coping in the previous COPE, this inventory is considered to be more effective in exploring coping and has a relevant focus on the emotional aspects of coping. The 18 subscales of coping belong to five groups of coping strategies in the R-COPE (Figure 3.7). The first is *self-help coping* which signifies seeking support and dealing with the incident by understanding and expressing one's own emotions. The second subscale is *approach coping* which focuses on problem solving. The third subscale is *accommodation coping* which measures the ability to accept that the problem cannot be resolved and to use positive reframing and develop an optimistic outlook of the incident. These three strategies of coping are collectively called *adaptive coping* as they relate to positive mental outcomes. The remaining two coping strategies, *avoidance* and *self-punishment* are grouped as *maladaptive coping.* Avoidance coping aims to direct the individuals away from the problem via disengagement, denial, and blaming external forces to cope with the situation. Self-punishment measures maladaptive coping strategies such as self-focused rumination and self-blame regardless of whether they had contributed to the incident in reality (Zuckerman & Gagne, 2003).

Figure 3.7. Fifteen subscales of coping separated into five groups of coping strategies (Zuckerman & Gagne, 2003)



Regarding the comparison of adaptive and maladaptive coping, past findings generally support the notion that utilization of adaptive coping strategies is more effective in difficult situations and when managing negative emotions compared to maladaptive coping strategies. For instance, increased use of maladaptive coping (self-punishment and avoidance coping) was associated with increased risk of suicidality in veterans (Pietrzak, Russo, Ling, & Southwick, 2011) and police officers (Pienaar, et al., 2007). However, similar to Study 1, these findings only focused on coping without considering how emotion regulation plays a part in the relationship for moderating suicidality, it is vital to incorporate this factor and outline how if differs from coping and interacts with suicidality.

3.3.3 METHOD

3.3.3.1 Design

The study used a correlational design to explore the relationship between suicidal behaviour, depression, coping strategies, and emotion regulation. The variable of suicide behaviour gave a measure of the extent of suicide behaviour including information such as past suicide attempts and thoughts. The variable of depression gave a measure of the severity of depressive symptoms. Coping was measured on five dimensions of self-help, approach, accommodation, self-punishment, and avoidance. The variable of emotion regulation was separated into cognitive reappraisal and expressive suppression.

3.3.3.2 Participants

One hundred and twenty undergraduate students from The Open University in HK (51 males, 69 females) were recruited for this study from a research talk on suicide prevention. Prospective participants were prescreened[17] for any previous history of neurological and mental health problems (e.g., anxiety, PTSD, and cognitive deficits). Two participants were excluded as they reported having recurrent or past history of

[17] In a section of the demographic questionnaire, participants were asked whether they have previously been diagnosed with any forms of neurological or psychological disorders that are known to affect cognitive performance or relate to emotional disturbance.

mental health problems leaving a sample size of 118 participants (50 males, 68 females). Their ages ranged from 18 to 28 years, with a mean of 23.14 years (SD = 5.51).

3.3.3.3 Materials

Five questionnaires were used for this study (see Appendix 1.1, 1.4-1.6) in order to measure general demographics, suicide behaviour, depression, emotion regulation, and coping. As in the previous studies suicide behaviour was measured using the SBQ-R (Osman, et al., 2001). Depression was measured using the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). This self-report inventory measures different aspects of depression such as sadness and anhedonia. This is a 21-item inventory with most items assessed on a four-point rating scale from zero to three (0 indicates no symptoms and a score of 3 indicates severe symptoms) except for item 16 and 18. Each item describes the way the individual has been feeling in the past two week such as “worthlessness” with 0 indicating “I do not feel I am worthless” to 3 indicating “I feel utterly worthless”. The total score for this inventory ranges from 0 to 63 with higher total scores indicating more severe depression symptoms. Clinical interpretation of total scores indicates that a score of 17 or above represents a risk of clinical depression (Beck et al., 1996).

Emotion regulation was measured using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). This is a 10-item questionnaire measuring habitual use of two strategies for regulating emotions; cognitive reappraisal (6 items) and expressive suppression (4 items). Cognitive reappraisal consists of regulation techniques to help reinterpret emotionally arousing stimuli and to regulate the impact of such stimuli.

Expressive suppression techniques inhibit on-going emotion expression. All questions are rated on a 7-point Likert-type scale (from 1 = strongly disagree to 7 = strongly agree), for example, “I keep my emotions to myself” is answered on a scale of 1 indicating “strongly disagree” to 7 indicating “strongly agree”. A higher score indicates greater use of the corresponding emotion regulation strategy. The range of scores for reappraisal is 6 to 42, and for suppression is 4 to 28. The measure has demonstrated good internal consistency (Cronbach’s alpha; cognitive reappraisal, $\alpha = .82$; expressive suppression $\alpha = .76$) and adequate test-retest reliability (MacDermott et al. 2010).

Coping strategies were measured using the R-COPE (Zuckerman & Gagne, 2003). This is a 40-item inventory that assesses 5 groups of coping in response to stress: self-help, approach, accommodation, avoidance, and self-punishment. The R-COPE has been modified from the classic coping inventory (COPE; Carver et al., 1989). Items such as “I blame myself” are responded to on a four-point Likert scale with 1 indicating “I usually don’t do this at all” to 4 indicating “I usually do this a lot”. Each of the 5 coping categories was measured using 8 questions, giving a minimum score of 8 and a maximum of 32, with higher scores indicating greater use of a particular strategy. The R-COPE has reported high discriminant and convergent validity with reliability ranging from .81 to .92 relatively (Zuckerman & Gagne, 2003).

3.3.3.4 Procedure

All questionnaires (demographics, SBQ-R, R-COPE, ERQ and BDI-II) were distributed to students during a lecture and they were asked to read the instructions and then individually complete each questionnaire at their own pace. The completion of the questionnaires took approximately 30 minutes, and following completion participants were debriefed.

3.3.4 RESULTS

Results included scores on the SBQ-R and the BDI-II, the scores for the two emotional regulation strategies, and scores for the five dimensions of coping. The data for the cope measure consisted of 117 participants as one did not complete the R-COPE questionnaire. The median scores and range for each measure can be found in Table 3.1.

***Table 3.1*. Median and range values for each of the study variables**

Measure	*Variable*	*Median*	*Range*
SBQ	Suicide Behaviour	5.5	3-15
BDI-II	Depression	15	0-50
ERQ	Cognitive reappraisal	27	10-40
ERQ	Expressive suppression	15	7-24
COPE-R	Avoidance coping	17	9-28
COPE-R	Self-punishment coping	19	9-31
COPE-R	Accommodation coping	21	12-32
COPE-R	Approach coping	23	15-35
COPE-R	Self-help coping	20	9-32

To analyse the relationship between suicidal behaviour, depression, and the different strategies of coping and emotion regulation, a series of Spearman's correlations were conducted as the data did not conform to parametric assumptions. It was evident that suicidality was significantly associated with depression, r (118) = 0.562, $p < .01$. Out of the 5 coping strategies, suicidality was positively correlated with avoidance coping, r (117) = .25, p < .01, indicating that higher levels of suicidality were related to increased use of avoidance coping (Appendix 6.2.1). Suicide behaviour was negatively correlated with accommodation coping, r (117) = -.20, p < .05, and self-help coping, r (117) = -.23, p < .05. This showed that participants who reported less use of accommodation and self-help coping showed higher levels of suicide behaviour. There was no significant correlation between suicidality and self-punishment, r (117) = .17, p >.05, or approach coping, r (117) = -.09, p >.05.

Table 3.2 **shows the correlation between different coping and suicide behaviour**

	1	2	3	4	5	6	7	8	9
1.Suicide behaviour	1.00								
2. Depression	.56**	1.00							
3. Cognitive reappraisal	-.34**	-.37**	1.00						
4. Expressive suppression	.001	.05	.13	1.00					
5. Avoidance coping	.25**	.27**	.00	.26**	1.00				
6.Self-punishment coping	.17	.30**	-.05	.24**	.44**	1.00			
7. Accommodation coping	-.20*	-.39**	.26**	-.12	-.05	.01	1.00		
8. Approach coping	-.09	-.13	.23*	.01	.16	.33**	.45**	1.00	
9.Self-help coping	-.23*	-.27**	.21*	-.42**	-.00	-.03	*36**	.31**	1.00

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

There was a negative correlation between scores on the SBQ-R and cognitive appraisal, r (117) = -.34, p < .01, with increased use of cognitive reappraisal relating to reduced suicidality. However, there was no relationship between suicide scores and expressive suppression, r (117) = .01, p >.05.

To assess the impact of cognitive reappraisal, avoidance, accommodation, and self-help coping on suicidal behaviour a multiple regression analysis was performed with scores on the SBQ-R as the dependent variable and the different coping and emotion regulation strategies as predictor variables (Appendix 6.2.2). Using the enter method, a significant model emerged, F (4,114) = 10.77, $p < .001$, adjusted R square = 0.255. The variables that were shown to significantly predict suicidal behaviour were avoidance coping (Beta = 0.275, $p < .001$) and cognitive reappraisal (Beta = -0.179, $p < .001$). Whilst they were associated with scores on the SBQ-R, accommodation coping (Beta = -0.102, p = .28) and self-help coping (Beta = -0.148, p = .11) did not predict suicidality.

3.3.5 DISCUSSION

Building upon the findings from Study 1 that emotional control plays a critical role in suicide behaviour, the present study aims to examine emotions to a greater extent by investigating how individuals regulate their emotions and how negative emotions (i.e. depression) are related to suicide behaviour. Another rationale for exploring emotion regulation in this study is the postulation that the use of reappraisal is resilience factor that protects against suicidality. In accordance to the process model of emotion regulation, it is predicted that expressive suppression (maladaptive emotion regulation) and cognitive reappraisal (adaptive emotion regulation) may play opposite roles in the manipulation of suicidality and depression. Extending from Study 1, the present study examined the relationship between different coping strategies with suicidality. Based on the Cry of Pain model that motivation to escape leads to increased suicidality, the current study predicted that the greater use of avoidance coping will be associated with increased levels of suicidality and depression. In support of the past literature reporting a high degree of comorbidity between suicide and depression (Pompeo, 2014; Potter et al., 2004; Sokero et al., 2005), the present results also found a strong relationship between depression and suicide behaviour.

3.3.5.1 Emotion regulation and suicidality

The present results revealed that the use of cognitive reappraisal is associated with reduced levels of suicidality. This complements the SAMS (Johnson et al., 2008) and the process model of emotion regulation that the ability to utilize cognitive reappraisal (regulate emotion by reinterpreting an emotion-eliciting situation) is adaptive for managing emotions and provides protection against suicide. Appraisal is important as it influences the degree to which events and experiences are viewed as stressful and challenging or as an opportunity (Johnson et al., 2008; 2010). One possible explanation for this from the SAMS perspective is that individuals who engage in positive appraisal are less likely to appraise a difficult situation as defeating, or feel entrapped due to the situation. The use of reappraisal will help individuals to see the situation in a more positive light and to actively try to find other resources to deal with the situation. For instance, Johnson et al. (2008; 2010) reported that those who frequently use reappraisal are more likely to seek alternatives by means of interpersonal problem solving and strengthening social support. This would help to prevent individuals from being trapped in a state where they cannot find rescue factors.

The present study is consistent with the past findings of Rajappa et al. (2011) and Sheppes et al. (2014) whereby higher levels of cognitive reappraisal were associated with decreased level of suicidality, this also gives support to the process model of emotion regulation (Gross & John, 1998) whereby the use of an antecedent focused strategy (cognitive reappraisal) may be a more effective way to regulate emotion compared to expressive suppression. However, the current results concerning expressive suppression are inconsistent with the past findings because it was not associated with increased suicide behaviour. The results contradict the process model of emotion regulation, which posits that the use of expressive suppression, a form of response-focused strategy which occurs later in the emotion generative process, is regarded as a less effective regulation for reducing suicidality.

In light of the previous studies which have shown that more frequent use of expressive suppression is related to increased suicide thoughts and behaviours (Campbell-Sills et al., 2006; Forkmann et al., 2014; Gross & John, 2003; Joormann & Gotlib, 2010), the current findings contradict them. Notably, there are key differences that might explain the result, in particular the sample. For instance, the majority of past studies listed were conducted using European and American participants (Butler, Lee & Gross, 2007; Forkmann et al., 2014; Soto, Perez, Kim, Lee, & Minnick, 2011) rather than a Chinese population such as that used in the current study. Similar to the cultural impact of coping whereby Chinese participants tend to use more emotion-focused or avoidance-focused coping (especially acceptance) than their Western counterparts, the present study similarly found that culture could potentially be a factor contributing to the different effectiveness in using expressive suppression.

In support of the assumption of cross-cultural differences in the adaptive use of emotion regulation strategies, Butler et al. (2007) observed that whilst emotional suppression was associated with more negative emotions and hostile behaviours in European Americans, these negative impacts were reduced or reversed in Asian

Americans who held Asian values. Consistent with this, Soto et al. (2011) conducted a cross sectional study with 71 European American students and 100 Chinese students from HK. All participants completed self-report measures of expressive suppression, life satisfaction, and depressed mood. Results showed that expressive suppression was associated with adverse psychological functioning for European American participants but not for Chinese participants. Butler et al. (2007) concluded that suppression might be as effective as, or even more effective than, acceptance in regulating negative emotion in Chinese individuals.

The current findings highlight the importance of the cultural factors when considering the effectiveness of any forms of emotion regulation or coping strategies, similar to the findings of Study 1. Cultural background may therefore be a critical factor in understanding the relationship between emotion regulation and psychological functioning. As mentioned previously, Western cultures are characterized by individualistic cultural values that encourage free emotional expression. In contrast, Chinese students in HK are from a culture characterized by collectivistic cultural norms with relational harmony and self-discipline. Emotional expression has previously been found to be moderated by differences in cultural norms (Butler, Lee & Gross., 2009; Soto, Levenson, & Ebling, 2005, Yuan et al., 2014). Chinese individuals are encouraged to suppress the expression of negative emotions therefore, to some extent suppression may be an adaptive and effective emotion regulation strategy in East Asian cultures. This suggestion is consistent with other studies that have also found emotional suppression to be culture-specific. For example, using emotional suppression may relate to fewer negative emotional experiences, improved social interactions, and more favorable physiological responses in individuals with East Asian cultural values (Butler et al., 2007; Mauss & Butler, 2010; Soto et al., 2011). With the comparison of American and Asian participants, Butler et al. (2007) found that the increased use of suppression was associated with self-protective goals and negative emotion in Americans, especially those who held individualistic values. They also reported the negative effects of suppression whereby its use was associated with reduced interpersonal responsiveness during face-to-face interaction, negative partner-perceptions, and hostile behaviour. However, these deleterious effects were mediated by cultural differences. This is because Asian individuals, especially those who hold more collectivistic values were in favor of using suppression. The negative impact reported by the American participants was not apparent in Asians, which suggests that the negative social impacts of suppression may indeed be moderated by cultural values.

3.3.5.2 Coping and suicidality

The results from the study showed that increased suicidal behaviour was related to increased avoidance coping, and reduced levels of accommodation and self-help coping. This suggests a generally protective effect of suicide via the use of self-help and accommodation coping, and a risk effect via the use of avoidant coping. Modeling the data with regression analysis indicated that avoidance coping was the strongest predictor for increased level of suicide behaviour. This has strengthened the existing relationship that the study of avoidance may better help to understand how individuals proceed to further suicidality along the suicide path. Avoidance coping is considered to be a maladaptive coping strategy (John & Gross, 2004; Zuckerman & Gagne, 2003) and the current findings support this. If individuals choose to use avoidance coping to avoid unwanted thoughts and negative emotions (rather than trying to alter them), these emotions may still be readily available despite the effort to keep them out of awareness. The negative thoughts and feelings they try to avoid may persist to a greater extent without being resolved (Najmi, Wegner, & Nock, 2007). As predicted by the Cry of Pain model (Williams 1997, Williams & Pollock, 2001), individuals who try to escape from an intolerable situation by trying not to think about the stressor are more likely to show increased suicide behaviour.

It is noteworthy that with the change of coping measure in this study, the present findings replicated the results of Study 1 whereby the use of avoidance coping was one of the most significant predictors of suicide behaviour. This again suggests that individuals who use high levels of avoidance coping may hold short-term goals instead of trying to resolve the problem. In the long term, the problem remains unresolved and may become more difficult and distressing in the future, and this can lead to greater engagement in suicide behaviour. The results also suggest that avoidance coping is an important factor in suicide behaviour even when a revised coping scale with fewer dimensions was used. This indicates that coping may be regarded as a stable trait that could be worth exploring from a neurological perspective in the proceeding studies.

In the current study, the increased use of accommodation and self-help coping was significantly associated with a reduced risk of suicidal behaviour. This suggests that individuals who more often seek support and express emotion (self-help coping) or accept a problem and positively reframe a situation (accommodation coping) are more likely to be protected against suicide behaviour. According to the arguments of the Cry of

Pain model (Williams, 1997; Williams & Pollock, 2001) and the SAMS (Johnson et al., 2008), individuals can feel trapped or defeated in a situation because they are unable to generate alternatives for an unbearable situation. In support of this, the current findings suggest that individuals who utilize different adaptive coping strategies in the form of accommodation and self-help can generate solutions to a stressful situation and may therefore be less likely to experience defeat and entrapment.

Whilst three of the coping strategies proposed by Zuckerman and Gagne (2003) were associated with a risk of suicide behaviour, self-punishment and approach coping showed no relationship with scores on the SBQ-R. This conflicts with previous research showing that suicide behaviour is best predicted by reduced use of approach coping (Pienaar, et al., 2007) and increased use of self-punishment coping (Pietrzak et al., 2011). Again, one reason for the disparity in the findings is that the samples used across the different studies vary quite substantially and participants may be exposed to different stressors. For example, the Pieenar et al. (2007) study recruited uniformed police officers from South Africa and Pietrzak et al. (2007) studied Veterans in the U.S. Coping strategies and behaviour of individuals from those groups may not be applicable to university students who tend to be younger and have less experience in mastering their approach coping (this requires problem solving based on knowledge and past experiences). The use of different coping strategies with regards to suicide behaviour has not been extensively investigated among university students and the present study has therefore shown that it is important to take account of the participant characteristics and the stressors they may experience before trying to encourage specific coping strategies.

The current findings have drawn attention to the appropriateness of categorizing coping as adaptive and maladaptive. It is suggested that the term maladaptive coping may not be consistent across all populations and all situations. For example, the use of approach coping, that is considered to be effective in reducing suicidality in police officers (Pieenar et al., 2007), may not apply to other populations. Conversely, maladaptive coping strategies that are widely identified to have a negative affect on wellbeing may be beneficial in dealing with some situations (Clarke, 2006; Zuckerman & Gagne, 2003). As outlined in Chapter 2, the use of active coping (directly dealing with the stressor itself) was associated with healthy functioning only in the experience of a controllable event, but was related to unhealthy functioning when dealing with an uncontrollable event (Clarke, 2006). This suggests that there are no definite ways of defining a coping strategy as either adaptive or maladaptive because a coping strategy that is effective in one situation may not be effective in other situations. Further to the correlational findings of Study 1 and the present study, researchers in the future should explore the coping strategies individually rather than grouping them as adaptive or maladaptive.

The current study builds on and expands both theoretical work and past research findings examining coping, emotion regulation, and suicidal behaviour. Overall, the findings indicate that lower levels of avoidance coping, in combination with higher levels of cognitive reappraisal may explain the resilience of some individuals against suicidal behaviour. This may help to improve prevention of suicide in younger populations. A further important point raised by the research, in combination with past findings, is that the use of coping and emotional regulation may be influenced by cultural context and the psychological processes that may be considered risk factors in some populations and situations may be beneficial in others. This supports the argument that emotion regulation strategies are similar to coping in that these strategies may be beneficial in certain situations and harmful in others. Therefore, there is no absolute way of defining them as adaptive or maladaptive. The research therefore raises the importance of accounting for the background and situation of the individual when trying to identify risk factors to suicide.

Overall, the current findings complement the SAMS and provide support for the argument that cognitive reappraisal is considered as adaptive emotional regulation. There is convincing evidence that the use of appraisal serves as an important resilient factor for reducing suicidality. In terms of coping, the findings complement the proposal of the Cry of Pain model in that motivation to escape is one important reason for individual to commit suicide.

CHAPTER FOUR

Experimental investigations of executive functions and frontal asymmetry of suicide individuals

4.1 Limitations of using the BRIEF-A

To determine which executive functioning components were key predictors for suicidality, Study 1 investigated the relationship between suicide behaviour and executive functions using self-report measure (BRIEF-A). Although the results were important in confirming that perceived difficulties in managing working memory, emotional control, shift, initiate, and inhibition were key variables in predicting suicide behaviour, there were limitations raised. For example, some researchers have critiqued the generalizability of the self-report measures of executive function as they often fail to capture the precise cognitive deficits in a real-world setting (Barkley, 2012; Manchester, Priestley, & Jackson, 2004), this leaves the possibility that the use of the BRIEF-A did not capture measures of executive function effectively. Therefore, more empirical work is needed to establish how executive function difficulties may impact suicide behaviour.

Although the role of different executive functioning components in exacerbating suicide behaviour can be specified using BRIEF-A, there remains uncertainty as to whether suicidal individuals have impairments in executive functions, or that their comparable cognitive abilities are more vulnerable under the influence of emotional interference. Extending from the limitation of assessing executive functions through self-report measures in Study 1, the current study will measure critical executive functions experimentally through the use of cognitive tasks with emotional stimuli.

4.1.1 The current challenges in predicting suicide behaviour

As outlined in Chapter 1, prediction and prevention of suicide is difficult because many individuals who experience suicide behaviour may avoid discussing this with others (Nock et al., 2010). Sharing feelings and thoughts can often trigger feelings of stigmatization and this can also lead to difficulties in predicting suicidality because assessments are largely based on clinical interviews and self-report measures (Wilson, 2009). Busch, Fawcett, and Jacobs (2003) found that 78% of patients who have attempted suicide explicitly denied having suicide ideation in their last clinical reports before the attempt. Another study conducted by Qin and Nordentoft (2005) also demonstrated that suicide risk increased immediately after patients were released from hospital care following their self-report that they were no longer experiencing suicidal tendencies. It was noted that some patients deliberately reported lower intention of suicide to avoid prolonged hospitalization. This highlights the importance of developing alternative measures for identifying individuals with a suicide risk. One potential option would be to use measures of cognitive and neurological processing. Support for this suggestion is based on past research that used cognitive tasks to show how deficits in executive functions were associated with suicidality (Cha et al., 2010; Jollant et al., 2008, 2010; Keilp et al., 2008, 2013; Mann et al., 2006; Westheide et al., 2008).

4.2 Exploring cognitive deficits in suicidal individuals

4.2.1 Deficits of attentional control

Building on the evidence from Chapter 1 which reported an attentional bias towards negative information in depressed patients (Keilp et al., 2001), Keilp, Gorlyn, Oquendo, Burke, and Mann (2008) specifically compared attentional deficits in depressed patients with varying degrees of suicidality. In the study, individuals with or without a past history of suicide attempt were assessed using Beck's medical damage rating of physical injury resulting from a suicide attempt (Beck et al., 1975). A total of 53 participants who had past suicide attepts of 'low lethality', 42 of 'high lethality', 83 with depression but no past history of suicide, and 66 controls completed a colour Stroop task as a measure of attentional control (the Stroop interference effect). The Stroop interference effect is apparent by the additional response time required to name the colour of incongruent versus congruent words. This is due to difficulties inhibiting an automatic process of reading the word (Beall & Herbert, 2008; MacLeod, 1991; Ovaysikia, Tahir, Chan, & DeSouza, 2010). Results showed an increased Stroop interference effect in all depressed patients relative to non-patients, but the effect was most apparent in patients reporting one or more high lethality attempt(s) in the past. The findings suggest that deficits in attentional control (indexed by lower accuracy and slower response times in the Stroop tasks) may predict suicide risk in clinical populations. Importantly, this replicated their earlier findings (Keilp et al., 2001) and shows that the extent of the attentional bias, as measured using the Stroop paradigm may be a useful indicator of suicide risk.

To explore how deficits of attentional control interact with emotions, some studies have used a modified version of the colour Stroop task; the emotional Stroop task. It is widely adopted and findings have consistently shown an emotional Stroop effect (Pratto & John, 1991). This is when there is an increased response times to name the colour of emotional words compared to neutral words. Several studies have specifically found an emotional Stroop effect for negative emotional stimuli only. This is when there is an increased response time to name the colour of negative words (e.g. death) but not for naming the colour of positive or neutral words (Algom, Chajut, & Lev., 2004; Gilboa-Schechtman, Revelle, & Gotlib, 2000; McKenna & Sharma, 2004). Such attentional bias towards negative stimuli is also referred to as a negativity bias. Though the emotional Stroop effect is consistently reported in prior studies, this effect has been shown to be more robust in depressed patients than the non-clinical population (Gotlib & Cane, 1987; Gotlib & McCann, 1984). In particular, there is more instances of negativity bias with larger emotional Stroop effect for negative information (e.g., words such as sad, down, hopeless) than for positive information. One explanation for this is that depressive individuals may have attentional bias and enhanced sensitivity to information congruent to their emotional state (Epp, Dobson, Dozois, & Frewen, 2012; Gotlib et al., 1996). This is based on supposition of mood-congruency hypothesis (Bower, 1981; 1991) which explains the influence of emotion on information processing. The model posits that individuals would prioritize the processing of emotional information consistent with their current mood states. Therefore, a positive mood state will facilitate processing of positive information whilst negative moods will facilitate processing of negative information (Bower, 1981). From this perspective, when depressed individuals feel negative they will also pay more attention to negative information, and subsequently it is more difficult to inhibit the meaning of the word and focus on the colour naming task.

The attentional bias for emotional information (sometimes also called a processing advantage) is explained from the evolutionary perspective where it is beneficial to prioritize such information that may signal environmental danger (Öhman, Flykt, & Esteves, 2001). However, there are instances in which this bias can lead to processing costs, therefore attentional control would be crucial to maintain focus on task-relevant information in the presence of distraction (Riddle, 2007). Gotlib et al. (2004) explored the extent of attentional bias in depressive patients and healthy controls using images of emotional faces. Facial stimuli depicting sad, angry, and happy expressions were used in an emotional Stroop task. In accordance with the mood congruency hypothesis, it was predicted that depressed patients would exhibit a bias consistent with their emotional state and would preferentially focus on sad faces. Results showed that depressed participants exhibited attention depression-relevant (sad) faces but not to other faces such as angry and happy faces. Gotlib and Joormann (2004; 2010) argued that the attentional bias in the depressed group may manifest depressed individuals to become more vulnerable to negative information, and have more difficulties in inhibiting irrelevant information that is negative. Concurrently, these are also the common factors contributing towards the increasing intensity of depressive symptoms (Gotlib et al., 2004).

Inhibition is one important cognitive aspect of attentional control and it was identified as a predictor of suicide behaviour in Study 1. As mentioned earlier, inhibition supports the orientation of attention, behaviour, thoughts, and emotions through the ability to actively ignore irrelevant information (Blasi et al., 2006; Boehler, Appelbaum, Krebs, Hopf, & Woldorff, 2010; Diamond, 2013). The ability to exert inhibitory control is essential to enable individuals to behave in socially appropriate ways. It can also help to suppress unwanted thoughts or distractions that occur or are presented together with important, relevant information. Excessive worrying and rumination are characteristics of anxiety and depression (Joormann & Gotlib, 2010) and it has been suggested that these are a result of an inability to inhibit negative thoughts.

Followed from the findings of Gotlib et al. (2004), Gotlib et al. (2010) suggested that depression is characterized by ruminative responses to negative emotional states and distressing life events, the inability to regulate one's own negative emotion, increased elaboration of negative information, and difficulties disengaging from negative material. Evidently, these emotional disturbances correspond to the deficits in inhibition, attention, and working memory. This is because when depressed individuals have attentional bias for negative information, their cognitive abilities to deal with overriding prepotent responses, to inhibit the processing of irrelevant material, the ability to respond flexibly and to adjust adaptively to changing situations are all thought to be disrupted. Gotlib et al. (2010) concluded that among all cognitive aspects, deficits in inhibitory control play a central role in the exacerbation of depression.

Complementing the proposal of Keilp et al. (2008) which is to use Stroop interference effect to predict suicide risk, Jollant et al. (2011) extended this idea and found that the emotional Stroop task could similarly be used to differentiate suicide attempters from those without suicide risk. Jollant et al. (2011) used the severity of cognitive deficits as indexed by performance in the Stroop task to distinguish depressed patients with a past suicide act from patients without a past suicide act and healthy controls. Results showed that individuals with suicide behaviour experienced more difficulties with the task as they were more distracted by negative or suicide-related stimuli. This shows that the Stroop task can be a useful method for predicting suicide.

4.2.2 Deficits of Working Memory

According to Lustig, May, and Hasher (2001), individuals with large working memory spans are better able to deal with increased amount of information, these can equip individuals to handle proactive interference that builds up across a series of test trials within a given task. This ability is crucial for cognitive demands such as tracking written or spoken language, formulating plans or considering relationships between ideas, items and multitasking (Chung et al., 2014; Diamond, 2013).

Richard-Devantoy, Berlim and Jollant (2014) reviewed 24 studies (including 2,595 participants) on the relationship between memory deficits and vulnerability to suicide behaviour. Four different types of memory (i.e., working memory, short- and long-term memory, and autobiographical memory) were examined. It was found that autobiographical memory was significantly less specific and more general in patients with a history of suicide attempt relative to those without. Notably, both long-term memory and working memory were markedly impaired in suicide attempters relative to patients without suicide attempts and the healthy controls. The meta-analysis concluded that long term and working memory play a significant role in the risk of suicidal acts as deficits may impede the retrieval of past experiences to solve current problems and to envision the future, and by altering inhibitory processes. In support of Richard-Devantoy et al. (2014) postulations, other literatures (e.g. Joormann & Gotlib, 2007) have also reported working memory deficits to be associated with suicidality, whilst Keilp et al.

(2001) reported that impaired working memory was only specific to high suicide risk groups. Consistently, the findings from Study 1 support the argument that difficulty with working memory is associated with increased suicidality. It should be noted that this argument is limited given that the findings are only based on self-report measures and did not measure executive functions experimentally. However, related studies have shown that difficulties in self-reported working memory of patients measured using the BRIEF-A) were associated with experimental measures of working memory, such as the Digit Span Backwards task (Garlinghouse, Roth, Isquith, Flashman, & Saykin, 2010).

Extending from the link between working memory and suicidality, Joormann and Gotlib (2008) further explored how working memory associates with inhibitory control and depression. Participants were shown two lists of emotional words, one to remember (the relevant word list) and one to inhibit (the irrelevant word list). Recognition of the relevant words was assessed when participants were presented with the words a second time and for each one they were asked to decide if it had been present on the relevant word list. Difficulties in recognition (longer response times to make a judgement) were attributed to an inability to inhibit irrelevant words, thereby creating more interference in working memory. They found that depressed individuals had greater difficulty inhibiting irrelevant emotional information during a working memory task compared to healthy controls. Depressed participants showed poorer memory performance compared to the controls as they had more difficulties inhibiting information that interfered with the memory task. However, the distraction was only exclusive to the negative irrelevant words as inhibition of positive words did not vary between the two groups. The results support the earlier argument that different aspects of executive functions are at times intertwined in such a way that it is difficult to determine which executive functions is causing an effect (Jollant et al., 2011), therefore it is important to have different sets of cognitive tasks to measure each aspect individually. It is noteworthy that although a cognitive account for the exacerbation of depression and suicide behaviour has been provided, with the few attempts made to integrate these findings with neurological examination, the underlying mechanisms underpinning suicidality remains unknown.

With the evidence of individuals suffering from Traumatic Brain injuries who had damage in the ventral and dorsal prefrontal cortices (Christodoulou et al., 2001; Takahashi et al., 2004) impairments in working memory were apparent. These neuroimaging data also indicate that neurological deficits may be one explanation for the impairment of in executive functions in patients. Moreover, these deficits were also shown to deplete the resources of other brain areas required to accomplish tasks including emotional and cognitive regulation. Subsequently, the working memory deficits also resulted in disrupted ability to regulate their own emotions, which ultimately put individuals in a prolonged negative emotional state.

4.3 Prefrontal involvement in managing executive functions

The study of executive function deficits has been widely examined using different behavioural and neurological measures in recent years (Baddeley, 1992; Imbir & Jarymowicz, 2013; Løvstad et al., 2016). With the current advancement of neuroimaging technologies such as MRI, Positron Emission Tomography (PET), and fMRI, researchers and clinicians have successfully pinpointed how some executive functions are controlled by the PFC and its distributed network. For example, some predictors for suicidality identified in Study 1, namely inhibition, working memory, and attention are predominantly controlled by the PFC (Baddeley, 2003; Desmyter, van Heeringen, & Audenaert, 2011; Goldstein & Naglieri, 2013; Huntley & Howard, 2010; Marzuk et al., 2005). Other executive function components including planning and decision-making are also found to correspond to neural pathways within the PFC (Barkley, 2012).

The PFC has been shown to interact closely with its adjacent brain regions such as the anterior cingulate and the amygdala (Anderson, 2008; Diamond, 2013). Indirect supporting evidence is gleaned from neurological findings using fMRI study (Hoffmann et al., 2014) that examine brain activations in response to brief presentation of emotional and neutral word stimuli to participants. Additionally some recent EEG studies (Hatzidaki, Baus, & Costawere, 2015; Imbir, Jarymowicz, Spustek, Kuś, & Żygierewicz, 2015) indicate that there may be more processing cost and longer response time for naming the colour of emotional words relative to neutral words. In these studies, the ERP measures were taken while participants were listening to positive, negative, and neutral words. The findings showed that emotional words corresponded to more brain activation as they yielded longer latencies and larger amplitudes of the ERP compared to neutral words. This fits well with the prediction by Algom el al. (2004) that there is increased processing cost for emotional stimuli.

Some researchers specified that the dlPFC and the vlPFC in particular are responsible for guiding attention, maintaining information within the mind, shifting cognitive resources between different sources of information, and inhibiting the processing of task-irrelevant information (Compton et al., 2003; Miyake & Friedman, 2012; Ochsner et al., 2012). These cognitive aspects are also thought to be crucial in controlling and reducing suicidal behaviour (Carter & van Veen, 2007) since response inhibition can help individuals resist the urge to act impulsively, whilst interference control can help to inhibit irrelevant and intrusive thoughts of self-harm (Diamond, 2013). Consequently, deficits in the neural interactions within the PFC may impede an individual's ability to deal with emotional disturbances and solve problems, and they may exacerbate other symptoms that are commonly found in suicidal patients (e.g. feelings of hopelessness; Desmyter et al., 2011; Jollant et al., 2011).

Desmyter et al. (2011) reviewed a selection of functional imaging reports in suicidal patients and found that they showed impairments in executive functions and these impairments were associated with prefrontal activity. Using MRI, fMRI, and PET measures, neural deficits of patients were illustrated in the form of reduced volume of grey matter and abnormal metabolism in the PFC. This suggests that suicidal patients differ from healthy individuals with regard to both activity and structure of the PFC. Compared to a control group, the functional neuroimaging measures taken during resting conditions revealed a decreased perfusion (reduced activity) in the PFC of suicidal patients. These deficits were more pronounced during cognitive activation such as during completion of a task that required increased cognitive resources. The findings show the benefits of using brain activation measures as a reliable method for distinguishing suicidal patients from healthy controls. However, whilst significant structural and functional differences were found in this study, similar to other studies, it is uncertain how the findings could be applied to a non-clinical population with relatively lower levels of suicidality.

It is noteworthy that in early empirical studies attention was placed on the neurological basis of patients with affective disorders, in particular, those with clinical depression. There are comparatively fewer studies that have focused on the neural basis of suicide behaviour. Therefore, most of the neurological research surrounding suicide often coincides with the study of depression.

4.3.1 Asymmetric frontal cortical activity and affective disorders

The initial argument that deficits in PFC activity may be related to affective disorders came from observations of patients who had experienced a stroke and were suffering from clinical depression (Gainotti, 1972; see Harmon-Jones et al., 2010 for a review). It was evident that following damage to the left prefrontal regions some patients became increasingly depressed, whilst damage to the right frontal lesions resulted in increasing levels of manic symptoms. Schaffer, Davidson, and Sarson (1983) explored this dissociation by measuring cortical activity in patients who were suffering from depression to varying extents. Their aim was to identify any ‘asymmetry’ of activity to support the claim that different patterns of frontal activation may be related to the severity of the disorder. The terms brain asymmetry is often used to refer to neurological differences between the left and right sides of the brain or lateralization of brain functions (Tomarken, Davidson, Wheeler, and Kinney, 1992). Electroencephalogram (EEG) electrodes were placed in the frontal and parietal regions of the brain and similar to the clinical report of Gainotti (1972), patients indicating more severe symptoms of depression showed greater activity in the right compared to the left. Importantly, this pattern was only found in the frontal regions, not the parietal regions.

These findings led to a rapid expansion of research surrounding lateralized frontal activation and EEG has been a common tool used to measure the correlates of relative hemispheric dominance (Tomarken, et al., 1992; Tucker, 1981). Since then, research spanning 30 years has provided support for the relationship between asymmetric frontal activation and depression (Allen & Kline, 2004; Allen & Reznik, 2015; Thibodeau, Jorgensen, & Kim, 2006; Tomarken, et al., 1992; Tucker, 1981). The majority of findings show that patients with a history of depression, or with recurrent depression exhibit relatively lower left frontal cortical activity (Gotlib, 1998; Ranganath, & Rosenfeld, 1998). This is also known as left frontal hypoactivation and it corresponds to rightward frontal cortical activity (for reviews, see Davidson et al., 2002; Miller & Cohen, 2001; Miller, Crocker, Spielberg, Infantolino, & Heller, 2013). In contrast, healthy controls reveal the opposite pattern, with greater leftward frontal cortical activity (Stewart, Bismark, Towers, Coan, & Allen, 2010; Thibodeau et al., 2006). Saletu et al. (2010) also found that the increased level of rightward brain activity also corresponded to increased level of depression reported, suggesting that brain asymmetry may provide a potential marker for assessing severity of disorders in patients.

Despite the compelling neurological evidence for frontal asymmetry in depressive samples, some findings are mixed and studies have often reported non-significant results (Kemp et al., 2010; Ranganath & Rosenfeld, 1998; Reid, Duke, & Allen, 1998). For example, in some studies the analysis of EEG activity demonstrates that frontal asymmetrical differences in depression are relative rather than absolute (Coan et al. 2006). This means that the frontal cortical activity varies depending on different contexts (e.g. resting[18] state versus active state) and is not solely based on the effects of depression.

Inferred from the studies showing frontal asymmetry in depressed patients who reported having emotional disturbance, it is reasoned that a possible factor that may play a pivotal role in frontal asymmetry is emotion. Support for this came from an early finding of Schaffer et al. (1983) where depressed students showed more rightward cortical activation than a control group. More importantly, although both groups of participants showed a leftward lateralization in the dlPFC in response to positive affect they had different neurological responses to negative affect. The depressed group showed right-lateralized activity and the control group showed left-lateralized activity. This suggests that the type of affect that is being experienced may moderate frontal asymmetry differently in depressed and non-depressed individuals. This has raised questions as to what other factors may account for asymmetric brain activation.

Using an fMRI study Herrington et al. (2010) investigated how emotional processing was associated with asymmetric brain activation in university students. The colour Stroop and emotional Stroop task performance of 11 depressed and 18 healthy control undergraduate students were compared. Both tasks measure attentional aspects that are predominantly controlled by the dlPFC and the anterior cingulate (Anderson, 2008; Diamond, 2013). They found that activity in the dlPFC increased in the colour Stroop task for trials in which the word was incongruent to the colour (i.e. the word red presented in green font). The increased cortical activity was also apparent during the emotional Stroop task for trials in which negative words were presented. This shows that

[18] Resting EEG activity is usually obtained by asking participants to relax and not performing any tasks. There will usually be an equal amount of time having eyes opened and eyes closed during resting state.

inhibiting automatic responses (reading a word) and inhibiting negative information was associated with increased brain activity in the dlPFC, providing a direct link between frontal activity and inhibitory control. Herrington et al. (2010) concluded that frontal asymmetry is likely to occur in depressed populations under negative circumstances and therefore demonstrates specific difficulties in managing the processing of negative information.

Building from the evidence, there were increasing neuroimaging studies that have studied brain lateralization in relation to emotional biases and affective disorders (Ambrosini, & Vallesi, 2016; Auerbach, Stewart, Stanton, Mueller, & Pizzagalli, 2015; Koslov, Mendes, Pajtas, & Pizzagalli, 2011). For instance, using EEG measures, Auerbach et al. (2015) revealed a negative emotional processing bias in depressed female adolescents (n=23) compared with health controls (n=36). A facial recognition task was given where faces of 4 expressions (happy, sad, fearful, and angry) were presented. Participants were asked to identify a particular emotion in each trial as quickly as possible. Consistent with the majority of the literature, results showed that the depressed group had a greater propensity to identify sad than happy facial expressions. This cognitive bias was again characterized by left dlPFC hypoactivity (low activity) in the EEG recordings. They came up with a conclusion consistent with Gotlib et al. (2010), that the neural frontal asymmetry in depressed patients corresponds to the degree of attention put towards sad emotions and reduced recognition of happiness, therefore rightward frontal cortical activation signifies an increased risk for and the persistence of depression.

4.4 Theoretical models and empirical findings of frontal asymmetry

The method of studying frontal asymmetrical activity was initially used to measure "traits" (e.g. depressive traits). However, as will be discussed below, it is now argued to be a measure of emotional processing, emotional state, and motivational tendency (Davidson, 1992, 1998). The theoretical models used to account for frontal asymmetry will be examined.

4.4.1 Dispositional model of frontal asymmetry

According to a critical review of frontal asymmetry by Allen and Kline (2004), Davidson et al. (1979) were among the first to use asymmetric frontal cortical activity to make inferences about asymmetrical brain activity and emotion. They argued that the left hemisphere is dominant for processing positive emotions whereas the right hemisphere is dominant for processing negative emotions. This means that if individuals have greater electrocortical activity in the right frontal region, they will have a disposition towards focusing on negative emotions and information. Supporting evidence for this came from Davidson and Fox (1982) who suggested that patterns of lateralized brain activity can be identified as early as infancy and to test this hypothesis they measured activity of 10-month old infants while they viewed videotapes consisting of happy or sad facial expressions. Activity in frontal and parietal regions was recorded and it was found that viewing happy faces corresponded to increased activation in the left cortical region (relative to the right) whilst viewing sad faces corresponded to increased relative activation in the right. The findings also supported the work of Schaffer et al. (1983) that this differential pattern of activity was only found in the frontal regions, not the parietal regions.

Followed from this, Davidson and Fox (1989) further examined whether temperament might be related to individual differences in asymmetry of frontal cortical activation. Again, EEG recordings were taken from the left and right frontal and parietal scalp regions of 10-month-old infants (n=13) and behaviour was observed during a brief period of maternal separation. It was found that infants who cried in response to maternal separation showed greater rightward frontal activation compared with infants who did not cry. Both studies by Davidson and Fox (1982, 1989) concluded that frontal asymmetry may serve to indicate the emotional reactivity or the emotional state of an individual (collectively known as the affective style). Based on the findings of frontal asymmetry, Davidson et al. (1979, 1984) developed the '*dispositional model'*. The model holds a valence hypothesis that predicts frontal hemispheric asymmetry for different types of emotional processing (Davidson, 1992; Davidson, Ekman, Saron, Senulis, & Frieson, 1990; Tomarken, Davidson, & Henriques, 1990). Specifically, the right hemisphere is responsible for the processing of negative affect while the left hemisphere is responsible for the processing of positive affect. To support this argument, Tomarken et al. (1990) compared the EEG recordings from 32 female participants under varying emotional states. Recordings were taken before and after watching video clips that aimed to elicit amusement and happiness, or fear and disgust. Consistent with the dispositional model, participants induced into negative mood (fear and disgust) showed greater activity in the right prefrontal region, however there was no significant association between positive mood (amusement and happiness) and relative leftward frontal activation. On the basis of this Tomarken et al. (1992) suggested that frontal asymmetric indices not only reflect an individual's emotional state, but they may also be an indication of how an individual might respond to different emotional stimuli (also referred to as affective responsivity).

There are ample findings on asymmetric frontal cortical activation to support the argument that the use of frontal asymmetric index can serve as an indicator of emotional state and response, yet in some instances it has proven difficult to reconcile findings (Kemp et al., 2010; Ranganath & Rosenfeld, 1998; Tomarken et al., 1990). Compared with the stronger evidence regarding depressive traits, there is less evidence to show that frontal asymmetrical activation may be related to suicidality. This has initiated interest to investigate to what extent suicidality may impact frontal asymmetry.

4.4.2 Frontal asymmetry and suicidality

To date, the literature has focused on depression and emotional responsivity and these are well substantiated by the related theoretical models. Building from this, Graae et al. (1996) have attempted to investigate frontal lateralization in relation to suicidality. They recorded EEG from 16 adolescents with a history of suicide attempts and compared this with 22 healthy controls. The EEG recordings were taken during eyes open and eyes closed resting state. Results showed that individuals with a past suicide attempt differed from healthy controls in their levels of frontal brain activity. Specifically, the healthy control group had relatively less activation in the right hemisphere, whereas suicidal adolescents showed a trend in the opposite direction (exhibiting greater rightward frontal activation). Moreover, compared to controls, past suicide attempters also displayed lesser brain activation in the left hemisphere than the right in the posterior regions (temporal and parietal lobes). This shows that brain lateralization between the left and the right hemisphere may help to distinguish between individuals with or without suicide behaviour.

Using event-related fMRI, Jollant et al. (2008) compared the neural activity of previously depressed men with past suicide attempts, previously depressed men with no suicide attempts, and healthy male controls. All participants were shown a series of faces expressing happiness, anger or neutral emotions followed by a short recognition memory test for faces. This test intends to confirm participant's ability to process facial information. Across the three groups of participants, only those with a past history of suicide attempts showed frontal asymmetrical differences in response to emotional faces (angry, happy, and neutral). Specifically, they showed increased neural activation in the right lateral orbitofrontal cortex in response to angry faces relative to neutral faces. Jollant et al. explained that increased sensitivity to another person's disapproval (e.g. in the form of an angry facial expression) and a higher propensity to process and act on negative emotions may exacerbate suicide behaviour. Notably, for the other two groups of participants who had no past history of suicide behaviour, activation in the frontal regions did not differ in relation to emotion. This brain laterality may represent vulnerability markers of suicide behaviour in those with a history of depression. As the study specifically recruited male participants mostly middle-aged, and with a history of major depressive disorder, this has questioned the replicability of the findings to those who may have milder forms of suicidal behaviour but may not be categorized as having a clinical disorder (e.g. a non-clinical student population in the current research). Moreover, the authors also acknowledged that their study did not control factors such as age, education and did not assess the duration of symptom-free periods in patients. These are all potential confounding factors (especially when taking medication at the time of scanning) in neurological studies and will need to be considered for the investigations of this thesis.

There is additional empirical evidence from neuroimaging studies that pinpoint specific deficits in executive functions may be related to frontal brain activity and degrees of suicidality. To investigate the links between inhibitory control deficits and suicidality, Pan et al. (2011) measured response inhibition using the Go/No-go task in adolescents with various degrees of suicidality. The sample included 15 depressed adolescents with a history of suicide attempts, 15 depressed adolescents with no history of suicidality, and 14 healthy controls. The Go/No-go task requires participants to press a button in response to a target stimulus (Go), but to inhibit the button press and do nothing in response to a non-target stimulus (No-go). Go trials (when a target is presented) usually make up 75% of trials within a Go/No-go task to create a prepotent response that must then be inhibited on the less frequent No-Go trials (Garavan, Ross, Murphy, Roche, & Stein, 2002). The number of errors on no-go trials across the whole task for happy and sad faces served as the measures of behavioural inhibition and emotional modulation of this inhibition, respectively. There was no significant difference in task performance (both accuracy and response times) between the three groups of participants. However, in the healthy controls fMRI recordings showed increased activation of the prefrontal, anterior cingulate, and parietal cortical regions. The anterior cingulate in particular is considered crucial for inhibitory control (Løvstad et al., 2016) and whilst the depressed individuals with no past history of suicidality did not differ from the controls with regard to activity in this area, the depressed adolescents with a history of suicide attempts showed significantly reduced activity. This indicates impairments in neural activation during inhibitory control for suicidal individuals and also shows the relationship between cognitive processing and cortical activity. The findings suggest that this association may constitute a neurobiological basis for predisposition to suicide behaviour. It is proposed that suicidality corresponds to lateralized frontal cortical activity and therefore neurological measures may be used to predict suicidality of individuals beyond the currently used self-report measures.

4.5 Study 3: Exploring the neurological markers and testing the cognitive markers as potential indicators for characterizing suicide behaviour

The previous findings of this thesis have successfully pinpointed suicidality to be related to depression and difficulties in attentional control and working memory, and they will be the main focus of investigation in the present study. With the use of cognitive tasks to measure these aspects objectively, this will help to determine whether high and low suicide risk individuals differ in these cognitive performances in general, or whether the difference is more apparent under emotional interference (positive, negative, or neutral).

An additional line of investigation in this study is the neurological basis of suicidality. As stated in the previous chapter, due to the limited evidence for the neural correlates of suicidal behaviour, Study 3 will aim to explore the neurobiological basis of different degrees of suicidality using electrophysiological tools. Based on prior findings that have established the link between cognitive deficits and suicidality (Johnston et al., 2017; Jollant et al., 2011; Wagner et al., 2012; Willeumier et al., 2011), it is postulated that differences in cortical activity is related to suicidality and this could serve as a potential marker for characterizing suicide risk.

4.5.1 The use of Electroencephalogram to measure lateralized activity in this study

The research discussed thus far shows that EEG is a popular method for measuring asymmetry. Among the range of neuroimaging tools to measure frontal brain activity, Electroencephalogram (EEG) is one of the least invasive and easily employed tools (Babiloni et al., 2015; Başar, Başar-Eroğlu, Güntekin, & Yener., 2013; Coan & Allen, 2004). It is also considered to be relatively inexpensive and widely available compared to other neuroimaging methods for recording electrocortical activity (e.g., fMRI). In addition, EEG has a long history of measuring rhythmic neural activity in the brain (also referred to as oscillatory states). It can provide high temporal resolution in milliseconds and has been used to measure the effects of health, affective traits, and arousal states on neural activity (Davidson et al., 2004; Urry et al., 2004).

Electroencephalogram involves the use of electrodes to measure electrical potential (i.e. cortical activity) on the surface of the scalp. The measures collected, which vary across a range of frequencies from 1-30Hz, are decomposed into distinct frequency bands through a process called Fourier analysis. This helps to decompose the raw EEG data into various frequency bands such as delta (0-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-20 Hz), and low gamma (30-60 Hz). The power spectral analysis is one of the common methods used to quantify the distribution of each frequency band of an analyzed EEG signal. Changes in the power spectrum give important information about the changes in the constituents of each frequency band, and it thereby reflects a change in cognitive state (Allen et al., 2004; Davidson, 1998). For example, a high frequency band of beta waves reflects an individual is feeling diligent and alert. Conversely, the alpha measure is also argued to be an effective way to examine asymmetric frontal cortical activity (Coan & Allen, 2004). For instance, alpha (α) frequency bands reflect a relaxed state of wakefulness. An increase in the alpha frequency band reflects a resting state with relatively low levels of cortical activity (Allen et al., 2004). However, when the cortex is active such as when an individual is engaged in a cognitive task, the alpha rhythm is suppressed and the alpha frequency band detected is significantly reduced (Davidson et al., 2000).

Due to individual differences in the thickness of the scalp, there are differences in the degree of cortical activity detected between different people making the study of individual differences in brain lateralization difficult. The asymmetric index (uV^2) avoids this issue because it allows the comparison of relative activity in the left and the right cortical regions (Davidson et al., 2000). Alpha asymmetry is calculated by subtracting overall activity in the alpha frequency band at left electrodes from alpha activity at right electrodes. With this measure any unwanted individual variance such as skull thickness or scalp-related impedence can be removed (Coan & Allen, 2004). Given the inverse relationship between alpha power and cortical activity (Oakes et al., 2005), positive alpha asymmetry scores are interpreted as left-frontal activity relative to right, while negative scores are interpreted as right-frontal activity.

More recently, there are increasing studies of lateralized brain activity using EEG Emotiv, a relatively low-cost EEG device that is more easily accessible than the traditional EEG or MRI. Turner, Burnet, and Turner (2017) complement the benefits of using this commercial low-cost EEG device as it is highly portable, it can allow collection in many places outside of the laboratory such as schools, child-care centers, hospitals, and private clinical practices. This provides meaningful application for a wide variety of research purposes that are not achievable with conventional tools such as fMRI and traditional EEG. Turner et al. (2017) also commented that the frontal cortical asymmetry can be reliably collected using low-cost EEG hardware. With a series of experiments comparing EEG Emotiv with other consumer EEG systems such as the OpenBCI[19], and the Brain Rhythm Inc[20], they contended that the EEG Emotiv is best used for robust measurements such as alpha or other spectral comparisons, or for the study of slow changes over longer EEG time-course recordings.

4.5.2 Aims and intention of Study 3

Extended from the initial investigation of executive functions in Study 1, the current study aims to investigate the executive functions that predict suicide behaviour, namely attention, inhibition, and working memory, together with the neurological correlates of suicidality. It was predicted that high and low suicidality group would differ in these executive functions. Three cognitive tasks were used to measure inhibition, attention, and working memory namely, the emotional Stroop task, Go/No-Go task, and N-back task (which consisted of a 0-back and a 2-back) respectively. In the N-back task, which

[19] The OpenBCI consists of a standard 32 channel electrode cap, it can record simultaneously from up to 16 electrodes. The acquisition system for the EEG headset is based on a Texas Instruments ADC, which has sampling frequency from 250 Hz to 16 kHz, but most configurations of the OpenBCI equipment work at 250 Hz. This is twice the speed of the EEG Emotiv used in the current study.

[20] Compared to the EEG Emotiv, the Brain Rhythm Inc is a relatively new company supporting EEG, offering 8 and 32 channel wireless EEG systems. Similar to the OpenBCI, the system can use spring-loaded dry electrodes or an innovative foam-block type dry electrode. Their 32-channel system (the BR32S) uses an electrode cap similar to traditional research EEG systems.

measures working memory, participants are presented with stimuli one after the other and for each one they have to identify whether it matches the stimulus ‘N’ positions back. The task requires information to be held in working memory and this information needs to be continually updated as new stimuli are presented. The working memory load can be manipulated through the task. For instance, in a 1-back task participants have to match each stimulus to the one presented previously and in a 3-back they have to match each stimulus to the one presented three positions back.

For measures of executive functions, there was a self-report measure of executive functions (BRIEF-A) and behavioural measures of inhibition (Go/No-go task), attentional control (emotional Stroop task) and working memory (N-back task). As high levels of suicide will relate to poor executive functions, it is predicted that participants with high levels of suicidality is associated with poorer performance in all cognitive task performance (lower accuracy and longer response times). It was predicted that participants in the high suicidality group would report greater perceived difficulties in executive functions (as reflected by increased scoring on BRIEF-A).

Whilst most of the past EEG findings focused on clinical populations with patients diagnosed with depression, the scarcity of studies using a non-clinical sample (e.g. Herrington et al., 2010) has drawn interest to see if the frontal asymmetrical studies on non-clinical population could replicate works in clinical populations (Allen et al., 1993; Urry et al., 2004). The literature has provided evidence for the association between frontal asymmetry and depression and the current study will explore whether frontal asymmetry can also link to suicide. To achieve this the frontal asymmetry of individuals with high and low levels of suicidality will be examined using EEG during resting and task performing state. It is predicted those with a high suicide risk will display higher rightward frontal activation (reflected by negative asymmetric index) and those with a low suicide risk will show leftward frontal activation (reflected by positive asymmetric index).

4.5.3 METHOD

4.5.3.1 Design

The study used a mixed measures design to investigate the effects of suicide behaviour on executive functions and frontal activity. Suicide behaviour was a between-participants variable with two conditions, high and low levels of suicidality. Executive functions were measured using the BRIEF-A (incorporating a Behavioural Regulation Index and a Metacognitive Index) and three cognitive tasks. These tasks measured inhibition, attentional control, and working memory, with accuracy (%) or/and response times (ms) recorded for each. The emotion of stimuli presented in each task was a within-participants independent variable, with positive, negative, and neutral conditions for the emotional Stroop and N-back and positive and negative conditions for the Go/No-Go task.

A measure of depression was also taken using the Beck Depression inventory (BDI-II; Beck, Steer, & Brown, 1996) that distinguishes participants as having high or low levels of clinical depression. The asymmetric frontal cortical activation was indexed by the alpha asymmetry index. Frontal asymmetry was recorded during resting state and during the emotional Stroop tasks. In the emotional Stroop task asymmetry was compared between these two the high and low suicidality groups. A positive alpha asymmetry index reflects higher left frontal alpha power and relatively lower right frontocortical activity. A negative asymmetry index reflects higher right frontal alpha power and represents relatively lower left frontocortical activity.

4.5.3.2 Participants

Forty Psychology students (16 males, 24 females) studying at The Open University in HK were recruited using convenience sampling. Age ranged from 18 to 28 years, with a mean of 22.03 years (SD = 2.06). Prospective participants were pre-screened for previous history of neurological and mental health problems known to affect neurological performance (e.g., currently taking medication known to affect cognitive performance, cognitive deficits, and diagnosis of PTSD).

4.5.3.3 Stimuli and Materials

4.5.3.3.1 Questionnaires

A total of 3 questionnaires were used for this study. As in previous studies, suicide behaviour was measured using the SBQ-R (Osman et al., 2001), executive functions were measured using the BRIEF-A (Malloy & Grace, 2005), and depression was measured using the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996).

4.5.3.3.2 Cognitive tasks

The experiment consisted of three tasks, an emotional Stroop task, a Go/No-Go task, and a N-back task (including a 0-back and a 2-back task). All were compiled and run using E-Prime software (Psychology Software Tools, Inc., Pittsburgh, PA; Schneider, Eschman,

& Zuccolotto, 2002). Each task was presented on a 16″ CRT monitor with a refresh rate of 75 Hz).

The emotional Stroop task was modified from Herrington et al. (2010) and consisted of 189 emotional words in English (see Table 4.1 for details of the ratings for valence and arousal), with 9 words for the practice trials and 60 words for each emotion (see Appendix 5.1 for the full list). These words were selected from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999); positive (e.g. *friend*, *good*), negative (e.g., *prison, burn*), and neutral (e.g., *bottle, elbow*). All words were presented in Times New Roman font, size 36, and were displayed in one of four colours (red, yellow, blue, and green).

Table 4.1 **presents the means (M) and standard deviation (SD) for the scores for suicide, depression, and the BRIEF-A**

	Words					
	Positive		Neutral		Negative	
Ratings	Mean	Range	Mean	Range	Mean	Range
Valence	7.68	7.06-8.72	5.44	5.03-6.36	2.52	1.24-3.08
Arousal	5.39	4.96-6.97	3.22	1.66-4.36	5.14	4.06-7.55

The stimuli used for Go/No-go task and N-back tasks were faces (see Figue 4.1) selected from the NimStim Face Set (Tottenham et al., 2009). All facial images used in the cognitive tasks were matched on dimensions of colour hue, saturation, contrast, and size (96 × 72mm). Faces are commonly used as emotional sti, partial $\eta^2 = 0.215$muli for these two tasks because they are emotionally salient and socially significant. Moreover, the interference effects linked to emotional faces are likely to reflect emotional distractibility and capture of attention when compared with neutral faces.

Figure 4.1. Examples of facial stimuli used for the Go/No-Go task and the N-back task

The Go/No-go task was modified from Garavan et al. (2002). The face stimuli consisted of images of 24 individuals (12 male and 12 female African American and Caucasian faces) each showing three emotions (happy, sad, and neutral). These were presented in one of four colours (red, yellow, blue, and green). To achieve this a colour filter was applied to each face using the GNU Image Manipulation Program for Windows systems (GIMP, 2.6) and images were cropped so that the facial stimuli were free from hair or other external attributes that could serve as distracters or distinguishers.

The N-back task consisted of 2 parts, a 0-back task and a 2-back task (see Appendix 5.2). Both N-back tasks were adopted from the ones used by Levens and Gotlib (2010).

4.5.3.4 EEG equipment

EEG activity was recorded using an Emotive EEG Neuroheadset (Emotiv Technology Inc., USA) that records from 14 sites (AF3, AF4; F3, F4; FC5, FC6; F7, F8; T7, T8; P7, P8, O1, O2) and 2 references sites (CMS, DRI) using a 16-channel Biosemi Active Two system. All sites were referenced to the average during recording, and re-referenced off-line to derive an averaged (CMS/DRL) reference, which was used as the reference of choice for all analyses. Frontal electrodes were F3, F4, F7, F8, AF3, and AF4. Central electrodes were FC5, FC6, T7, and T8. Parietal electrodes were P7 and P8 and occipital electrodes were O1 and O2. The numbers also indicated on which part of the right/left side of the scalp an electrode was located, where even numbers represent the right and odd numbers refer to the left. The data were sent to a notebook computer via Bluetooth and a USB dongle was utilized to communicate using the 2.4 GHz band (see Appendix 5.3). Prior to use, all felt pads on top of the sensors were moistened with a saline solution. A bandpass filter of 2-45Hz and a notch filter of 50Hz were applied to the raw data with 128Hz sampling frequency per channel. A Hamming window (1024 sample and 50% overlap) was also applied to the data in preparation for spectral analysis, from which the power and asymmetry estimates were derived. A frontal asymmetry index (uV2) was calculated for each condition. The validity of the EEG neuroheadset measures has been confirmed by numerous researchers (Badcock et al., 2013; Debener, Minow, Emkes, Gandras, & de Vos, 2012).

4.5.3.5 Procedure

All participants were given an information sheet and consent form together with the questionnaires. They were asked to read the instructions and then complete the questionnaires, which took approximately 30 minutes. Scalp sites were then located according to the 10/20 system (Malmivuo & Plonsey, 1995). The impedence at each electrode site was checked carefully to ensure good contact quality (large signal to noise ratio). After checking, participants were instructed to remain seated in a relaxed state in a dimly lit room, EEG recordings were taken with the eyes closed for 2 minutes and the eyes open for another 2 minutes to provide a baseline measure. Participants were then asked to complete the three computerized tasks. Instructions were given verbally and displayed on the computer screen.

In the emotional Stroop task each trial consisted of a fixation cross for 500ms, followed by a word presented in red, blue, yellow, or green font. Participants were asked to respond to the colour of the word by pressing the corresponding key on the keyboard (R, B, Y, or G). The word remained on the screen until a response was made, or for a maximum of 1500ms. Participants completed three blocks consisting of positive, negative, and neutral words. Block order was randomized. In each block there were 60 trials with 15 words presented in each colour in each block.

The Go/No-go task consisted of four blocks of 64 trials in addition to 12 practice trials that were not scored. Each block had 48 go trials (75%) and 16 no-go trials (25%), making a total of 192 go trials and 64 no-go trials. Participants were presented with either a Go stimulus or a No-go stimulus for 500ms and were instructed to respond as rapidly as possible by pressing the ‘2’ button on the keyboard for a go stimulus, while not pressing anything for no-go stimulus. Instructions were displayed on the computer screen at the beginning of each block. In each trial a face was presented in the centre of the screen followed by an ISI of between 1250ms and 1750ms to discourage anticipatory responses (this was pseudorandomized and the mean across each block was 1500ms). Happy and sad facial expressions were alternated as go and no-go cues across the four blocks in the same order for all participants (happy-sad-sad-happy). This arrangement adds a set-shifting component to two of the blocks (one block each with happy and sad go cues), therefore participants must stop responding to stimuli that were targets in the previous block and begin responding to stimuli that were previously non-targets. There were equal numbers of happy and sad faces for both go and no-go cues.

In the 0-back task, participants were first presented with an “expression label” (happy, sad, or neutral) together with a face displaying that expression. The trials then began and participants were presented with a series of emotional faces, each followed by an ISI of 2500ms. Participants were asked to press ‘s’ on the keyboard if the facial expression was the same as the expression label and ‘d’ if the facial expression was different. Each face was presented for 2000ms or until participants had responded. Three blocks were completed using this procedure and the expression label differed in each block (happy, sad, or neutral). The order of blocks was randomized and the trials within each block were presented in a random order.

In the 2-back task which consisted of presenting participants with faces, they had to decide whether the emotional expression was the same as the face presented two positions earlier. They were asked to press ‘s’ if it was the same and ‘d’ if it was different. For the first two faces in each block participants were advised to press ‘d’ and if they lost their place during a block they should respond ‘d’ to two faces in a row and start again. Similar to the 0-back task, each face was presented for 2000ms or until participants had responded and each face was followed by an ISI of 2500ms. For all the tasks feedback was provided for the practice trials but not for the experimental trials.

The N-back task consisted of 96 trials separated into 3 blocks of 32 trials, in addition to 12 practice trials that were not scored. Both N-back tasks used the same faces selected for the Go/No-go task. The 2-back task was separated into 6 blocks of 62 trials (124 happy faces, 124 neutral faces, and 124 sad faces). There was an additional of 16 practice trials that were not scored.

4.5.3.6 EEG data processing

All artifact screening, re-referencing, and spectral analysis was performed using EEGLAB toolbox (Delorme & Makeig, 2004) and custom scripts in Matlab (release 2007b, The Mathworks Inc., Natick, MA). Each data file was visually inspected to manually remove artifacts such as aberrant signals due to large non-blink eye movements, muscle movements, or signal discontinuities. Then further EEG artifacts were removed by an independent component analysis (ICA; Delorme & Makeig, 2004) during offline signal processing.

Frontal alpha asymmetry was calculated in 1-Hz frequency bins and averaged across the frequency bandwidths of interest: delta (1.5-3.5Hz), theta (4-7.5Hz), alpha (8-13Hz), alpha1 (8-10Hz) alpha2 (10-13Hz), beta1 (13-20Hz) and beta2 (20-28Hz). Frontal alpha asymmetry was calculated for F3 (left frontal) and F4 (right frontal) electrodes using the Fast Fourier Transform (FFT) method. The alpha power values for F3 and F4 were natural log transformed (Delorme & Makeig, 2004) such that an asymmetry score comparing right hemisphere (RH) to left hemisphere (LH) was computed: ln ALPHA=(ln[RH] - ln[LH]). Analyses were conducted on the frontal pair (F3, F4).

Frontal asymmetry indices were calculated by subtracting the natural log of the power of the left hemisphere electrode from that of the right hemisphere electrode (ln [right (F4)] − [left (F3)]) (Allen et al., 2004).

4.5.4 RESULTS

Three participants were excluded from the original sample of forty participants due to poor EEG data or missing behavioural data. The remaining 37 participants (15 males and 22 females) were categorized into two groups based on scores in the SBQ-R. Participants with a score less than 7 were categorized as low suicidality (Median = 3.00, range = 1-5), whilst participants with a score of 7 or above were categorized as high suicidality (Median = 8.00, range = 7-13). There was a total of 16 participants in the high suicidality group and 21 in the low suicidality group, out of which no participants reported having past history of suicide attempt. Medians and the ranges for the scores for suicide, depression, and the BRIEF-A in participants with high and low levels of suicidality are shown in Table 4.2.

4.5.4.1 Difference in suicidality, depression, and executive function measures between high and low suicidality groups

To investigate emotional and behavioural differences between groups of high and low suicide risk, Mann Whitney U tests were used as the data did not conform to parametric assumptions. Suicide risk was the between participant variable, the dependent variables were self-reported measures of depression, suicide behaviour, perceived difficulties of executive functions (indexed by scores on the BRIEF-A). All the raw scores on BRIEF-A were transformed into an age-corrected T-score relative to the published normative data. As predicted, the group with high suicide reported higher levels of depression, *U* = 87.00, z = -2.488, *p* <.05, than the group with low suicide. However, there was no significant difference between suicide risk groups for all measures of the BRIEF-A: GEC, *U* = 153.00, z = -.460, *p* = .645, BRI, *U* = 155.00, z = -.400, *p* = .689, and MI, *U* = 161.00, z = -.215, *p* >.05 (Appendix 6.3.1).

Table 4.2 **presents the means (M) and standard deviation (SD) for the scores for suicide, depression, and the BRIEF-A**

	High suicide risk		**Low suicide risk**	
	(n=16)		**(n=21)**	
	Median	*Range*	*Median*	*Range*
Suicidality	8.00	7-13	3.00	3-5
Depression	16.00	6-38	9.00	0-27
GEC	108	90-144	108	82-140
Initiate	56.00	40-69	56.00	37-82
Working memory	54.50	46-79	56.00	39-93
Plan/organize	55.50	41-78	52.00	41-81
Organization of material	50.00	36-75	53.00	36-75
Self-monitor	59.00	37-67	50.00	37-63
Task monitor	54.00	45-81	54.00	36-90
Inhibit	53.00	46-74	53.00	36-77
Shift	62.00	47-81	60.00	43-86
Emotional control	59.50	38-80	54.00	26-80

4.5.4.2 Cognitive task performance

To investigate differences in cognitive task performance in relation to suicidality, the level of suicidality (high and low) was the between participant variable and task performance (accuracy and response time) was the dependent variable.

4.5.4.2.1 Emotional Stroop task performance

For the response time calculation, all incorrect trials were removed in addition to any trials for which response times were more than 2.5 standard deviations from the mean were classed as outliers and removed. This accounted for 3.59% of the trials in total. Response times from the emotional Stroop task were analyzed using a 2 (suicidality) x 3 (emotion) mixed measures ANOVA. Means and standard deviations are summarized in Table 4.3.

Table 4.3. **Performance in the emotional Stroop task. This table shows response times (ms) in relation to emotion of the stimuli presented**

Task performance	High		Low		Total	
Response times (ms)	(n=16)		(n=21)		(N=37)	
Emotion	M	SD	M	SD	M	SD
Happy	544.39	77.94	555.89	96.19	550.91	87.77
Neutral	551.97	82.56	559.43	97.52	556.21	90.21
Sad	557.01	80.95	545.91	85.13	550.71	82.38
Overall	551.12	75.96	553.75	89.00	552.61	82.50

For response time, there was no significant effect of suicide, F (1, 35) = .009, MSE = 6999.312, p = .925, no effect of emotion F (2, 70) = .279, MSE = 1098.493, p = .757, and no interaction between emotion and suicidality, F (2, 70) = 1.20, MSE = 1098.493, p = .307 (Appendix 6.3.2).

4.5.4.2.2 Go/No-go task performance

For the response time (the average of the go and no-go trials) calculation in the Go/No-Go task, all incorrect trials were removed and any responses that were more than 2.5 standard deviations from the mean were classed as outliers and removed. This accounted for 3.69% of the trials in total. Means and standard deviations for accuracy and RT in the Go/No-Go task are summarized in Table 4.4 and 4.5.

A 2 (suicide risk) x 2 (go or no-go) x 2 (emotion) mixed measures ANOVA showed a significant difference in accuracy (Appendix 6.3.3). The means indicated that accuracy for responding to Go trials was significantly higher than No-go trials, $F(1, 35) = 57.01$, $MSE = 108.212$, $p < .001$. There was no significant effect of suicide, $F(1, 35) = 0.03$, $MSE = 144.667$, $p = .864$, no effect of emotion, $F(1, 35) = 2.00$, $MSE = 32.068$, $p = .166$, and no interaction between emotion and suicide $F(1, 35) = .08$, $MSE = 32.068$, $p = .780$.

Table 4.4. **Accuracy (%) in Go-No-Go task in relation to emotion of the stimuli presented**

	Suicide risk					
	High (N=16)		Low (N=21)		Total (N=37)	
	M	SD	M	SD	M	SD
Accuracy (%)						
Happy go	95.77	6.08	96.23	2.9	96.03	4.49
Happy No-go	82.62	11.86	81.99	11.04	82.27	11.24
Sad Go	96.62	5.14	96.73	2.91	96.68	3.97
Sad No-go	84.96	11.54	83.63	11.94	84.21	11.62
Overall	89.99	10.96	89.65	10.74	89.80	10.80

A 2 (suicide risk) x 2 (emotion) mixed measures ANOVA for Go response times yielded no significant effect of suicide *F* (1, 35) = 0.32, *MSE* = 2689.942, *p* = .574, no significant effect of emotion *F* (1, 35) = 2.513, *MSE* = 313.891, *p* = .122, and no significant interaction between suicide and emotion *F* (1, 35) = .40, *MSE* = 313.891, *p* = .530 (Appendix 6.3.4).

Table 4.5 **Response times (ms) for the Go trials in relation to emotion of the stimuli presented**

	Suicide risk					
	High (N=16)		Low (N=21)		Total (N=37)	
	M	SD	M	SD	M	SD
RT (ms)						
Happy	352.49	37.24	356.75	34.95	354.91	35.51
Sad	356.44	42.30	365.98	40.66	361.86	41.07
Overall	354.46	39.25	361.37	37.73	358.38	38.29

4.5.4.2.3 N-back task performance

Percentage accuracy for the 0-back task (see Table 4.6) was analyzed using 2 (suicide risk) x 3 (emotion) mixed measures ANOVA followed by planned contrasts to compare accuracy in the positive and negative conditions to that in the neutral condition. Where assumptions of sphericity were violated, Greenhouse-Geisser corrections are reported. There was no significant effect of suicide, *F* (1, 33) = 1.88, *MSE* = 36.547, *p* > .05, but a significant effect of emotion *F* (1.55, 51.15) = 5.215, *MSE* = 88.041, *p* < .05. The planned contrasts showed that accuracy was significantly higher for positive faces compared to neutral faces, *F* (1, 33) = 5.215, *MSE* = 141.066, *p* < .05, but there was no difference in accuracy to sad faces and neutral faces *F* (1, 33) = 0.326, *MSE* = 191.707, *p* = 0.572. There was no significant interaction between suicide and emotion, *F* (1.55, 51.15) = 2.458, *MSE* = 88.041, *p* = .108 (Appendix 6.3.5).

Table 4.6. **Accuracy (%) in the 0-back task in relation to emotion of the stimuli presented**

	Suicide risk					
	High		**Low**		**Total**	
0-back	Accuracy (%)	SD	Accuracy (%)	SD	Accuracy (%)	SD
Happy	98.75	1.58	95.98	4.75	97.13	3.92
Neutral	91.67	8.07	85.72	12.29	88.26	10.86
Sad	86.25	8.25	88.84	7.56	87.76	7.85
Overall	92.29	8.21	90.18	9.65	91.08	9.09

Note. Response times are presented in milliseconds. Accuracy is presented as percentage correct.

From the initial sample of 37 participants, 20 of them withdrew after the 0-back tasks and they did not want to further participate in the 2-back task. Therefore, there were only 17 participants who completed the 2-back task (9 in the high suicide risk group and 8 in the low suicide risk group). Percentage accuracy is reported in Table 4.7 (Appendix 6.3.6). A 2 (suicide risk) x 3 (emotion) mixed measures ANOVA conducted on 2-back task accuracy yielded no effect of suicidality, *F* (1, 15) = 1.01, *MSE* = 22.068, *p* = .332, no effect of emotion, *F* (2, 30) = 2.17, *MSE* = 38.864, *p* = .132, and no significant interaction between emotion and suicide risk, *F* (2, 30) = 0.28, *MSE* = 38.864, *p* = .758.

Table 4.7 **Accuracy (%) in the 2-back task in relation to emotion of the stimuli presented**

	Suicide risk					
	High		**Low**		**Total**	
2-back	Accuracy (%)	SD	Accuracy (%)	SD	Accuracy (%)	SD
Happy	57.17	7.05	53.73	4.02	55.56	5.92
Neutral	52.78	6.63	52.32	10.20	52.56	8.22
Sad	58.42	5.30	55.45	7.01	57.02	6.16
Overall	55.27	6.56	54.80	7.12	55.05	5.88

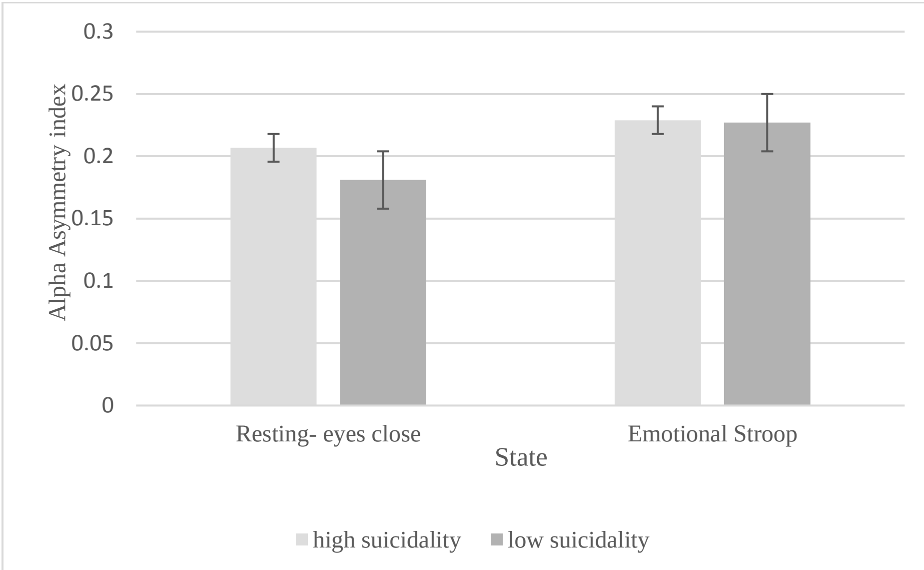
Note. Response times are presented in milliseconds. Accuracy is presented as percentage correct.

4.5.4.3 Frontal Asymmetry

Using the log transformed EEG power in the alpha bandwidth from frontal (F3, F4) recording sites, the alpha asymmetrical index was calculated and used as the dependent variable. Two independent t-tests were conducted to examine the impact of suicidality on frontal alpha asymmetry during resting state and during the emotional Stroop task. Suicide risk (high and low) was the between participant variable. According to the Figure 4.2, all participants generally showed positive asymmetric values (uV^2) at resting and in the emotional Stroop task regardless of the suicidality group.

There was no significant difference in alpha asymmetrical index between high and low suicide risk group measured during the resting state t (35) = 0.21, $p > .05$ and during the emotional Stroop task, t (35) = 0.018, $p > .05$ (Appendix 6.3.7).

Figure 4.2. Comparison of frontal alpha asymmetry between in high and low suicidality groups



Note: Error bars showing standard error

4.5.5 DISCUSSION

Building upon the correlational findings from Study 1 which established a relationship between perceived difficulty in executive functions and increased suicidality, the current study further examined critical executive functions experimentally using cognitive tasks. The study also explored the neurological basis of suicide behaviour by comparing asymmetric frontal cortical activity among participants with high and low levels of suicidality. As the dispositional model (Henriques & Davidson, 1990) has established the use of the frontal asymmetry index as one useful indicator for revealing psychopathological traits such as depression (Henriques & Davidson, 1990, 1991), the study sought to extend from this to see if frontal asymmetry could similarly be used as a valid indicator for characterizing suicide risk. For example, it is predicted that high levels of suicidality may corresponds with rightwards frontal asymmetry.

4.5.5.1 Suicidality and executive function

The measures of executive functions were indexed by self-report measure and performance in three cognitive tasks. The findings did not show any significant differences in self-report measures of executive functions between groups of high and low levels of suicidality. The results contradict the findings in Study 1 where the high suicidality group reported significantly more difficulty with each aspect of executive functions (as indexed by higher scoring on BRIEF-A). The disparity of findings may be attributed to the suicide severity of the participant sample in this study. The median score on the SBQ-R for the high suicidality group was 8.00, and none of the participants in this group reported any history of suicide attempts. This is a relatively mild level of suicidality compared to that in Study 1 where the median score for the high-risk group was of 10.00 and with 10 participants (7.1%) reporting suicide attempts. Consistent with the past findings (Keilp et al., 2001; 2008), this implies that differences in executive functions will only be apparent for individuals with high levels of suicide risk.

In support of the results from the self-report measures of executive functions, the comparison of performance within the cognitive tasks indicates that there was no significant difference in measures of attention (emotional Stroop task), inhibition (Go/No-Go task), and working memory (N-back task) between the high and low suicide risk groups. Similar to the present findings, there has been a number of studies examining cognitive impairments in patients with suicidal behaviours that have also yielded non-significant results (Becker, Strohbach & Rinck, 1999; Cha et al., 2010; Keilp et al., 2001, 2008; Marzuk et al., 2005). Keilp et al. (2001) used a neuropsychological battery to assess patients with prior suicide attempts on general intellectual functioning, motor functioning, attention, and memory. Although deficits of working memory were noted in patients with a history of suicide attempts compared to a healthy control group (Keilp et al., 2001), only prior attempters with high lethality performed significantly worse on all executive functioning measures compared to low lethality attempters, depressed non-attempters, and a control group. No differences were found between the other three groups. Moreover, Keilp et al. (2012) recruited participants with a milder form of suicidality and found no severe impairment of executive functions. These studies highlight the fact that suicide severity has a significant impact on executive function deficits. Added to the prior findings, the present results suggest that deficits in executive functioning abilities (as indexed by task performance across all three cognitive tasks) are not found in participants with low levels (i.e. those who contemplate suicide ideation without action). However, based on this and the prior findings on executive functions and suicidality, it is reasoned that executive function difficulties will only be more apparent as suicide severity increases. This suggests that general models of suicidal behaviour (e.g. the Escape theory; Baumeister, 1990) which postulate how disinhibition and poor working memory may not be applicable to all types of suicidal behaviour.

On the basis of the findings from Study 1 that perceived difficulty in emotional control was associated with suicidality, the present study assessed the impact of emotion interference on cognitive performance using emotional stimuli. It was predicted that the high suicidality group would be distracted by emotional information to a greater extent because they would have deficits in their emotional control and in their ability to inhibit irrelevant emotional information (specifically negative information). However, the results of the emotional Stroop task and the Go/No-go task showed no significant difference in emotional interference between the high and low suicidality groups. There was no evidence that the high suicide risk group suffered emotional interference to a greater extent, and the interference did not vary according to the emotionality of stimuli used. Despite evidence for an emotional Stroop effect the literature, a meta-analysis by Epp et al. (2012) found several inconsistent findings in clinical populations. Several factors seemed to influence the effect including the words used in the task, specifically the valence, arousal, and frequency of these words. Arousal refers to how calm or excited an individual is feeling, and valence refers to how positive or negative the individual is feeling (Bradley, & Lang, 1999).

Regarding the selection of word list used for the current study, it is noteworthy that Herrington et al. (2010) also used the ANEW database and the valence ratings of their selected words (mean of 7.83 and 2.47 for positive and negative respectively) were similar to the current study (mean of 7.68 and 2.2 for positive and negative respectively). This suggests that the words used in the present study were carefully selected but have yielded divergent findings. Notably, the emotional Stroop task used in the current study was adopted from Herrington et al. (2010) who also investigated frontal asymmetry in relation to emotional stimuli in university students. With similar emotionality of word stimuli but yielding divergent results, it is suggested that because participants in this study were from HK and it is possible the language of presentation may affect task performance compared to participants in the study of Herrington et al (2010) who were all undergraduates from United States. This suggestion is based on the comparison of emotional Stroop task performance between Herrington and the current study. In the present study, the overall response time was relatively faster for all conditions (approximately 500ms) compared to that of Herrington's (approximately 650ms). This reflects that they might have been less likely to process the emotional words and the words were less interfering to them for the colour naming task. As the current study did not control the word stimuli for valence and frequency, the assumption remains speculative. For preceeding studies in this thesis, it is necessary to control for these factors, or make use of other stimuli that may not be influenced by these variables (e.g. faces or images that is non-word form).

Regarding the comparison of attentional control between individuals with different severity of emotional disturbance, many clinical studies involving patients who have suffered traumatic experiences show that emotional Stroop effect is larger (shown by slower response times) for words that are related to the exact traumatic experience the patients suffered from. For instance, a larger emotional Stroop effect is found for words such as *sad, down, hopeless* in depressed patients (Epp et al., 2012; Gotlib et al., 1996). It is reasoned that these words are more distracting because they have greater self-relevance thereby depressed individuals will be more attentive to them. This highlights the importance of word selection in that the words must be specific to the affective disorder. This leads to the suggestion that a Stroop interference effect would be apparent if suicide-related words were used in the present study rather than just general negative words as suicidal individuals are likely to have more attentional bias to them. However, as the current study did not include words specific to suicide this assumption could not be tested. One supporting evidence for this suggestion is provided by Cha, Najmi, Park, Finn, and Nock (2010a) who compared 68 patients with a history of attempted suicide with 56 non-attempters. An emotional Stroop task was used with positive, negative, neutral, and suicide-related words. Similar to the current findings, the results showed no effect of emotion as there was no group difference in response times to the different emotions of word stimuli. However, patients with a past history of suicide attempts displayed an attentional bias towards suicide-related words (indexed by slower response times) relative to neutral words. Following from this, Richard-Devantoy, Ding, Turecki, and Jollant (2015a) conducted a meta-analysis including a total of 233 suicide attempters and 768 non-suicidal patient controls. The meta-analysis also showed no significant group differences in Stroop interference for negative words compared to neutral words, and only a significant but small effect for attentional bias toward suicide-related words. This supports the current findings that emotional Stroop effect are not consistently reported in studies even with individuals reporting more severe form of suicidality.

More recently, Chung and Jeglic (2015) compared individuals with high versus low levels of suicidality (indexed by scorings on SBQ-R), though suicidal individuals have reported a Stroop interference effect for suicide-related words only. However, similar to the present findings, they also reported no emotional Stroop effect. Both Cha et al. (2010) and Chung and Jeglic (2015) came to the same conclusion that suicidal individuals exhibit specific attentional bias (Stroop interference for the word *suicide),* rather than a general negativity bias for negative words such as *vomit* and *cancer*.

In terms of the attentional bias towards emotional stimuli for the 0-back task, only happy faces (but not sad faces) elicited higher accuracy compared to the neutral faces, suggesting a processing bias for positive emotions. Therefore, the results are partly consistent with past literature wherein an attentional bias for emotional stimuli was evident compared to neutral stimuli. However, the processing advantage for emotional stimuli was only apparent in the 0-back task but not in the Go/No-go task, emotional Stroop task and 2-back task. This may be due to the nature of the task whereby 0-back task requires simple stimulus matching rather than working memory (Legrain, Crombez & Mouraux, 2011). It could be that whilst attention has been prioritized to processing emotional stimuli in the 0-back task, when the cognitive demands increase in the 2-back task, this attentional bias disappears. However, this assumption remains inconclusive due to the substantial drop out rate of participants in completing the 2-back task. Specifically, 20 withdrew from the initial sample of 37 participants after the 0-back task expressing that they did not want to further participate in the 2-back task. The most common reasons for withdrawal was the difficulty, long duration, and tedious structure of the task (i.e. repeating the same procedure for six blocks of trials). This has impeded the comparion of cognitive task performance in the 2 N-back tasks of this investigation. It also reflects that the use of a less difficult task such as the 1-back task may be more appropriate to use in the future.

Despite the non-significant findings in the cognitive tasks, the basic results within each task shows that they were designed effectively and they measured what they intended to measure. For example, having significantly higher accuracy in the go relative to no-go condition illustrates that the requirement to inhibit a no-go cue has affected the performance in the task as expected. Similarly, the lower accuracy evident in the 2-back task compared to the 0-back is consistent with past findings showing that the difficulty of the task increases in conjunction with an increase in the number of positions back the participant needs to remember. This means that the cognitive tasks were generally well designed to fit for the purpose and show the basic interference effects, therefore the non-significant findings in this study are not due to errors in the tasks themselves but could be explained by other factors such as participant sample who have reported relatively low levels of suicide compared to Study 1.

4.5.5.2 Frontal asymmetry and suicidality

Despite the evidence regarding how frontal asymmetry varies according to different emotional and psychopathological contexts in past studies, the current findings showed no frontal asymmetrical variation between high and low suicide risk groups. In general, all participants showed leftward frontal cortical activity (more positive alpha symmetric index) regardless of suicidality. In relation to this frontal asymmetrical pattern, a recent study by Kann, Zhang, Manza, Leung and Li (2016) also examined lateralization of the brain in healthy adults. Similarly, they found that there was a significantly higher level of brain activity in the left PFC, particularly, the dorsomedial prefrontal cortex (dmPFC) and inferior frontal cortex (IFC) when EEG recording was used to measure frontal asymmetry. This left lateralization found in healthy adults is also consistent with the earlier findings, which reported that compared to individuals with affective disorders, healthy controls exhibit greater leftward frontal cortical activity (Stewart et al., 2010; Thibodeau et al., 2006).

As there was no significant effect of suicidality on frontal alpha asymmetry the present study has failed to provide support for the argument that right frontal cortical activation is linked to increased suicide risk. Therefore, the measure of frontal alpha asymmetry does not seem to be a promising marker for suicide. In relation to the non-significant findings, Thibodeau et al. (2006) conducted a meta-analysis evaluating frontal asymmetry in depressed and anxious populations compared with healthy controls. The majority of studies in the review also showed non-significant effects for frontal alpha asymmetry as from the 26 studies reviewed, only ten found statistically significant differences in frontal alpha asymmetry. Within the 10 studies showing significant findings, both depression and anxiety were shown to be related to right-sided resting frontal EEG asymmetry, with moderately large effect sizes. This reflects the variability of examining frontal asymmetry as only less than half of the prior literatures found a significant association between clinical disorders and frontal asymmetry.

Thibodeau et al. (2006) tried to reconcile the inconsistent findings in this meta-analysis by investigating the importance of different variables including, gender, age, resting EEG strength, and scalp site. It was found that all of these variables influenced the effect size across the different studies. Notably, they specified that when examining resting frontal asymmetry, it is better to take EEG recordings of shorter periods of around 2 minutes rather than longer periods of 8 minutes. This is based on the comparison analysis that shorter recording periods were associated with larger effects on frontal asymmetry. Thibodeau et al. (2006) explained that this is possibly due to the more enriching emotional state that is elicited at the beginning of an experimental condition shortly after presentation of the emotional stimuli. When the recording was taken for a longer duration at rest, the emotional state may have worn off. Taking note of Thibodeau et al.'s (2006) meta-analysis, the present study adopted the resting EEG measure for a duration of 2 minutes. However, aside from the duration of EEG recordings, it is noted that asymmetry can be affected by a number of factors. Thibodeau et al. also noted that age is an important factor in moderating frontal asymmetry, with younger participants showing more variations in frontal cortical activations than older participants. This may have affected the impact of depression on frontal asymmetry. As the current study only examined university students, age would not be a factor to explain the findings because all participants were of a similar age range. Thibodeau et al.'s meta-analysis shows the sensitivity of using EEG measures and argues for more consideration over future EEG experimental paradigms.

Regarding the EEG frontal activity that was taken during the resting state, Coan et al. (2006) have questioned the reliance of using resting EEG data as a stable measure of individual traits. Instead, they argued that frontal EEG should be measured in specific situational contexts (i.e. under situations that require more emotional and cognitive demands) to assess an individual's capacity to respond emotionally. They also disputed that consideration of dispositional trait alone may not be sufficient to account for changes in frontal asymmetry, therefore, other variables may influence frontal alpha asymmetry in relation to suicidality.

As the present EEG findings provide no support for the dispositional model which posits that positive affect is associated with leftward frontal cortical activity, and negative affect is associated with rightward frontal cortical activity. This leads to the argument that dispositional traits alone may not be sufficient to account for frontal asymmetrical activation. Following from the dispositional model was the development of the approach withdrawal model (Henriques & Davidson, 1990; 1991 which explains frontal asymmetry with regards to the different approach and withdrawal systems. These systems originated from the theory of fundamental appetitive and defensive motivation systems that aid survival (Jones & Schneirla, 1959). The approach system specifies a motivation and action towards any stimuli, usually with the intention to achieve or to acquire it (e.g. to obtain food or reward). Conversely, the withdrawal system specifies action away from any stimuli one does not want to be involved in (e.g. to get away from a threatening event or attack). Based on these definitions, a wide range of negative emotions or feelings (fear, sadness, disgust, and shame) can be related to withdrawal whilst many positive emotions or feelings (joy, excitement, and interest) may relate to approach. However, withdrawal and approach are not specific to negative and positive emotions respectively. For instance, some negative emotions such as anger would be related to the motivation to take action (approach) and some positive emotions are associated with withdrawal (e.g. contentment). Central to the proposal of the approach withdrawal model is the idea that the two fundamental systems are lateralized within the PFC, with the left side facilitating a propensity to approach or engage a stimulus, and the right facilitating a propensity to withdraw or disengage from a stimulus (Tomarken et al., 1992). This has raised questions regarding whether prefrontal asymmetrical activity is associated with emotional valence or motivational tendencies.

In relation to the approach withdrawal model (Henriques & Davidson, 1990; 1991), in Study 3 it is uncertain what types of motivations participants were experiencing at the time of the EEG recordings. For instance, participants with high suicide risk might display rightward prefrontal activity (more negative alpha symmetric index) initially, but they might have approach-related behaviour such as feeling motivated to complete the experiment. This may impact the asymmetrical cortical activity towards a leftward cortical activation. Since suicide behaviour was not related to any frontal asymmetrical differences in the present study, it is worth exploring other behavioural variables in relation to approach and withdrawal. These variables may include coping and emotion regulation which are critical in the progression of suicidality, they may also be related to the approach withdrawal model (Henriques & Davidson, 1990, 1991).

In summary, the current study is among the first to examine frontal activity in relation to suicide in a non-clinical population. The findings found no differences in executive functions according to levels of suicidality thus provide no support for the neural underpinnings of suicide. Nevertheless, the results have highlighted the need for revising some of the designs in experiment and consider the importance of selecting sample with higher levels of suicidality for the investigations.

CHAPTER FIVE

Selecting the most suitable stimuli for investigating the emotional Stroop effect

5.1 Rationale for conducting two pilot studies

From the findings of Study 3 it is evident that none of the cognitive tasks revealed differences in executive functions between individuals with high and low suicide risks, and this was explained by the mild suicidality in the sample. With substantial evidence supporting the use of emotional Stroop tasks to reveal attentional bias in individuals with suicide behaviours or affective disorders (Chung & Jeglic, 2015; Epp et al., 2012; Keilp et al., 2013), Study 5 aims to continue examining attentional control to a greater extent. Indeed, past research shows that the emotional Stroop task is a powerful tool for investigating the influence of emotion on attentional control (Bittencourt-Hewitt, & Sebastian, 2015; Epp et al., 2012; Gilboa-Schechtman et al., 2000). This task has been used extensively and is among the most commonly used tasks to assess attention and inhibition (Cothran & Larsen, 2008), therefore the current study will focus on attentional control using emotional Stroop task only. However, based on non-significant findings in Study 3, some methodological issues will need to be addressed.

Aside from the issue with participant sample who had reported lower levels of suicidality, another suggestion for the absence of emotional Stroop effect in Study 3 was attributed to the use of stimuli in that the emotional stimuli. It was suggested that the emotions of stimuli were not fully processed by the participants. This raises the necessity to reconsider the emotional stimuli used in the final experiment (Study 5). To reconsider the choice of stimuli for this task there are two possible options: to increase the salience of the stimuli by using others such as images, or to change the language of the word.

Research shows that saliency may have an impact on the emotional Stroop effect (Palermo & Rhodes, 2006). It was posited that faces are the most biologically and socially significant visual stimuli in the environment, and might therefore be expected to receive enhanced processing compared to other types of stimuli. The idea for changing the language of the word stimuli is based on the argument that the participant sample in Study 3 were all Chinese but had been educated in English. With the arguments set for each option two pilot studies (Study 4a and 4b) were conducted to explore the most effective stimuli to use for the proceeding studies.

5.2 Study 4a: Comparison of the emotional Stroop effect for faces and for words

5.2.1 Existing literature on word and facial processing

Whilst the majority of research from the emotional Stroop task uses words, there are comparatively fewer studies that have used other stimuli such as pictures or faces (Ben-Haim et al., 2016; Williams et al., 1996). It has been argued that processing of faces would be prioritized over words because faces may elicit stronger emotional responses that are important for communication and social relationships (Beall & Herbert, 2008). In order to compare processing of faces and words Ovaysikia et al. (2010) conducted a Stroop task in which emotional faces (happy, sad, and angry) were presented alongside emotional words (also happy, sad, and angry). In the face condition, participants had to judge the emotion of the face and ignore the word. In the word condition, they responded to the emotional content of the word and ignored the face. In a congruent trial, the emotion of the word and face matched (e.g. a smiling face with the word “happy”) and in an incongruent trial the emotion of the word and face was different (e.g. a smiling face with the word “sad”). Overall responses were faster for words relative to faces, showing a more spontaneous and automatic processing of words. This was also confirmed when there was a larger emotional Stroop effect in the face condition whereby words interfered with face expression judgements to a greater extent than how faces interfered with word reading. Ovaysikia et al. (2010) concluded that word processing is the more dominant form of processing. They also suggested that both the word and face conditions induced different kinds of processing, with deeper, expression analysis needed for faces, whereas a superficial perceptual analysis of the word (also referred to as semantic lexicon) was sufficient to complete the task.

As the processing of word and faces occurs unconsciously and automatically (Schupp et al., 2004), one way to directly contrast these two processes is via the use of ERP (Herbert et al., 2008; Schupp et al., 2004). This measures early attentional processes associated with the emotional bias of processing information such as words or faces. It can provide an indirect measure to show which emotional words capture attention for sustained processing and activation of the emotion regulation system (Schacht & Sommer, 2009). Bayer and Schacht (2014) studied modulations of early posterior negativity (EPN) [21] and late positive complex (LPC)[22] for emotional words, pictures, and faces. They found that both words and faces elicit rapid sensory processing in early EPN at a similar time interval (around 100ms). Importantly, there was a bias

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[21] The EPN is a relative negative evoked potential found near the posterior cortical regions that reflects initial visual encoding (Strien, Franken, & Huijding, 2014). It usually starts around 150-250ms after stimulus onset depending on the type of stimuli (Schupp et al., 2004) and characterizes the post-lexical processing stage for words (e.g. Palazova et al., 2011). The EPN also indicates enhanced attentional allocation and sensory processing of emotional stimuli in comparison to neutral stimuli.

[22] The LPC is an enhanced parietal positive evoked related potential for emotional stimuli starting from 300–400ms after stimulus onset. It is suggested to reflect higher-order stimulus evaluation (e.g., Bayer & Schacht, 2014; Herbert et al., 2008; Schupp et al., 2004).

towards faces shortly after stimulus onset (after 100ms). The ERP findings indicated that modulations of EPN and LPC were visible for words, pictures, and faces, and the differences were more profound when the words, faces, and pictures were emotional. In particular, the researchers found that an EPN of 170-190ms was specific to facial stimuli, which is earlier than the EPN onset for words at around 250ms. Compared to facial processing, the post-lexical processing in words occurred at a later time interval potentially reflecting that more time was needed to retrieve the meaning of the word. This showed that word processing seems to be automated to a much lesser degree than facial and picture processing. Interestingly, the positive and neutral words received higher valence ratings than the positive and neutral pictures and facial expressions. This means that although increased time is needed to process the words compare to picture and faces, words actually elicit stronger emotional effects.

5.2.2 Aims and intentions of Study 4a

Given that the emotional Stroop effect is highly dependent on the type of stimuli used for the emotional Stroop tasks (Ovaysikia et al., 2010), it remains unclear which type of stimuli to use to elicit an emotional Stroop effect in a HK sample since the effect was not apparent in Study 3. To investigate this, an emotional Stroop task with emotional and neutral stimuli was conducted to compare the emotional Stroop effect for faces and for words. It was hypothesized that emotion Stroop effect would be apparent for both stimuli, with slower response time for emotional stimuli compared to neutral stimuli. Moreover, it was predicted that the use of word or facial stimuli would elicit different degrees of emotional Stroop effects.

5.2.3 METHOD

5.2.3.1 Design

This investigation used a within-participants design to compare the emotional Stroop effect between faces and words. The first independent variable was the type of stimuli presented (words or faces). The second independent variable was the emotional content of the stimuli (positive, negative, or neutral). The dependent variable was response times (ms) to correctly identify the colour of each stimulus.

5.2.3.2 Participants

Twenty-six participants (10 males, 16 females) were all Chinese aged 18 to 25 (Mean = 21.38, SD = 3.21) and were recruited from The Open University in HK via convenience sampling.

5.2.3.3 Stimuli and Materials

The experiment consisted of two Emotional Stroop tasks, one with facial and one with word stimuli. Both tasks were compiled and run using E-Prime software (Psychology Software Tools, Inc., Pittsburgh, PA; Schneider et al., 2002). Each task was presented on a 16″ CRT monitor with a refresh rate of 75 Hz).

The word emotional Stroop task was adapted from Herrington et al. (2010) and consisted of positive, neutral, and negative words presented in one of four colours (red, yellow, blue, and green). A total of 192 words (presented in bold Times New Roman font, size 36) were selected from the Affective Norms for English Words (ANEW, Bradley & Lang, 1999); positive (e.g. *birthday, holiday, laughter*), negative (e.g., *suicide,* *funeral, victim*), and neutral (e.g., *jungle, handle, carpet*). The words were selected on the basis of valence in the English language (Bradley & Lang, 1999). There were 64 positive words (valence ranged from 6.92 to 8.32 with a mean of 7.50, and arousal ranged from 4.88 to 6.83 with a mean of 5.26), 64 negative words (valence ranged from 1.31 to 2.89 with a mean of 2.21, and arousal ranged from 4.39 to 7.45 with a mean of 5.21), and 64 neutral words (valence ranged from 5.14 to 6.56 with a mean of 5.34, and arousal ranged from 1.59 to 4.55 with a mean of 3.43).

In order to check the differences in valence of emotional stimuli a one-way ANOVA was conducted followed by planned comparisons that compared the valence of each emotion. For the analysis of valence based on the ANEW ratings, there was a significant effect of emotion, F (2, 189) = 986.12, MSE = 0.459, $p < .001$. The comparisons showed that the valence ratings (from the ANEW) were higher for the positive than the neutral words, F (1, 57) = 306.968, MSE = 453.263, $p < .001$, and rated the valence of negative words significantly lower than the neutral words, F (1, 57) = 23.192, MSE = 114.028, $p < .001$. For the analysis of arousal there was a significant effect of emotion, F (2, 189) = 38.674, MSE = 1.793, $p < .001$. Planned comparisons also revealed that participants rated the arousal of positive words, F (1, 57) = 150.52, MSE = 3.474, $p < .01$, and negative words, F (1, 57) = 24.513, MSE = 9.691, $p < .01$, higher than the neutral words.

The facial-emotional Stroop was adapted from Isaac et al. (2012). Faces were selected from the NimStim Face Set (Tottenham et al., 2009). A total of 60 emotional faces were used comprised of 20 individuals (10 males and 10 female African American and Caucasian faces) showing three different emotions (happy, sad, and neutral) and illustrated in 4 colours (red, yellow, blue, and green). A colour filter was applied to each face using the GNU Image Manipulation Program for Windows systems (GIMP, 2.6) and images were cropped so that the facial stimuli were free from hair or other external attributes that could serve as distracters or distinguishers. All facial images were matched on dimensions of colour hue, saturation, contrast, and size (96 × 72mm).

5.2.3.4 Procedure

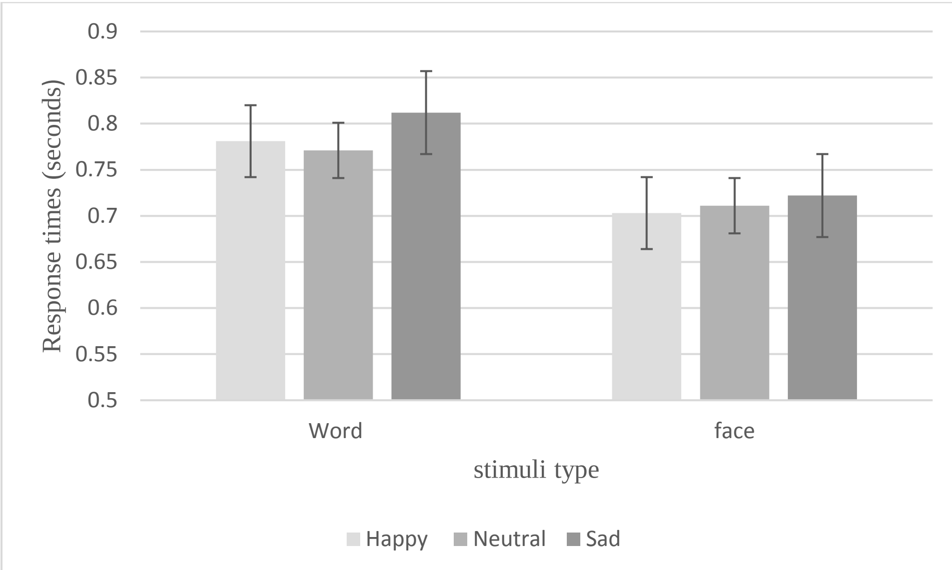
Each participant was asked to complete both Stroop tasks. Both tasks consisted of three emotional blocks showing positive, negative, and neutral stimuli and the order of the tasks and blocks was counterbalanced across participants. For both tasks, a trial began with a fixation cross of 500ms followed by the presentation of a word/face in the center of the computer screen. The word/facial stimulus remained on the screen until a response was made, or for a maximum of 1500ms. For each one participants were asked to identify the colour it was presented in as quickly as possible by pressing the corresponding key (R, Y, B, and G). In the emotional Stroop task with word stimuli, there was a total of 12 practice trials followed by 180 test trials separated into 3 (positive, negative and neutral) blocks of 60 trials. There were an equal number of words presented in red, yellow, blue, and green and all trials were presented in a random order. For the facial stimuli, there were 12 practice trials that were not scored followed by 240 trials separated into 3 (positive, negative and neutral) blocks of 80 trials. An equal number of faces were presented in each of the four colours within each block (i. e., there were 20 words presented in each colour in each block), and all trials were presented in a random order.

5.2.4 RESULTS

Two participants were excluded from the analyses due to incomplete data. The remaining 24 participants were all right handed. To compare the emotional Stroop effect for words and faces, the type of stimuli and the emotions were the within participant independent variables, the response time of the Stroop task was the dependent variable. All incorrect trials were removed in addition to any trials for which response times were more than 2.5 standard deviations from the mean. This accounted for 3.27% of the trials in total. Means and standard deviations are summarized in Figure 5.1

Response times from the emotional Stroop task were analyzed using a 2 (type of stimuli) x 3 (emotion) mixed measures ANOVAs followed by planned contrasts to compare performance in the positive and negative conditions to that in the neutral condition (Appendix 6.4.1) There was a significant effect of stimulus type, $F(1, 23) = 13.881$, $MSE = 0.015$, $p < .01$, with longer response times for words (M = 788ms) than faces (M = 712ms). There was also a significant effect of emotion, $F(2, 46) = 3.474$, $MSE = 0.003$, $p < .05$. The planned contrasts revealed that response times were significantly slower for negative (M = 767ms) compared to neutral stimuli (M = 741ms), $F(1, 23) = 4.088$, $MSE = .008$, $p < .05$, but there was no difference between positive and neutral stimuli $F(1, 23) = .006$, $MSE = .007$, $p = .939$. There was no interaction between stimuli and emotion, $F(2, 46) = 1.05$, $MSE = .002$, $p = .358$.

Figure 5.1. The mean and standard deviation of response times in the emotional Stroop tasks for word and facial stimuli



5.2.5 DISCUSSION

The principal aim of the present study was to compare the emotional Stroop effect for words and faces. The results would reflect whether the absence of the emotional Stroop effect in Study 3 was due to limited emotional salience of the words used in the task, it would also help to select the most appropriate stimuli for the proceeding Stroop experiment. The pertinent finding of this study is that there were no significant differences between words and faces in eliciting the emotional Stroop effect, participants took longer to respond to negative stimuli (showing a negativity bias) regardless of the type of the stimuli. This is consistent with the past literature that the emotional Stroop effect, in particular, attentional bias to negative information was repeatedly documented in previous Stroop findings (Beall & Herbert, 2008; Williams et al., 1996). Estes and Adelman (2008) posited that when confronted with a negative stimulus, initial stimulus evaluation would take place and attention should be disengaged more slowly from negative stimuli than from stimuli of other emotions. This would be reflected by slower responses to negative stimuli than to positive stimuli (e.g., Algom et al., 2004; McKenna & Sharma, 2004). Some researchers explained that the negativity bias is a form of evolutionary adaptation for detecting stimulus important for survival (Öhman et al., 2001; Pratto & John, 1991; Williams et al., 1996). Negative stimuli are considered to be more important because failure to avoid a negative stimulus (such as a predator) may be fatal. In contrast, failure to recognize a positive stimulus (such as prey) is less urgent because additional opportunities may be forthcoming (Pratto & John, 1991).

Cisler et al. (2011) posit that personal relevance and emotional salience of the stimuli can have a significant impact on the emotional Stroop effect. This may explain the longer response time for words compared to faces in the current study. It might have been that words had a stronger emotional salience and personal relevance than faces, especially when the faces were selected randomly from a different ethnic group to the participants, thereby hindering the personal relevance of those facial stimuli. When comparing the valence ratings of words in the current study with that of Study 3, it is noted that in Study 3 the valence ranged from 7.06 to 8.72 with a mean of 7.68 for positive for positive, from 1.24 to 3.08 with a mean of 2.52 for negative, and from 5.03 to 6.36 with a mean of 5.44 for neutral. In comparison, the current study reported valence ranged from 6.92 to 8.32 with a mean of 7.50 for positive, from 1.31 to 2.89 with a mean of 2.21 for negative, and from 5.14 to 6.56 with a mean of 5.34 for neutral words. The comparison reveal that negative words were rated as more negative (lower valence) in the current study relative to Study 3. This could be a factor for explaining why there was no emotion Stroop effect in Study 3 but the effect (negativity bias) was apparent in the current study. It also infers that the absence of emotional Stroop effect in Study 3 was not due to the fact that words were used, but perhaps attributed to the possibility that participants were not fully processing the emotional content of stimuli as the negative words were generally ‘less negative’.

Reflecting on the difference in emotional Stroop designs in Study 3 and the current study, it is noted that the emotional Stroop effect could be due to the fact that blocked designs (i.e. all positive words in one block and negative words in the other) were used rather than the randomized designs in Study 3. Support for this suggestion is derived from past evidence that the emotional Stroop effect is larger in blocked compared to randomized designs (Bar-Haim et al., 2007; Cisler et al., 2011; McKenna & Sharma, 2004). Moreover, Cisler et al. (2011) explained that attentional control resources may deplete across repeated exposure to one set of emotional stimuli during blocked designs (e.g. exposing participants to many slides of threatening stimuli). Compared to randomized designs the relatively longer exposure to one set of emotions leads to greater intensity of specific emotion and results in a larger emotional Stroop effect. Nevertheless, with the emotional Stroop effect found in the current study, it is indicated that the word stimuli have elicited the desired effect as expected this time.

The current findings emphasized that the emotional Stroop effect does not differ due to stimulus type as emotional Stroop tasks using words or faces both elicit emotional Stroop effect, this means that words do elicit an emotional response to the same degree as faces. As emotional Stroop effect was found in the tasks using both words and faces, this indicates that both types of stimuli are appropriate to use for the current studied population. However, since the use of word is the most well-established version of emotional Stroop task and the majority of past Stroop studies use words, it is best to continue using word stimuli in the proceeding experiment (Study 5).

Considering that the current participants were all Chinese speakers, it would be assumed that the use of English word stimuli would differ among participants who consider English as their native or as their second language. Empirical support for this assumption is based on Westefeld et al. (2008) who posited that emotional salience of words may vary depending on an individual's cultural background. Therefore when selecting the language of words for Stroop task these factors should be taken into consideration. When choosing stimuli for cognitive task, it is vital to have careful selection of language to ensure that significant emotions can be elicited as planned. In a related vein, Eilola and Havelka (2010) also suggested that the use of words for the emotional Stroop task may manipulate the Stroop effect. With the use of words in bilinguals first versus second language, they recorded greater level of arousal (increase in skin conductance response[23]) when negative and taboo words were presented in an emotional Stroop task using bilingual's first language. Complementing the emphasis of personal relevance and emotional salience for stimuli in Stroop design (Cisler et al., 2011), the findings from Eilola and Havelka (2010) draws attention to the importance of examining whether the use of Chinese versus English words may have different impact on Stroop performance.

[23] The skin conductance response (SCR) is an objective, transient indication of autonomic nervous system arousal in response to a stimulus (Bach, Friston, & Dolan, 2010). It serves as an indication of physiological or psychological arousal because it measures changes in sweat gland activity on the skin.

5.3 Study 4b: Variations in bilingual processing of emotional information presented in a speaker's first and second language

The participants in Study 3 were undergraduate students from HK proficient in both Chinese (L1) and English (L2). This distinctive charateristics of the sample who are all proficient Chinese-English bilinguals have raised questions regarding whether language has an impact on emotional Stroop effect. Previously, researchers have suggested that careful selection of language of stimuli is crucial in shaping performance in a Stroop task (Dresler et al., 2008; 2009; Imbir & Jarymowicz, 2013), this is especially crucial when the participants are bilinguals. It is important that participants can read and fully understand the words, and if using the emotional Stroop task it is important that the emotionality of each word is clear. Therefore, to ensure the emotional Stroop task measures attentional control without the confound of language factors, this second pilot study investigates the influence of language used in the word stimuli.

5.3.1 Word processing in skilled and non-skilled readers

When individuals become proficient in the language that they use, word processing (which includes the processing of orthographic[24] and semantic lexicon[25]) becomes more automatic (Abdullah, 1993; Yeatman, Rauschecker & Wandell, 2013). This is partly because the lexical access in proficient readers becomes a more automatic process and

[24] The orthography of a word is the study of language concerned with how letters are arranged to compose words (Cambridge Dictionary, 2017). Orthographic neighbors refer to the number of words one can produce by changing some letters in the target word.

[25] The lexical route gives access to a mental dictionary of word meanings (semantic lexicon). This is also known as the semantic lexicon, which provides a pool of word-specific information associated with the semantic knowledge of each word (Jackendoff, 2002; Nation, 2013). The semantic lexicon forms a mental network of information regarding a word's meaning, pronunciation, and syntax. It helps to deal with how thousands of words are stored, activated, processed, and retrieved. This network is constantly developing as new words are learnt (Jackendoff, 2002).

reduces the cognitive load needed for constructing meaning from text. Subsequently, there will be reduced time needed for reading (Yeatman et al., 2013). This is evident from brain imaging findings that the brain circuits within the left occipital-temporal area (especially the visual word form area) are differentially activated during the reading process. In an fMRI study, Yeatman et al. (2013) investigated the difference in activation of the visual word form area when 35 children (aged between 7-12 years old) were shown block of real words or scrambled words. It was found that viewing words evoked a series of neurological responses in several areas around the primary visual cortex and the visual word form area. Evidently, as reading experience increases, the neural activity evoked by words increases, becomes more connected and converges into a skilled neural network. This increased neural network distinguishes skilled readers from non-skilled reader and explains the automaticity in recognizing and reading with no conscious effort (Yeatman et al., 2013). The neurological responses in these areas are found to be linked to proficiency of reading and damage to these area or nearby white matter can produce severe reading deficits.

Warrington (2006) compared skilled and non-skilled readers and identified some cognitive features that distinguished between the two. He stated that skilled readers can read automatically, recognizing letters and words while at the same time maintaining a flow that allows them to make connections and inferences to make text understandable. In comparison to this, non-skilled readers are less able to master such skills to the point where they can perform integrative and complex language commands, communication skills, and literacy. For example, it has been suggested by Baron (2003) that non-skilled readers, such as children under the age of eight, may engage in the slow analysis of words presented in text because the automaticity in reading is not fully integrated at this stage. Subsequently, children may need to use more memory capacity and increase attention for reading comprehension (Baron, 2003).

Early theoretical frameworks have posited that language and emotion are closely linked (Caldwell-Harris, 2014; Eilola & Havelka, 2010; Ho et al., 2015). For example, Lindquist, MacCormack, and Shablack (2015) have shown that language can influence the intensity of emotions being experienced and perceived (including anger, disgust, fear, and sadness). Related work also reveals that reducing one's access to the meaning of emotional words also reduces their ability to perceive the emotional content of stimuli (Havas & Matheson, 2013). These findings together suggest that access to the meaning of emotional words is an important element for recognizing emotional information (Lindquist et al., 2015), and that language processing has an impact on the ability to detect emotion.

5.3.2 Language processing in monolinguals and bilinguals

The majority of past cognitive investigations using words have been carried out using monolingual participants (especially English speakers) rather than bilinguals. To investigate the effect of bilingualism on emotional processing, Colbeck and Bowers (2012) conducted an experiment using a rapid serial visual presentation (RSVP) task to compare the ability of English monolinguals and Chinese-English bilinguals to detect visual targets. Participants were asked to identify a coloured word embedded within a stream of black distracter words. A critical distracter was presented prior to the target that was an English taboo or sexual word and the impact of this on identification of the target was measured. Results showed that both the taboo and sexual words were more distracting than neutral words, but only for English monolinguals. Chinese bilinguals were less affected by these words and were better able to ignore the emotional distractors. The researchers argue that this is because emotionality is reduced in their second language (L2). Consistent with this, bilinguals often report that although they know the emotional meaning of words in L2, the words do not trigger the same emotional effect as they do when presented in their first language (L1; Pavlenko, 2005).

Consistent with Pavlenko's (2005) view, bilingual speakers are generally more willing to discuss potentially uncomfortable topics (e.g. sex) in their L2 than their L1 (Altarriba, 2008; Altmann, Bohrn, Lubrich, Menninghaus, & Jacobs, 2012; Dewaele, 2010; Pavlenko, 2008). It has been proposed that the dissociation between processing of emotional information in L1 and L2 occurs because bilinguals can process information presented in their L2 semantically but not emotionally (Pavlenko, 2012). This means that although bilinguals understand the affective meaning of emotional words presented in L2, the words are unable to trigger the heightened level of automatic arousal that occurs in L1. In support of this explanation, bilinguals generally have greater autonomic and psychophysiological activation for L1 processing relative to L2 (Harris, Gleason, & Ayçiçegi, 2006). This includes the recordings of increases in skin conductance response. It has therefore been suggested that whilst L1 processing relies on rapid and automatic activation of semantic and affective information simultaneously, L2 processing is slower and parallel activation of semantic and emotional information is not possible. This would suggest that when using an emotional Stroop task to measure attentional bias in bilingual participants it would be important to present words in L1 rather than L2.

Given the assumption that processing of L2 is generally less efficient and automatic than processing of L1 in bilingual speakers (see Van Heuven, Mandera, Keuleers, & Brysbaert, 2014), this raises the question as to whether the use of Chinese words (L1) would have a larger emotional Stroop effect relative to the use of English words (L2). One way to explore this is to investigate the difference in intensity of emotions experienced and expressed (referred to as emotionality) in L1 compared to L2. Chinese is a very distinctive language and the difference between Chinese and English is much greater than the differences between English and languages such as Spanish, Dutch, and French (Chen et al., 2015; Ho et al., 2015). Although Chinese is the world's oldest written language (Oxford Dictionaries, 2015) and the most popular spoken language in the world (Ethnologue, 2014), there is insufficient research to confirm whether there are differences in how Chinese-English bilinguals process emotional information in their first (L1) and second language (L2). However, there is a general assumption that a bilingual's L2 has less emotional impact relative to their L1 (Marian & Kaushanskaya, 2008) and this is attributed to the fact that emotional words learned in L1 are coded more deeply because they are experienced in a wider range of contexts and are applied in more situations compared to the words learned in L2 (Sutton et al., 2007). Therefore, the emotional impact for L1 emotion representations is stronger than for L2 emotion representations.

5.3.3 Neural correlates of emotional processing in L1 and L2

More recently, the difference between emotional processing in L1 and L2 has also been investigated by measuring neurological activation in the brain. For instance, the dissociated pattern of neurological activation elicited by L1 versus L2 is often investigated using ERP, a typical method to investigate the automatic sub-processes in emotional word processing (Opitz & Degner, 2012). The ERP studies have consistently found augmented EPN amplitudes in response to emotionally significant compared to neutral stimuli (Schacht & Sommer, 2009; Strien, Franken, & Huijding, 2014). The neurological investigation in bilingual participants conducted by Opitz and Degner (2012) illustrate that emotional words of both L1 and L2 have enhanced EPN relative to neutral words. Evidently, L1 and L2 do not differ in the amplitude of the EPN and showed similar processing of emotion words in both languages. The main difference between L1 and L2 is that words presented in L2 elicit longer delays of EPN compared to when presented in L1. This implies that processing of emotionality of L2 words is slower than L1 as a result of delayed lexical access. Although emotionality of both languages may be equivalent, as shown by comparable amplitude in EPN and similar emotionality of words, the delayed processing of L2 is often misinterpreted as L2 having lower emotionality than L1 when in fact it is due to the different processing of L1 and L2 (Opitz & Degner, 2012).

5.3.4 Aims and intentions of the current study

In this study it is essential to explore how Chinese-English bilinguals respond to emotional words presented in their L1 and L2. The work will specifically address how an individual assesses the emotionality of words in L1 and L2 by asking participants to rate the valence and arousal of a series of positive, negative, and neutral words. It was predicted that ratings of valence and arousal would be significantly different in L1 and L2, with words presented in L1 to have higher ratings for both measures.

5.3.5 METHOD

5.3.5.1 Design

This study compared valence and arousal ratings of words presented in Chinese and English to Chinese-English bilinguals. A 2x3 within-participants design was used with two independent variables; the language each word was presented in: Chinese (L1) and English (L2), and the emotion of words: positive, negative, and neutral. The dependent variables were the mean ratings of arousal and valence.

5.3.5.2 Participants

The present study used opportunity sampling to recruit 58 undergraduate Psychology students (40 females, 18 males) from The Open University Hong Kong. Their ages ranged from 18 to 52 years, with a mean age of 23.17 years (SD = 6.61). All participants were Chinese-English bilinguals. They were all studying for a degree in their L2 so were considered proficient in both languages, and all acquired L2 prior to the age of 6.

5.3.5.3 Stimuli and Materials

One hundred and twenty English words (40 positive, 40 neutral, and 40 negative) were selected from the ANEW; Bradley, & Lang, 1999). Each word had been rated for valence and arousal on a 9-point scale, with 1 being lowest, and 9 being highest (see Appendix 5.4). Participants rated the valence and arousal of each word using the 9-point Self-

Assessment Manikin scale (SAM; Bradley, & Lang, 1999). The valence scale consisted of 9 faces ranging from an unhappy, frowning face (1) to a smiling, happy face (9). The arousal scale consisted of 9 faces ranging from a relaxed, sleepy face (1) to an excited, wide-eyed face (9). The positive words had a mean valence of 7.52 (ranging from 7.06 to 8.33) and a mean arousal of 6.90 (ranging from 6.74 to 7.83). The negative words had a mean valence of 2.32 (ranging from 1.29 to 2.93) and a mean arousal of 6.72 (ranging from 6.33 to 7.86). The neutral words had a mean valence of 5.42 (ranging from 5.06 to 6.26) and a mean arousal of 3.82 (ranging from 3.22 to 4.34).

To compare differences in valence a One-way ANOVA was completed followed by planned comparisons that compared the valence of each emotion. For the analysis of valence there was a significant effect of emotion, F (2, 120) = 326.617, MSE = 0.673, $p <$ .001. The comparisons showed that participants rated the valence of positive words higher than the neutral words, F (1, 57) = 306.968, MSE = 453.263, $p < .001$, and rated the valence of negative words significantly lower than the neutral words, F (1, 57) = 23.192, MSE = 114.028, $p < .001$. For the analysis of arousal there was a significant effect of emotion, F (2, 120) = 75.535, MSE = 1.588, $p < .001$. Planned comparisons revealed that participants rated the arousal of positive words, F (1, 57) = 150.52, MSE = 3.474, $p < .01$, and negative words, F (1, 57) = 24.513, MSE = 9.691, $p < .01$, higher than the neutral words. There was no significant effect of language, F (1, 57) = 2.327, MSE = 2.137, $p >$ .05. However again there was a significant interaction between language and emotion, F (1.353, 77.142) = 37.811, MSE = 7.846, $p < .001$.

All words were obtained from the list in English and translated into Chinese using two dictionary sources, the Cambridge Dictionary (2015) and the Longman English-Chinese Dictionary of Contemporary English (Longman & Co., 1988).

5.3.5.4 Procedure

The words were presented in a random order on a sheet of paper and participants were asked to rate the arousal and valence of each word. All participants saw each word once therefore for each participant half the words (20 negative, 20 neutral, and 20 positive) were presented in English and the other half (again, 20 for each emotion) were presented in Chinese. The language of presentation and the order of presentation were counterbalanced across participants. Participants were given six practice words and if they were satisfied with the procedure they continued. They were asked to complete the task as quickly as possible and overall the ratings took a maximum of 20 minutes to complete.

5.3.6 RESULTS

Mean ratings for valence and arousal were calculated for each category of emotion for each language (see Table 5.1). The effects of language and emotion were analyzed using two 2 (language) x 3 (emotion) within-participant ANOVAs (one for valence and one for arousal) followed by planned comparisons that compared the negative and positive conditions to the neutral condition. Where sphericity was violated, corrected degrees of freedom are reported using the Greenhouse Geisser.

For the analysis of valence there was a significant effect of emotion, F (1.341, 76.425) = 121.572, MSE = 3.25, p < .001 (Appendix 6.4.2). The comparisons showed that participants rated the valence of positive words higher than the neutral words, *F* (1, 57) = 306.968, *MSE* = 453.263, *p* < .001, and rated the valence of negative words significantly lower than the neutral words, *F* (1, 57) = 23.192, *MSE* = 114.028, *p* < .001. There was no significant effect of language, *F* (1, 57) = 0.022, *MSE* = 1.203, *p* = .883. However, there was a significant interaction between language and emotion, *F* (1.17, 66.668) = 15.725, *MSE* = 3.772, *p* < .001. The planned comparisons showed that participants rated the valence of positive words higher than neutral words when presented in both English and Chinese, *F* (1, 57) = 0.318, *MSE* = 0.792, *p* > .05. However, the difference in the valence rating for negative and neutral words was only found when the words were presented in English, *F* (1, 57) = 15.683, *MSE* = 6.953, *p* < .001. In Chinese, the negative words were rated as having a similar valence to the neutral words (means of 4.18 and 4.20 respectively), whereas in English the valence of negative words was rated significantly lower than neutral (means of 2.93 and 4.89).

Table 5.1. **Mean valence and arousal rating for each category of words presented in Chinese and English**

	Language	**Emotion of Words**					
		Negative		Neutral		Positive	
		M	SD	M	SD	M	SD
Valence	Chinese	4.18	2.38	4.20	1.45	6.22	1.44
Rating	English	2.93	0.86	4.89	0.44	6.82	0.84
Arousal	Chinese	5.34	1.80	2.64	1.59	5.00	1.62
Rating	English	4.04	1.69	3.88	1.73	5.77	1.69

For the analysis of arousal there was a significant effect of emotion, F (1.539, 87.714) = 41.488, MSE = 4.261, $p < .001$ (Appendix 6.4.3). Planned comparisons revealed that participants rated the arousal of positive words, F (1, 57) = 150.52, MSE = 3.474, $p < .01$, and negative words, F (1, 57) = 24.513, MSE = 9.691, $p < .01$, higher than the neutral words. There was no significant effect of language, F (1, 57) = 2.327, MSE = 2.137, $p > .05$. However again there was a significant interaction between language and emotion, F (1.353, 77.142) = 37.811, MSE = 7.846, $p < .001$. The difference between arousal ratings for negative and neutral words was more pronounced in Chinese (mean of 5.34 vs. 2.64) than in English (mean of 4.04 vs. 3.88), F (1, 57) = 48.039, MSE = 3.899, $p < .01$. This was also the case for positive compared to neutral words with greater differences between Chinese (positive mean of 5.00) than English (positive mean of 5.77), F (1, 57) = 7.205, MSE = 0.872, $p < .01$.

5.3.7 DISCUSSION

The aim of this study was to investigate emotional responses of participants who were all Chinese-English bilinguals to emotional words presented in their first and second language. The results would help to determine the most effective stimuli to use for the proceeding studies. This was achieved by asking participants to rate the valence and arousal of positive, negative, and neutral words shown in Chinese (L1) and English (L2). The majority of past findings show a processing advantage in L1 whereby emotional words in L1 are processed automatically at both a semantic and emotional level whilst emotional words in L2 are processed for meaning before emotionality (Marian & Kaushanskaya, 2008; Pavlenko, 2005). However, most work in this area compares bilingual processing across similar languages such as English and French and very little work has been conducted using Chinese. Given that Ayçiçegi-Dinn and Caldwell-Harris (2009) have argued that the characteristics of a language may affect emotionality the current study had the potential to show whether this may be a factor in emotional processing. This is important as the results could help determine the most appropriate language used for the word stimuli in the preceding Stroop task. It was predicted that words shown in Chinese (L1) would elicit higher emotionality than words shown in English (L2).

The results showed that participants rated the valence of positive words at a similar level in both languages, but the negative words were rated as having a lower valence when presented in English compared to Chinese. In order to elicit differences between neutral and negative words (in addition to neutral and positive) it would therefore be prudent to present stimuli in a Stroop task in L2. The findings from arousal show the opposite to this, with the differences between the three emotion conditions more pronounced when presented in Chinese compared to English. This would actually argue for use of L1 words in the final experiment.

5.3.7.1 Proficiency and frequency of language use

In the current study, although participants may consider Chinese as their L1 and English as L2, their frequent use of English for studying their full-time overseas degree program should be accounted for. These students may have high proficiency for L2 in addition to high frequency of L2 usage. Both may contribute to higher emotionality of L2. This is consistent with the arguments of Degner, Doycheva, and Wentura (2012) who have explored automatic emotional language processing in bilinguals with similar characteristics as the participants in the present study. The study recruited French-German bilinguals who share similar characteristics as the Chinese-English bilinguals in the present study. For example, both samples were not immersed in an L2 culture but used L2 frequently in daily life. Their results confirmed semantic processing effects and emotionality in both L1 and L2 with comparable degrees of fast word processing regardless of language. Therefore, frequency of use is an important factor together with proficiency of L2 (Degner et al., 2012; Opitz & Degner, 2012). Indeed, processing of L2 can elicit high emotionality just like L1 if L2 is used frequently and was learned via immersion rather than in the classroom (Dewaele, 2010; Degner et al., 2012).

Regarding the comparisons of arousal ratings in L1 and L2, participants identified larger differences in arousal for the three emotion conditions in L1 compared to L2. When compared with neutral words, they rated the Chinese version of the emotional words as more arousing than the English version. This supports past research that there is greater emotional distance to words presented in L2 relative to L1 (Altarriba, 2008; Dewaele, 2004; Pavlenko, 2008), but only for arousal, not for valence. On the basis that positive/negative emotion is more pertinent to the current research than arousal, the results for valence suggest a processing advantage for L2. Due to the fact that the final investigation aims to assess the effects of negative and positive stimuli in participants with suicide behaviour the valence ratings are more relevant than the arousal ratings. It is therefore proposed that for the final study the stimuli should be presented in English.

5.4 CONCLUSION

With the two pilot studies conducted it is clear from Study 4a that the use of word stimuli is more appropriate than faces for the final study. Following from this, Study 4b compared perceived emotionality (valence and arousal) of words presented in Chinese and English to Chinese-English bilinguals. In contrast to the predictions made, participants rated English words as more emotional than Chinese words, therefore providing no support for the argument that emotional stimuli presented in L1 is automatically processed at both a semantic and emotional level, whereas stimuli presented in L2 is processed at a semantic level. The conclusion outlined that for proficient bilinguals, emotional words in L2 are processed automatically in the same way as words in L1. They can elicit strong and automatic associations between emotion and meaning in L2 and therefore show the same emotionality in L1 and L2. Based on the findings, it is concluded that as long as participants are proficient they will be able to complete an emotional Stroop in their L2. This confirms the use of English words over Chinese words for the emotional Stroop task in the final study (Study 5).

CHAPTER SIX

Experimental investigation of frontal asymmetry in relation to suicidality and inhibition of emotional stimuli

6.1. Development from Study 3 to the current study

Study 3 was conducted to explore the differences in attentional control, inhibition and working memory between individuals with high and low suicidality, and to examine frontal asymmetrical activities underlying suicide behaviours. The work was based on the dispositional model (Davidson et al., 1979; 1984) which proposed a neurological predisposition for depression whereby positive affect is associated with leftward frontal cortical activity, and negative affect is associated with rightward frontal cortical activity (e.g. Tomarken et al., 1992). Extending from the evidence for how frontal asymmetry relate to depression, it was expected that frontal asymmetry could similarly be used for characterizing suicide behaviour. It was also predicted that any neurological difference in individuals with high suicide risks may help to explain why they report greater difficulties in executive functions. However, as there was no alpha asymmetrical difference between individuals with high and low levels of suicidality, frontal alpha asymmetry did not appear to be a promising indicator for characterizing suicide behaviour. Therefore, the EEG findings provide no support for the dispositional model.

Building upon Study 3, the non-significant findings support the early findings by Keilp et al. (2001) that suicidality may impact executive functions but this is limited to those who have dangerous levels of suicidality but not those (Study 3) who only reported having milder form of suicide behaviours. To test this assumption, the present study has carefully selected the high suicidality group to ensure they reported higher levels of suicidality, but still focusing on individuals with suicide ideation rather than suicide attempt. The current study also aims to explore other important factors from Study 1 and 2 that were strong predictors for suicidality, namely avoidance coping (from Study 1 and 2), and cognitive reappraisal (from Study 2).

Alongside the investigation of how suicide impacts frontal asymmetry, some researchers posited that affective responsivity has a pivotal role in this relationship (Coan et al. 2006; Jollant et al., 2008). It is postulated that frontal asymmetry corresponds to inhibition of different emotions. However, as the trials in the emotional Stroop task in Study 3 lacked clear emotional blocks in which responsivity to specific emotions could be manipulated, the extent of emotional interference on frontal asymmetry could not be verified in Study 3. On the basis of prior studies (Bar-Haim et al., 2007; Cisler et al., 2011; McKenna & Sharma, 2004; Wyble et al., 2008) and the comparative Stroop findings in Study 3 and 4a, it is evident that using blocked design in emotional Stroop tasks may elicit greater extent of emotional interference on attentional control. Therefore, the current designs of emotional Stroop task have improved from Study 3 in that there are separate emotional blocks. For example, all positive words in one block and negative words in the other. Moreover, recognizing that the exploration of attentional bias towards suicide-related information was not possible in Study 3, the revised emotional Stroop task in this study has incorporated the use of words such as *suicide* to test its Stroop interference effect.

6.2 Limitations of the dispositional model to account for frontal asymmetry

The dispositional model (Davidson et al., 1979; 1984) has sparked decades of research on frontal asymmetry with a focus on affective traits (for reviews, see Coan & Allen, 2004; Harmon-Jones et al., 2010). Initially, the valence hypothesis derived from the dispositional model (Davidson, 1992; Davidson et al., 1990) proposed that asymmetrical frontal cortical activation is dependent on the emotionality of the stimuli presented to the individual and the emotional response to it. It is posited that the left hemisphere is dominant for processing positive emotions (e.g., happiness and surprise) whereas the right hemisphere is dominant for processing negative emotions (e.g., fear, anger, disgust, and sadness). The predictions in Study 3 were based on the dispositional model whereby the resting frontal alpha asymmetry serves as one primary manifestation of an individual's suicidal traits. This means that if an individual has more electrocortical activity in the right frontal region, they have a disposition towards focusing on negative emotions and process more negative information. In relation to this, there is supporting neurological evidence of patients suffering from depression and anxiety (Coan & Allen, 2004; Thibodeau et al., 2006), wherein rightward frontal cortical activity was considered as a reliable marker of their vulnerability to these affective disorders. Auerbach et al. (2015) found that depressed female adolescents, particularly those who showed an attentional bias towards negative information in a facial recognition task, exhibited less cortical activity in their left dlPFC. This complements the proposal of the dispositional model that relative rightward frontal cortical activity corresponds to more negative affect and responsivity.

One of the issues for the dispositional model highlighted by Watson (2000) is that it holds the assumption that positive emotion is always associated with leftward frontal activation whereas negative emotion is always associated with rightward frontal activation. This postulation has been challenged because some emotions such as feeling surprised, confused, attentive, and overwhelmed could fall under positive or negative emotions depending on the circumstances. This has led to the necessity to review other existing models for frontal asymmetry to account for different emotions and consider situational contexts (Coan et al., 2006). Following from this, a similar model named *the approach withdrawal model* (Henriques & Davidson, 1990; 1991) was developed that links frontal EEG asymmetry to opposing motivational states. It is posited that frontal asymmetry is not related to the valence of an emotional stimulus but rather to the motivational system that is engaged by that stimulus. Specifically, the model proposes that the left PFC is involved in a system facilitating approach behaviour towards stimuli (e.g., fighting with a competitor, or motivate to obtain a reward), whereas the right PFC is involved in a system facilitating withdrawal behaviour from stimuli (e.g., withdrawal from threat or from loving care).

A study by Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones (2003) specifically focused on anger emotion because it is an example of a negative emotion characterized by approach motivation. This serves as a good emotion to test between the two models because whilst the dispositional model would predict anger to be associated with rightward frontal cortical activation, the approach withdrawal model would predict the opposite. Forty-two university students were randomly assigned to a control or anger condition and those in the anger condition were given negative feedback on their written work. Electroencephalogram recordings were taken shortly after the mood induction and showed that anger was indeed related to relatively greater left PFC activity. This supports the approach withdrawal model rather than the valence hypothesis whereby it is the motivation that leads to the asymmetry and not the emotion itself.

6.2.1 The capability model

Based on the groundwork of Davidson et al. (1984; 1998), a later model named *the capability model* (Coan et al., 2006) compliments the approach withdrawal model in that it supports the claim that individual differences in frontal EEG asymmetry exist as traits. The approach withdrawal model focuses on measuring individual approach versus withdrawal dispositions under resting conditions, it takes little to no account of the situation the individual is in. In contrast, the capability model, as the name suggests, predicts an individual's capability to respond to emotional stimuli effectively (Coan & Allen, 2003; Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). Therefore, any asymmetrical difference with approach versus withdrawal responses is more likely to be revealed under certain situational contexts. This means that whilst the approach withdrawal model posits that individuals with rightward frontal activity measured at rest will correspond to more withdrawal related behaviour under all types of emotional situations, Coan and Allen (2006) contended that frontal cortical activity varies depending on different contexts (e.g. resting state versus active state) and is not solely based on the effects of traits. Therefore, the capability model predicts that when an individual is faced with a fearful situation they would have a withdrawal response that is characterized by greater activity in the right hemisphere (Coan et al., 2006). However, unlike the dispositional model, the capability model would not additionally assume that the individual would be inclined to withdrawal-related behaviour in other emotional contexts. The capability model assumes that various emotions and motivational tendencies can vary from one situation to another. Since there were no alpha asymmetrical differences between individuals with high and low levels of suicidality, the findings from Study 3 fail to support the dispositional model. The capability model highlights that other factors such as situational contexts should be taken into consideration in the final study.

6.3 Exploration of important factors attributed to suicidality

Based on the Cry of Pain model and the process model of emotion regulation, attentional bias and appraisal are both critical in the progression of suicide behaviour and the findings of Study 1 and 2 support this. Specifically, perceived difficulties with inhibitory control were associated with increased suicidality whereas the use of cognitive reappraisal was associated with reduced suicidality.

6.3.1 Cognitive reappraisal and association with frontal asymmetry

Referring back to the steps within the process model of emotion regulation (Gross 1998; Gross & Thompson, 2007), cognitive reappraisal and expressive suppression were highlighted as the most studied emotion regulation strategies. These emotion regulation strategies appear to have opposite impacts on depression (Soto et al., 2011) and suicide behaviour (Rajappa et al., 2012). As outlined previously, the use of expressive suppression is often linked to poor psychological health (Cutuli, 2014; Gross & John, 2003; Richards & Gross, 2000). Gross and John (2003) claimed that the frequent use of expressive suppression may lead to less control over the emotion and lead to increased depressive symptoms. Contrary to this claim, Study 2 revealed no relationship between suicide and expressive suppression and this was explained by the distinctiveness of the sample population who were all Chinese. It was found that the use of expressive suppression may be associated with adverse psychological functioning in general but this was not apparent for Chinese participants. Study 2 found that suppression did not seem to be a maladaptive emotional regulation strategy as it was not associated with increased suicidality in the Chinese sample. Regarding cognitive reappraisal, whilst the existing literature and the findings in Study 2 generally support the use of cognitive reappraisal and its relationship with decreased suicide behaviour, there are few empirical studies that can explain how cognitive reappraisal may benefit psychological health and execute its resilience effect. The underlying mechanisms of this resilience factor is therefore largely obscure. With the pivotal role of cognitive reappraisal to act as resilience against suicide behaviour, it is worthy of further investigation in the current study.

Tomarken et al. (1990) were the early pioneers to have used differences in resting frontal asymmetry to predict affective responses to films, this was similar to using emotion regulation in response to negative emotions. Resting EEG measures were taken during a 30 second eyes-open resting state, after which participants watched film clips intended to elicit positive and negative affect. It was revealed that rightward frontal cortical activation corresponded with a lowered threshold for negative affective reactions to aversive stimuli. This suggests that resting frontal asymmetry predicted subsequent positive and negative affective responses. Building upon this, Two EEG investigations completed by Parvaz, MacNamara, Goldstein, and Hajcak (2012) who investigated how emotion regulation impacted frontal asymmetrical activation. Forty-four participants were asked to view unpleasant and neutral pictures and were instructed to view them as they would normally do, or to reduce the emotional response by using cognitive reappraisal. When measuring frontal alpha asymmetry in these participants, they were also taught how to use cognitive reappraisal. An example would be to tell themselves that the people depicted in a house-fire would survive, or that the photo of a gruesome war scene was taken from a movie. To ensure these participants had understood the instructions and used reappraisal correctly, they were asked to indicate how they had reduced their emotional response to the pictures. Parvaz et al. (2012) reported that the use of cognitive reappraisal corresponds with increased cortical activation in the left PFC. Both findings suggest that the association between suicidality and inhibition or reappraisal may constitute a stronger effect on moderating frontal asymmetry. Results showed that frontal alpha decreased bilaterally in response to viewing unpleasant versus neutral pictures, this means there was increased brain activation during exposure to emotional stimuli. However, for those who had used cognitive reappraisal this corresponded to reduced left frontal alpha band power (i.e. increased cortical activation only in the left PFC). This area has been previously documented as a key region that is activated during cognitive reappraisal of picture stimuli regardless of the type of emotion displayed (Davidson, 2004; Ochsner et al., 2004). Notably, Parvaz et al. (2012) reported that the effect of using cognitive reappraisal may have a stronger impact on frontal asymmetry than the type of emotional stimuli an individual is being exposed to. Importantly, reappraisal-related reductions in frontal alpha were observed on the left but not right frontal electrode sites, which is of interest because previous functional neuroimaging studies (Ochsner, Bunge, Gross, & Gabrieli, 2002) have also demonstrated greater activation in the left PFC during cognitive reappraisal.

Viviani et al. (2010) looked at another way of modulating emotions, avoidance of emotions. They used perfusion imaging, a non-invasive measure to assess various hemodynamic measurements such as cerebral blood volume and blood flow, and examined how the data differed according to spontaneous or instructed avoidance of negative information. To investigate this, a scrambled sentences task[26] was presented before and during the perfusion scan. In the instructed group, participants were asked to form a positive sentence from the word bank and to avoid forming negative sentences. In the spontaneous group, they were simply told to form grammatically correct sentences without specific requirements. For the spontaneous group of participants, Viviani et al. (2010) reported overall decreased brain activity in the dlPFC (in both the left and right side) during avoidance of unpleasant relative to neutral stimuli. This suggests that there was less recruitment of executive attentional areas when exposed to emotional material from the task. There is prior support for Viviani et al. (2010) as previous researchers have reported that individuals who attempt to deal with emotional interference (from negative words or faces) by avoidance may require more attentional resources, thereby taxing executive control systems. This was indicated by increased brain activity in the lateral PFC (Viviani et al., 2010).

[26] The task requires participants to assemble sentences from a set of scrambled words. When legal sentences with different meanings are possible given the words in the set, a choice is implicitly made among the alternative solutions to the task. For example, “bright the very dismal looks future” may be unscrambled to form a negative thought, “the future looks very dismal,” or a positive thought, “the future looks very bright.” When the alternative sentences have an affective meaning, as in this example, healthy participants are remarkably selective and avoided the pessimistic version, forming 70–80% positive sentences even if the existence of emotional words was not mentioned in the explanation of the task.

In contrast, participants in the instructed group had increased activity in the dlPFC during avoidance. This suggests that they may need to recruit the PFC to execute the instruction (i.e. to actively avoid negative information), and this may be a more effortful control process compared to the spontaneous group that were not given specific instructions. Consequently, the use of instructed avoidance was associated with the increase in frontal activation reflecting an effortful recruitment of frontal regions to cope with the high cognitive demands. The study relates to the Study 1 and 2 of this thesis that have also explored avoidance coping. Although the findings have established a relationship between the use of avoidance coping and increased suicidality, the underlying mechanisms of this association remains unknown. Therefore, investigating how avoidance impacts frontal asymmetry may help to explain why it increases the risk of having suicide behaviour.

6.3.2 Attentional control and association with frontal asymmetry

Alongside the impact of appraisal, information processing bias is another factor shown to be important in the progression of suicide behaviour (Johnson et al., 2008). There is substantial evidence to support how deficits in attentional control (including selective attention to relevant information and inhibition of irrelevant information; Riddle, 2007) may be revealed by asymmetrical frontal cortical activity. Miyake et al. (2000) explained that in most situations inhibitory control is vital for ignoring distractions especially those that are highly aversive and emotionally disturbing. Frontal asymmetry may then be able to reflect inhibitory control processes and to facilitate attentional disengagement from emotion (Sanchez, Vanderhasselt, Baeken, & De Raedt, 2016). It is certainly true that inhibitory control underlies the relationship between frontal asymmetry and attentional disengagement from emotion.

To investigate the link between PFC activity and inhibitory control, Compton et al. (2003) measured PFC activity using fMRI in a colour Stroop and an emotional Stroop task. Twelve university students completed both tasks requiring attention and inhibitory control. The stimuli were shown in the form of emotional (positively and negatively valenced) and neutral word stimuli displayed in four colours. They found that activity in the dlPFC increased during the colour Stroop task when the word presented was incongruent to the colour (i.e. the word red presented in green font). Comparable activation was also apparent during the emotional Stroop task when negative words were presented. This shows that inhibiting automatic responses (reading a word) and inhibiting negative information both require PFC activity. It also provides a direct link between frontal activity and inhibitory control. Notably, the recruitment of left (relative to the right) frontal brain regions is important for dealing with increased cognitive demands in inhibiting information that is incongruent and negative in nature. Similar results were conveyed by later studies that repeatedly revealed that failure to recruit the left dlPFC (as indexed by lower frontal cortical activation or more negative alpha symmetric index) in the face of negative distraction is associated with depression (Herrington et al., 2010), and trait negative affect (Crocker et al., 2012). The neurological findings suggest that the alpha symmetric index may be linked to ability in inhibitory control. This indicates that both cognitive and neurological factors may interact to provide a more valid indicator for predicting suicide risk than when only one factor is considered alone.

Joormann and Gotlib (2007) postulated that due to the difficulty in recruiting the left PFC regions for accomplishing tasks such as those in Study 3, this neurological shortcoming in depressed individuals may ultimately lead them to be more prone to negative interference as they are less able to deal with the distraction. These results may explain why depression is often associated with cognitive deficits. For instance, depression (linked to greater rightward frontal activity) is characterized by poor inhibition of negative (but not positive) distractors (for reviews, see Cisler et al., 2011; Gotlib & Joormann, 2010; Snyder, 2013).

When examining frontal asymmetry with attentional control, Miyake et al. (2000) cautioned that aside from inhibition, other control mechanisms such as updating, attention, and shifting may be involved (see Miyake et al., 2000). Therefore, it is difficult to conclude whether frontal asymmetry is impacted by inhibition, other cognitive factors or a combination of both. Pérez-Edgar et al. (2013) conducted a study investigating frontal asymmetry in relation to attentional bias and avoidance. Frontal EEG was measured from young adults at rest and under a socially threatening situation (preparing to give a short speech about their most embarrassing moment in public). Following this, participants performed a dot-probe task in which they stared at a fixation cross in the center of a screen with two facial stimuli presented randomly to either side. There were two photographs of the same face presented in each trial; one portraying an emotional expression (angry or happy) and the other portrayed a neutral expression. A dot was then presented in the location of one face and participants had to indicate the location of this dot as quickly as possible. In general, responses are faster to dots that appear in the location of the emotional stimulus, though this varied according to the stimulus and any emotional bias that the participant had. Results showed that frontal alpha asymmetry in the resting state did not predict performance in the dot-probe task, however there was a strong link between behavioural performance and frontal asymmetry in the socially threatening situation condition. Specifically, an increase in rightward frontal alpha asymmetry in this condition was associated with increased attentional bias to angry faces and avoidance of happy faces but there was no association between leftward frontal asymmetry and emotion of the faces. This finding also complements the capability model in that the situation context has a critical impact in moderating EEG asymmetry aside from the importance of the emotion of stimuli as stated by Davidson et al. (1984).

In an investigation by Grimshaw, Foster, and Corballis (2014) who have used a dot-probe task that is similar to the one in Pérez-Edgar et al. (2013), participants were instructed to respond to probes appearing in the same spatial location as emotional faces. Results replicated the findings of Pérez-Edgar et al. (2013) as individuals with rightward frontal asymmetry showed an attentional bias towards angry faces but away from happy faces. It was concluded that this pattern is similar to the attentional bias towards negative information found in depressed individuals and the association of this with reduced leftward frontal cortical activation. However, participants with leftward frontal asymmetry showed no attentional bias towards any emotion.

From these findings, Grimshaw and Carmel (2014) stated that lateralized frontal asymmetrical differences may impede inhibitory control, an important cognitive aspect in managing and reducing suicidal behaviour (Carter & van Veen, 2007). For instance, effective response inhibition can prevent an individual from acting impulsively, whilst interference control can help them to selectively inhibit irrelevant and intrusive thoughts, such as those relating to self-harm (Diamond, 2013). Deficits in attention and inhibitory control have also been linked to the reduced ability to deal with emotional disturbances that are commonly found in suicidal patients (Desmyter et al., 2011; Jollant et al., 2011). Grimshaw and Carmel (2014) provided an explanation for the inhibitory difficulties in depressed individuals arguing that they are unable to utilize the parts of the brain (i.e. the left PFC) responsible for inhibition, particularly the inhibition of negative information. Supporting evidence for this postulation is derived from Pan et al. (2011) who reported impairments in inhibitory control for suicidal individuals and shows the relationship between cognitive processing and asymmetrical cortical activity.

6.3.2.1 The asymmetric inhibition model

On the basis of how frontal asymmetry relates to inhibitory control, the *asymmetric inhibition model* (Grimshaw & Carmel, 2014) was recently developed to explain variations in frontal asymmetry as a reflection of inhibitory control. The model proposes that each frontal region specializes in the control of different types of emotions, with the left side controlling negative information and the right side controlling positive information. More specifically, the left dlPFC is anatomically specialized for inhibiting negative stimuli, and the right dlPFC is responsible for inhibiting positive stimuli. Therefore, frontal asymmetric activation reflects disproportionate ability to inhibit different types of emotional stimuli. Similar findings using fMRI have previously been noted by Compton et al. (2003) who reported increased activation in the left (but not the right) dlPFC during inhibition of irrelevant negative (compared to neutral) distractors during emotional Stroop task and in the incongruent trials of the colour Stroop task. However, findings that showed links between activity in the right dlPFC and control of positive distractors are less robust and inconclusive (Grimshaw et al., 2014, Herrington et al., 2010). This is because there are far more studies of negative than positive emotional processing, so the evidence is dominated by negative studies (e.g., Ochsner et al., 2012; Wager et al., 2003).

Supporting evidence for the asymmetric frontal activation in inhibitory control is derived-from a study by Richard-Devantoy, Szanto, Butters, Kalkus and Dombrovski (2015b) using a colour-word interference test similar to the Stroop task. Participants were 17 healthy controls and 38 depressed individuals with no past suicide attempts or suicide ideation, 16 depressed individuals with suicide ideation, 14 depressed low-lethality suicide attempters, and 17 depressed high-lethality suicide attempters. The task involved colour naming, word reading, inhibition, and switching trials. Compared to healthy controls and those with suicide ideation, high-lethality suicide attempters took longer to respond to inhibition trials. Based on the findings it was argued that whilst individuals with adequate inhibition may exert control over inappropriate behaviours (such as self-harm) and are better able to resist suicidal urges, those with impaired inhibition may be less able to exhibit control over these impulses, and may have difficulty resisting the urge to act on suicidal thoughts. Deficits in inhibitory control may therefore predict whether an individual will engage in suicidal behaviour. Richard-Devantoy et al. (2015b) argued that the results have important implications for suicide behaviour because deficits in inhibitory control may undermine the ability to deal with real-life emotional distractions. The authors do however state that executive control is impacted by age as older adults may go through cognitive decline and have more substantial deterioration of cognitive control, therefore their findings are limited due to the fact that they used a group of older adults. Consequently, it would be beneficial to assess such deficits in a younger population.

6.4 Study 5: Investigation of frontal EEG asymmetry and attentional bias as prospective markers of suicidality

6.4.1 Aims and intentions of the current study

Built upon the non-significant findings in Study 3, the current study aims to investigate the relationship between frontal asymmetry, suicidality, depression, and inhibition in a sample with higher level of suicidality. With the high comorbidity between suicidality and depression and the importance of avoidance coping and cognitive reappraisal in suicide behaviour, the present study will continue to examine these variables. It is predicted that reduced use of cognitive reappraisal, higher levels of depression and greater use of avoidance coping will correlate with higher levels of suicidality. Frontal asymmetry was recorded from individuals reporting high and low levels of suicide behaviour at resting state (both eyes closed and eyes opened) and during a colour Stroop task and an emotional Stroop task. With several methodological limitations raised in Study 3, the current study aims to revise the previous experimental design and reexamine how frontal asymmetry is linked to suicide behaviour. Therefore, the selection of high and low suicidality groups in Study 5 was carefully considered by recruiting participants with a higher severity of suicidality. It was predicted that with a sample of higher suicidality in the current study, the effect of suicide on frontal asymmetry will be significant.

Using the colour Stroop task will also allow differences in inhibition to be measured according to levels of suicidality. It was predicted that individuals with high suicidality would show a bigger Stroop interference effect than the low suicidality group. In terms of the previous emotional Stroop investigation in Study 3, the discussion raised the argument that suicidality is related to information processing bias, but perhaps a highly specific bias towards suicide related information only. This was explored in the present study by having the word *suicide* in the emotional Stroop task. For the emotional Stroop task, it was predicted that participants would show the expected emotional Stroop effect, but that the high suicidality group would show increased difficulty inhibiting negative words.

Further predictions were based on the asymmetric inhibition model that leftward frontal activation would correspond to inhibition of negative stimuli whereas rightward frontal activation would correspond to inhibition of positive stimuli. Additionally, it is predicted that difficulty in recruiting the corresponding brain region (i.e. the left) will impede inhibition, as such, those who report high levels of suicidality will show relatively higher rightward frontal activation during the colour Stroop task.

6.4.2 METHOD

6.4.2.1 Design

The study used a mixed measures design to investigate the effects of suicide behaviour in a colour Stroop task and an emotional Stroop task. Suicide behaviour was a between-participants variable with two conditions, high and low levels of suicidality. The dependent variables were response time for the Stroop tasks and frontal asymmetric index for the EEG measure. The dependent variables within the self-reported measures were coping, emotion regulation, and depression. In the colour Stroop task a 2 (suicide behaviour) x 2 (congruency) design was used. Congruency referred to whether each colour word was the same (congruent) or different (incongruent) to the colour in which the word was presented and this was a within-participants variable. In the emotional Stroop task a 2 (suicide behaviour) x 3 (emotion) design was used. Emotion was the valence of the words presented with positive, negative, and neutral words. This was a within-participants variable. The dependent variable was response times (milliseconds) to accurately respond to the colour of each word.

Frontal asymmetry was recorded during resting state and during the colour Stroop and emotional Stroop tasks. In the resting state and colour Stroop task asymmetry was compared between the high and low suicide group. In the emotional Stroop task asymmetry was compared between these two groups and across the three conditions of emotion.

For the EEG measures, level of suicidality (high or low) was the between-participant variable and the state that EEG measures were taken was a within-participant variable. The states include resting (eyes open and eyes closed), during the colour Stroop task, and the emotional Stroop task (positive, negative, and neutral). A positive alpha asymmetry index reflects higher left frontal alpha power and relatively lower right frontocortical activity. A negative asymmetry index reflects higher right frontal alpha power and represents relatively lower left frontocortical activity.

6.4.2.2 Participants

Fifty-four Psychology students (22 males, 32 females) studying at The Open University in Hong Kong were recruited by convenience sampling. Age ranged from 18 to 27 years, with a mean of 21.65 years (SD = 2.10). Within the sample, 22 participants were identified as having high suicidality and 32 were identified as having low suicidality. All participants were Chinese-English bilinguals. They were all studying for a degree in their L2 so were considered proficient in both languages, and all acquired L2 prior to the age of 6. Prospective participants were prescreened for previous history of neurological and mental health problems (e.g., currently taking medication known to affect cognitive performance, cognitive deficits, and diagnosis of PTSD).

6.4.2.*3 Stimuli and Materials*

6.4.2.*3.1 Questionnaires*

A total of 5 questionnaires were used for this study. Suicide behaviour was measured using the Suicidal Behaviour Questionnaire - Revised (SBQ-R; Osman et al., 2001), emotion regulation was measured using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003), coping strategies were measured using the R-COPE (Zuckerman & Gagne, 2003), the Beck Depression Inventory-II (BDI-II; Beck et al., 1996) was used to measure depression, and a questionnaire was included to collect general demographics.

6.4.2.*3.2 Behavioural tasks*

The Stroop tasks were presented on a 19″ computer monitor using E-Prime. In the colour Stroop task the words “red”, “yellow, “blue”, and “green” were presented in bold Times

New Roman font, size 36. Each word was presented in the colour red, yellow, blue, or green depending on the congruence of the trial.

The emotional Stroop task was adapted from Herrington et al. (2010). All words (see Appendix 5.5) were presented in one of four colours (red, yellow, blue, and green). A total of 192 words were used from the Affective Norms for English Words (ANEW, Bradley & Lang, 1999); positive (e.g. *birthday, laughter*), negative (e.g., *suicide, funeral*), and neutral (e.g., *handle, carpet*). There were 64 positive words (valence ranged from 6.17 to 8.43 with a mean of 7.49), 64 negative words (valence ranged from 1.61 to 3.69 with a mean of 2.27), and 64 neutral words (valence ranged from 4.02 to 7.57 with a mean of 5.64).

6.4.2.3.3 EEG equipment

The EEG activity was measured using the same Emotive EEG Neuroheadset as in Study 3 (Emotiv Technology Inc., USA).

6.4.2.4 Procedure

All participants were given an information sheet and consent form together with the questionnaires. They were asked to read the instructions and then completed each questionnaire (demographic, SBQ-R, BDI-II, ERQ, and R-COPE), which took approximately 20 minutes. After questionnaire completion, participants were seated in a dimly lit room and the EEG headset was affixed to the scalp with sites located according to the 10/20 system (Malmivuo & Plonsey, 1995). The impedence at each site was checked to ensure good contact quality (large signal to noise ratio). Participants were instructed to remain seated in a relaxed state and EEG recordings were taken with the eyes closed for two minutes and the eyes open for another two minutes to provide a resting state measure. Next, participants were asked to complete the colour and the emotional Stroop tasks whilst wearing the EEG emotive headset. The order of the tasks was counterbalanced across participants. For both tasks, a trial began with a fixation cross of 500ms followed by the presentation of a word in the center of the screen. For each word participants were asked to identify the colour of the text as quickly as possible by pressing the corresponding key (R, Y, B, and G). The word remained on the screen until a response was made, or for a maximum of 1500ms. A total of 60 trials were completed in the colour Stroop task with 30 congruent and 30 incongruent trials. There were an equal number of words presented in red, yellow, blue, and green (i. e. 15 words presented in each colour in each block), and all trials were presented in a random order. The emotional Stroop task consisted of three emotional blocks showing positive, negative, and neutral words. The order of the blocks was randomized and there were 64 trials in each block. An equal number of words were presented in each of the four colours within each block and all trials were presented in a random order.

6.4.3 RESULTS

Two participants were excluded from the analyses due to poor EEG data or missing behavioural data. The remaining 52 participants (21 males and 31 females) were all right handed and were not taking any medication known to affect brain activity or cognitive performance. Participants were separated into high and low levels of suicidality groups according to the total score in the SBQ-R. Participants with a total of below 7 (Median score = 5.00, range = 3-6), were categorized as low suicidality, whilst participants with a score of 7 or above (Median score = 9.50, range = 7-15) were categorized as high suicidality. There was a total of 30 in the low suicidality group, 22 participants in the high suicidality group of which 6 participants (11.54% of the total sample) reported having a past history of suicide attempt. The data did not meet parametric assumptions therefore a Mann Whitney U test was used. Difference in measures of suicide behaviour, depression, emotion regulation and coping between high and low suicidality groups are shown in Table 6.1.

As predicted, the group with high suicidality reported significantly higher scores for suicide behaviour, $U = 0.001$, $z = -6.162$, $p < .001$, and depression, $U = 106.0$, $z = -4.158$, $p < .001$, but lower cognitive reappraisal, $U = 223.50$, $z = -1.983$, $p < .05$ (Appendix 6.5.1). They reported significantly lower scores for self-punishment coping, $U = 208.50$, $z = -2.264$, $p < .05$, than the group with low suicidality. There was no significant difference between groups of high and low suicidality for all other measures of coping strategies and emotion regulation (i.e. expressive suppression).

***Table 6.1* presents the means and standard deviation for measures of suicide behaviour, depression, emotion regulation and coping**

	High suicidality n=22		**Low suicidality** n=30		**Total** N=52	
	Median	Range	Median	Range	Median	Range
Suicidality	9.50	7-15	5.00	3-6	6.00	3-15
Depression	28.00	8-42	9.00	1-33	15.50	1-42
Cognitive reappraisal	27.00	10-40	30.00	23-39	29.00	10-40
Expressive suppression	17.00	7-20	18.00	11-24	17.50	7-24
Avoidance coping	18.00	16-23	19.50	11-27	18.00	11-27
Self-punishment coping	20.00	14-26	22.00	13-27	21.00	13-27
Accommodation coping	21.00	13-27	20.00	15-27	21.00	13-27
Approach coping	23.00	17-31	24.00	19-35	24.00	17-35
Self-help coping	19.00	13-26	18.00	14-31	18.50	13-31

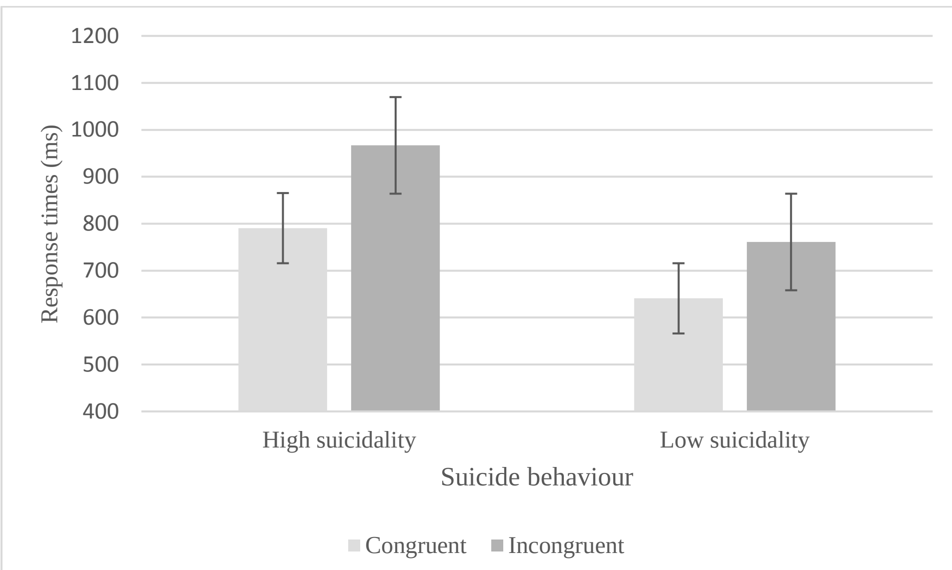
6.4.3.1 Stroop task performance

To analyse performance in the colour Stroop task, a 2 (suicidality) x 2 (congruency) mixed measures ANOVA was conducted (Appendix 6.5.2). All incorrect trials were removed and any correct response times that were more than 2.5 standard deviations from the mean were classed as outliers and removed (a total of 4.84% of trials).

The ANOVA showed a significant effect of suicide behaviour, F (1, 50) = 28.916, MSE = 27712.152, $p < .001$, partial $\eta2$ = 0.366. Participants reporting lower levels of suicide behaviour showed faster response times than those with higher levels (means of 700.95ms and 878.62ms respectively and standard deviations of 146.601 and 144.179). There was a significant effect of congruency, F (1, 50) = 127.853, MSE = 4360.631, $p <$ .001, partial $\eta2$ = 0.719, with faster response times to congruent (M = 704.17, SD =

135.59) than incongruent trials (M = 848.05, SD = 170.78). There was also an interaction between suicidality and congruency, F (1, 50) = 4.605, *MSE* = 4360.63, $p < .05$, partial η2 = 0.084. Simple main effects analysis showed that in both groups response times for incongruent trials were significantly slower than for congruent trials (all *ps* < .001), however the difference was greater in the high suicide behaviour group. This indicates that the difference in responding to congruent and incongruent trials was greater in the high suicide group (see Figure 6.1).

Figure 6.1. Colour Stroop task performance for the high and low suicidality groups

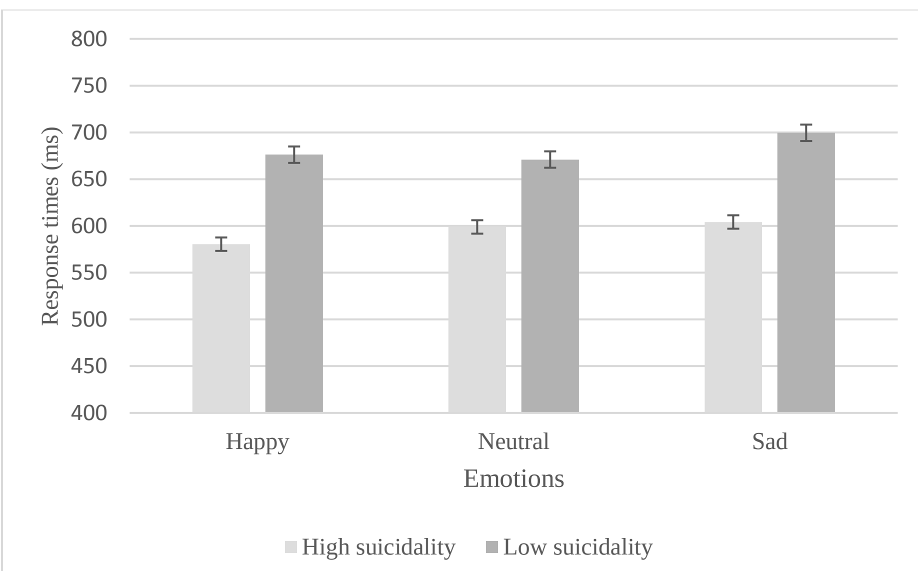


Note: Error bars showing standard error

To analyse performance in the emotional Stroop task a 2 (suicide behaviour) x 3 (emotion) mixed measures ANOVA was conducted (Appendix 6.5.3). A total of 4.21% of trials were removed due to response times that were more than 2.5 standard deviations from the mean. Mean response times are summarized in Figure 6.2. There was a significant effect of suicide behaviour, F (1, 50) = 11.30, *MSE* = 8495.123, $p < .001$, partial $\eta^2 = 0.184$, with faster response times in the high suicide group (M = 593.31ms, SD = 84.83) compared to the low suicide group (M = 679.76ms, SD = 94.95). There was no significant effect of emotion, F (2, 100) = 1.824, MSE = 3969.585, p = .167, partial η^2 = 0.035, and no interaction between suicide and emotion, F (2, 100) = .608, MSE = 3969.585, p = .546, partial η^2 = 0.012.

To assess inhibition of suicide-related stimuli response times were also considered across the two suicide behaviour groups when responding to the word "suicide". A between-participants t-test was conducted and this showed significantly longer response times in the high suicide group compared to the low suicide group (means of 726.20ms and 652.78ms respectively standard deviations of 126.32 and 116.12), t (50) = 2.17, p = .035.

Figure 6.2 Emotional Stroop task performance for the high and low suicide groups



Note: Error bars showing standard error

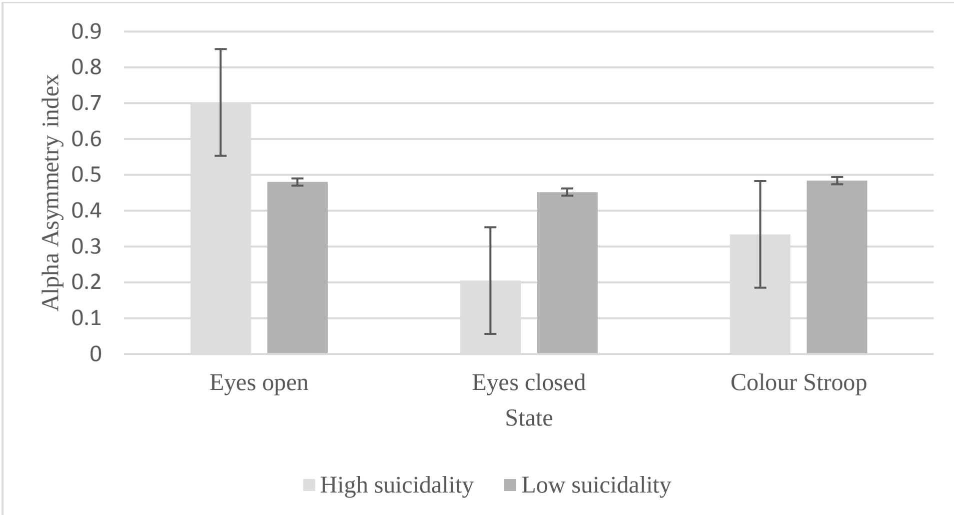
6.4.3.2 Frontal Asymmetry

Using the log transformed EEG power in the alpha bandwidth from frontal (F3, F4) recording sites during resting state and during the cognitive tasks, the alpha asymmetrical index was calculated and used as the dependent variable. According to the alpha asymmetric index (uV^2) in Figures 6.3 and 6.4, all participants generally showed positive asymmetric values across different conditions (except for the neutral condition in the emotional Stroop task) regardless of suicidality.

6.4.3.2.1 Frontal alpha asymmetry in resting state

To examine the impact of suicide on EEG asymmetry during resting state (eyes opened and eyes closed state), independent t-tests were conducted with suicide group as the between participant variable and alpha asymmetrical index as the dependent variable (Appendix 6.5.4). Opposite to what was expected, the alpha asymmetrical index was higher in the group with high suicidality (M = 0.70uV2, SD = 0.498) than the low suicidality group (M = 0.514uV2, SD = 0.666) during the eyes open resting state, t (50) = -2.63, p = .011. This means that whilst both groups showed more activity in the left compared to the right, this was most pronounced for the high suicidality group. However, there was no significant difference in alpha asymmetry between the high and low suicidality groups during the eyes closed resting state, t (50) = -1.497, p =.141 (see Figure 6.3).

Figure 6.3. Comparison of alpha asymmetry between suicidality groups in resting state and when completing the colour Stroop task



Note: Error bars showing standard error

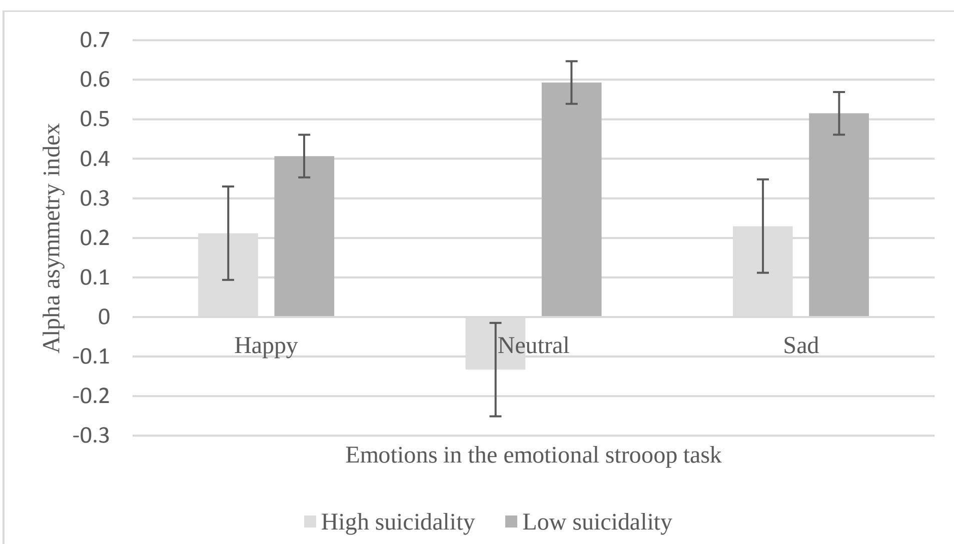
6.4.3.2.2 Frontal alpha asymmetry in colour Stroop and emotional Stroop tasks

To examine the impact of suicide on EEG asymmetry during the colour Stroop task independent t-tests was conducted with suicide group as the between participant variable and alpha asymmetrical index as the dependent variable There was no significant difference in alpha asymmetrical index between the high and low suicidality group in the colour Stroop task, t (50) = -.580, *p* =.564 (Appendix 6.5.5).

For the emotional Stroop task, emotion of stimuli (happy, sad, or neutral) was the within participant variable and suicidality (high and low) was the between participant variable. A 2 (suicide behaviour) x 3 (emotion) mixed measures ANOVA on alpha asymmetrical index showed a significant effect of suicide, *F* (1, 50) = 4.024, *MSE* = 0.484, *p* = .05, partial η^2 = 0.074, with a more positive index in the low suicidality group (M = 0.495 uV^2, SD = 0.811) than the high suicidality group (M = 0.103 uV^2, SD = 0.608). There was also a significant effect of emotion, *F* (1.358, 67.91) = 13.73, *MSE* =

0.113, $p < .001$, partial $\eta^2 = 0.215$ (Appendix 6.5.7). Planned contrasts were completed to compare asymmetry in the positive and negative conditions compared to neutral. These revealed that the alpha asymmetry index was significantly higher for negative words (M = 0.440 uV^2, SD = 0.782) compared to neutral words (M = 0.178 uV^2, SD = 0.804), F (1, 50) = 16.632, *MSE* = 0.231, $p < .001$, partial $\eta^2 = 0.250$, and higher for positive words (M = 0.369 uV^2, SD = 0.662) compared to neutral words (M = 0.178 uV^2, SD = 0.804), F (1, 50) = 12.852, *MSE* = 0.175, $p = .001$, partial $\eta^2 = 0.204$, see Figure 6.4. There was no interaction between emotion and suicide behavior, F (1.358, 67.91) = 3.068, *MSE* = 0.113, $p = .072$, partial $\eta^2 = 0.058$. There was however a trend indicating that the high-risk participants showed a negative asymmetry index in the neutral condition compared to the two emotional conditions, and this pattern was not found for the low-risk participants. This negative index here reveals relatively more rightwards activity.

Figure 6.4. Comparison of alpha asymmetry between suicidality groups when completing the emotional Stroop task



Note: Error bars showing standard error

6.4.4 DISCUSSION

To examine frontal asymmetry in accordance with some key models, frontal asymmetry was compared during resting state (both eyes closed and eyes opened) and during task performance state (a colour Stroop task and an emotional Stroop task). Extending from the two differing models of asymmetry, the dispositional model (Davidson et al., 1979; 1984) asserts that individuals who report higher levels of suicidality will correspond to rightward frontal activity compared to those with low suicidality regardless of the situation. However, the capability model (Coan et al., 2006; see also Stewart et al., 2014) argues that the effect of suicidality on asymmetric frontal brain activation will be more apparent during emotionally demanding situations. The present investigation has improved from Study 3 with revised selection of high and low suicidality groups, with a divergent range between two groups. The current study presented the high risk group with Median score = 9.50, range = 7-15, and low suicidality group with Median score = 5.00, range = 3-6. Conversely, Study 3 presented the high suicidality group with Median score = 8.00, range = 7-13 and low suicidality group with Median score = 3.00, range = 1-5. With the revised selection of sample, it was predicted that there will be frontal asymmetrical difference between individuals with high and low levels of suicidality.

Based on the previous findings in the current research, some variables were shown to be important in the manifestation of suicide behaviour, and they were further examined to see how they may impact frontal asymmetry. It was predicted that individuals with a high level of suicidality would show difficulties in inhibitory processing overall, difficulties inhibiting negative stimuli, and reduced leftwards frontal activity. The predictions were based on previous studies which have documented that deficits in cognitive processing and neurological activity have been consistently linked to suicide behaviour (Imbir & Jarymowicz, 2013; Richard-Devantoy & Courtet, 2016). The present study also aimed to determine whether difficulties in inhibitory control and patterns of frontal asymmetry could be used to identify those at risk of suicidal behaviour.

6.4.4.1 Stroop task performance

In the colour Stroop task, the high suicidality group took significantly longer than the low suicidality group to name the colour of each word, regardless of whether this was congruent or incongruent. This shows they have more difficulties with inhibitory control. The results fit well within previous research and are consistent with the findings of Richard-Devantoy et al. (2015b) that suicidal individuals have more limited inhibitory control processes and may be less able to withhold their impulses. In the emotional Stroop task, the high suicidality group responded quicker than the low suicidality group. This pattern was found for all three types of emotional words (positive, negative, and neutral) and would indicate that those reporting high levels of suicide behaviour are able to inhibit irrelevant information more effectively than those reporting low levels. This is inconsistent to the findings of the colour Stroop test. The overall lack of any emotional Stroop effect within this task is also inconsistent with past findings showing that response times in an emotional Stroop task are generally slower to emotional words compared to neutral words (Ben-Haim et al., 2016; Cothran & Larsen, 2008).

When interpreting the differences between the colour and emotional Stroop tasks between the two groups, individuals with high levels of suicidality are slower to inhibit irrelevant information at a general level, yet when presented with emotional stimuli they may act more quickly and somewhat impulsively. The importance of impulsivity has been previously documented in the warning signs for suicidal behaviour listed by the American Association of Suicidology and includes acting recklessly (American Association of Suicidology, 2017). The Association specified that the presence of impulsivity, inhibitory problems, and inflexible thinking processes may lead to an increased risk of suicide. Rudd (2006) has also incorporated the measures of impulsivity into suicide risk assessment tools. It is proposed that impairments in self-control, or difficulties in controlling one's own impulses are useful indicators of acute suicide risk.

Whilst it may be argued that those with high levels of suicidal behaviour can respond more quickly to emotional stimuli compared to neutral one, this may question why high risk group did not show longer response times in the neutral condition of the emotional Stroop task. It is acknowledged that the neutral words would not be considered as emotional stimuli yet this task is still substantially different from that of the standard colour Stroop task. In particular, in the incongruent trials of the colour Stroop task the to-be-ignored information (the word) is in direct competition with the to-be-identified information (the colour). This is not the case in the emotional Stroop task. Consequently, the differing patterns of inhibitory control across the two tasks may indicate that individuals with a greater risk of suicide will have more difficulty inhibiting directly competing responses, but not information that has not semantic relationship to the task they are completing. This would still support the notion of increased impulsivity but suggests that this impulsivity may be situation-specific.

Further support for this argument comes from the response times in identifying the colour of the word *suicide* in the emotional Stroop task. Results showed that the pattern of performance in the task reversed and the low suicidality group performed better. Those in the high suicidality group took longer to respond to the colour of this word showing that they have difficulties inhibiting emotionally relevant information. It is proposed that such “personally” relevant information is more salient and despite being irrelevant to the task it competes for attentional resources in the same way that the directly competing word meaning does in the colour Stroop. The bias of attention to emotionally significant stimuli supports the findings of Chung and Jeglic (2015) who also reported no emotional Stroop effect in individuals high in suicidality but found evidence for a specific attentional bias to the word *suicide*. This may also explain the absence of an emotional Stroop effect in Study 3, in that participants were not showing a general bias to positive or negative stimuli but were indeed having highly specific bias to suicide-related stimuli only. In Study 3 there was no emotional Stroop effect found and there may have been signs of a specific attentional bias if this word *suicide* had been included. In relation to the suicide specific Stroop interference in the suicidal population, Cha et al. (2010) propose that a stimulus-specific Stroop interference effect (whereby only disorder-related words lead to longer response times) may be particularly useful for clinicians. They found that it was able to predict, above and beyond other clinical measures, for those individuals who went on to make a suicide attempt within the following 6 months. Evidently, the current findings support this suggestion, in that a specific attentional bias may exceed the predictive validity of any general negativity bias and has the potential to be a useful marker for suicidality.

6.4.4.2 Frontal asymmetry and suicide behaviour

Consistent with the findings in Study 3, the EEG recordings in the eyes closed resting state gave no support for the dispositional model as individuals with high and low suicide risk did not differ in their alpha asymmetry index. Although there was a significant group difference during the eyes open resting condition, the difference was opposite to the predictions made. Individuals in the high suicidality group had more leftward frontal activity than the low suicidality group indicating that this side of the brain is more active at baseline. However, when the EEG recordings were taken during the colour Stroop task there was no significant difference in alpha asymmetrical index between high and low suicidality groups. This reveals that measurements of frontal asymmetry during a demanding task make no improvement on those taken in a resting state with regards to identifying individuals high in suicidality. Therefore, echoing the findings in Study 3, the present results contradict the dispositional model. Consistent with proposals of the capability model (Coan et al., 2006), the present results did however reveal a significant difference in frontal asymmetry between the high and low suicide suicidality group during the emotional Stroop task. In particular, the low suicidality group showed more leftward frontal activation compared to the high suicidality group. This supports past research (Compton et al., 2003) that recruitment of left (relative to the right) frontal brain regions is especially important when dealing with increased cognitive demands (e.g. inhibiting irrelevant stimuli in a Stroop task). The present findings also support past studies that failure to recruit the left dlPFC when exposed to distraction may be associated with more emotional disturbance, resulting in increased level of depression

(Herrington et al., 2010; Joorman & Gotlib, 2007), and trait negative affect (Crocker et al., 2012).

6.4.4.2.1 The use of reappraisal and avoidance

Consistent with the findings in Study 2, the high suicidality group reported less frequent use of cognitive reappraisal and showed higher levels of depression. However, there was no significant difference between high and low suicidality groups in terms of emotional suppression and all other measures of coping.

To investigate how frontal asymmetric activation may be associated with approach and withdrawal motivation, some researchers have presented participants with specific stimuli, inducing a particular state, or by using the BIS/BAS scale (Gable & Harmon-Jones, 2008; Neal & Gable, 2017), Harmon-Jones et al., 2009, 2010). For example, Wen et al. (2017) have recently examined withdrawal related behaviour by observing how participants avoid social interactions with others. It was found that right frontal EEG asymmetry was associated with negative affect and avoidance behaviour. Although there is convincing evidence that the use of cognitive reappraisal corresponds with increased leftward cortical activation (Parvaz et al., 2012) whereas avoidance corresponds with the rightward cortical activation (Wen et al., 2017), the present results failed to replicate these dissociated neurological patterns. There were no significant associations between alpha asymmetry and cognitive reappraisal or avoidance coping. Possible explanation could be that frontal cortical activation may only correspond to real-time behaviour of approach and avoidance. Differences may not be apparent in more general situations when EEG recording was taken, this activation may not be apparent in individuals who report a general use of such behaviour (as indexed by ERQ in this study) who but may not be executing such behaviour during the study when EEG measures were taken.

In prior studies where approach-related behaviour was studied in relation to frontal asymmetry (e.g. Lang, 1995), researchers have typically focused on aggressive and aversive stimuli to represent approach and withdrawal related behaviours respectively. These stimuli were chosen based on the appetitive and defensive systems (Lang, 1995). An appetitive system motivates life sustaining and reproductive (e.g. approach) related behaviours and responses in order to benefit from potentially advantageous situations. It is often associated with positive subjective feelings (e.g., enthusiasm or sexual arousal). In contrast, a defensive system motivates protective behavioural and physiological responses (e.g. withdrawal) in order to avoid harm or overcome threat. It is typically associated with negative subjective feelings (e.g., fear or disgust). Whilst the concept of aggression and fear fit well with the evolutionary perspective of approach (to attack) and withdrawal (to stay away) behaviour which incorporates vivid physical actions in relation to fight or flight responses, there are discrepancies in classifying other types of behaviours among studies and individuals. For instance, different researchers have their own definitions and ways of assessing behaviours. With the intention to assess frontal asymmetrical differences in relation to approach withdrawal behaviours, Davidson et al. (2000) hypothesized that the approach and withdrawal systems would be associated with pre-goal attainment emotions; that is, emotions that are typically generated while attempting to achieve a goal. This suggests that the approach system is linked to enthusiasm but not contentment. In a related vein, the findings in Study 3 suggested that participants might have different prefrontal activity at baseline (i.e. before the experiment), but because they were motivated to accomplish a goal (e.g. to complete the experiment), this could elicit approach behaviour and may in turn lead to greater leftward frontal activation across all participants during the study. Based on the alpha asymmetrical index in both Study 3 and 5, this suggestion may be valid since that most participants exhibit leftward frontal cortical activity (the frontal asymmetry associated with approach motivation) throughout the experiment.

6.4.4.2.2 Frontal asymmetry and inhibition of emotional distractors

Since both the dispositional model and the capability model have not addressed how an information processing bias may link to suicidality, the EEG investigation continued with a focus on frontal asymmetrical activation in relation to how difficulties in inhibitory control may be accounted for by frontal asymmetrical activation. The asymmetric inhibition model (Grimshaw & Carmel, 2014) suggests that inhibition of different emotional stimuli is linked to frontal alpha asymmetry and that individuals will exhibit leftward frontal cortical activity during inhibition of negative stimuli, and rightward frontal cortical activity during inhibition of positive stimuli. The current study made some advancement from the previous work in Study 3 whereby the emotional Stroop task was separated into blocks (positive, negative, and neutral emotions).

Previous studies have shown that using blocked versus randomized designs has been found to influence the emotional Stroop effect, wherein the effect is larger in blocked compared to randomized designs (Bar-Haim et al., 2007; Cisler et al., 2011, McKenna & Sharma, 2004). This is because attentional control resources may deplete across repeated exposure to one set of emotional stimuli during blocked designs (e.g. exposing participants to many slides of threatening faces), resulting in a larger emotional Stroop effect compared to randomized designs. Based on the claim that greater effects in the blocked design may indicate greater emotional disruption in attentional control (Wyble et al., 2008), the random presentation of emotional trials in the emotional Stroop task from Study 3 was modified to a blocked design for the current investigation. The comparison of frontal asymmetry in the emotional Stroop task depending on the presentation of stimuli (Study 3 and 5) provides support to these findings. With the blocked design, it was found that the examination of frontal asymmetry in different emotions is possible, alpha asymmetry index was significantly higher for emotional (both positive and negative) words compared to neutral words.

Although there is evidence to suggest that frontal asymmetry reflects the inhibitory control of emotions (e.g., Grimshaw & Carmel, 2014; Pérez-Edgar et al., 2013, see Neal & Gable, 2017), the current findings provide limited support for this model. Individuals were showing more leftward frontal activation during inhibition of negative stimuli as predicted, this suggests greater recruitment of left frontal areas during completion of a task that requires inhibition of emotional information. However, they did not show an increase in rightward frontal activity when inhibiting positive stimuli. These results are similar to some of the past findings (Grimshaw et al., 2014, Herrington et al., 2010; Pérez-Edgar et al., 2013) that have shown that the links between cortical activity in the right dlPFC and control of positive distractors are different to those between the left dlPFC and the control of negative distractors. Pérez-Edgar et al. (2013) and Grimshaw et al. (2014) suggest that positive and negative stimuli may not exert the same level of influence on frontal alpha asymmetry. Regarding the investigation of inhibition of emotional stimuli and frontal asymmetry, the frontal asymmetrical difference found during the emotional Stroop task raises questions as to whether the task measures inhibition, other aspects of executive functions or both.

One unexpected finding from the alpha asymmetry analysis was the trend towards a negative alpha asymmetry index in the neutral condition of the emotional Stroop task for the high suicidality group. The pattern of activation was markedly different to that of the other conditions. The finding shows that the high suicide group had relatively higher rightward activation in this condition suggesting that they only recruited more left frontal areas during completion of a task that requires inhibition of emotional but not neutral information. Contrary to the view that frontal asymmetry corresponds to inhibition of different types of emotional information Grimshaw & Carmel, 2014), Compton et al. (2003) argued that all distracters are difficult to inhibit, regardless of their precise emotional content (i.e. either positive or negative). They suggest that frontal asymmetry may reflect a general cognitive control mechanism rather than specific inhibition of different types of emotional information. This means that tasks that require greater inhibitory control such as the colour Stroop and an emotional Stroop task used in their study would have corresponded to individual differences in frontal asymmetry depending on the level of cognitive demands the task exerted.

The present results show some support for the association between frontal asymmetry, inhibition, and suicidal behaviour. However, the results do not fully support previous findings and therefore may indicate that other factors may be involved. Recently, Neal and Gable (2017) proposed that frontal asymmetry may reflect a wide range of cognitive mechanisms, not just inhibitory processes. For example, the dlPFC is activated during tasks requiring task switching (Ambrosini & Vallesi, 2016), working memory (Petrides, 2000), emotion regulation (for a review, see Ochsner et al., 2012), and attentional disengagement (Sanchez et al., 2016). All of these are implicated in vulnerability to psychopathologies associated with frontal asymmetry (Snyder, 2013). These processes require not only inhibitory control but additional control mechanisms such as updating, orienting, and shifting (see Joormann & Tanovic, 2015; Miyake et al., 2000). Therefore, the relationship between frontal asymmetry, emotional distraction, and suicide vulnerability may not be solely related to inhibitory processing.

Previous models (i.e. the SAMS; Johnson et al., 2008, and the Cry of Pain model; Williams, 1997; Williams & Pollock, 2001) have specified that having attentional bias to suicide related information and formation of a suicide schema may predispose individuals to be more vulnerable to such emotional interference. When interpreting the emotional Stroop findings from the perspective of these models it is evident that the attentional bias was linked to suicidality. This bias may lead to having more negative thoughts and increases the chance of carrying out the suicide plans.

6.4.5 CONCLUSION

The current study examined whether measures of cognitive and neurological processing can be used to identify individuals at risk of suicidality. In contrast to Study 3, the current study selected the high and low suicidality group carefully to achieve more difference in self-reported suicide behavior between the two groups. Using EEG in a standard colour Stroop task and an emotional Stroop task, the study identified some key cognitive and neurological differences between individuals reporting high and low levels of suicide behaviour. In particular, results showed that individuals reporting higher levels of suicide behaviour are more likely to encounter difficulties in inhibitory control and will struggle to disengage their attention from suicide-related information. The findings also indicate that frontal alpha asymmetry is a more powerful measure of suicidality when recorded during an emotional challenging task, therefore it would be prudent to take this into account when studying asymmetry in the future. With some support for the asymmetric inhibition model, inhibition of emotional stimuli was associated with leftward frontal asymmetrical activation, however this was the case for both negative and positive stimuli. The findings indicate that frontal alpha asymmetry may serve as one useful tool to distinguish between high and low suicide suicidality under certain emotional contexts. Nevertheless, the present results added that the information bias specified by these models may be over general since suicide individuals exhibited highly specific bias towards the word *suicide* rather than to general negative information as stated.

CHAPTER SEVEN

Discussion

7.1 Review of the research aims and objectives

There are considerable number of studies that have established the link between cognitive impairments and neurological deficits in relation to suicide, yet these findings are mainly based on clinical populations of patients who had a past history of one or more suicide attempts. As any attempt could be fatal, past research argues that suicide prevention by early identification of individuals at-risk of suicide is essential before they reach a dangerous level of suicidality (Palmer, 2004; Klonsky & May, 2014). Therefore, the findings based on clinical populations may not be helpful in this perspective. The focus of the research in this thesis was non-clinical populations, which gives wider application to the preventive and identification measures in predicting suicidality. What had been unclear prior to the present research was that there was a lack of empirical evidence on the neurological or cognitive basis of individuals with mild forms of suicidality, therefore the current research sets out to investigate these factors underlying the development of suicidal behaviours.

To achieve this aim, the initial work investigated a series of theoretically driven factors associated with suicide behaviour; executive function deficits, emotion regulation, coping, and their interactions; and to examine evidence that the use of avoidance, appraisal, and information processing bias comprise proximal predictors for suicide progression. Another aim of this thesis was to examine the cognitive and neurological factors that may confer early stages of suicidality in the student population. All the empirical work is based on previous suicide models which specified that suicide behaviour arises when there is an attentional bias to particular life events reflecting signals of defeat, difficulty in inhibiting irrelevant emotional distractions, and insufficient working memory capacity to solve problems.

With a clear understanding of the intention of this research, a review of literature was conducted regarding the theoretical understanding of suicidal behaviour. This literature review presented in Chapter 1 allowed the researcher to establish the direction that global research has taken and the associated trends regarding the prevalence of suicide behaviour. Although suicidality is a well-explored field of study, a review of previous studies highlighted the fact that limited data were available regarding the study of early stage of suicide. This has caused an obstacle for exploring strategies for early prevention of suicide, especially in a student population in which the prevalence of suicide is increasing at an alarming rate. Therefore, the research set out to investigate the cognitive and neurological underpinnings of suicide at an early stage in the suicide path. The current research aimed to identify the factors associated with suicide in the first studies (via questionnaires) and then experimentally test these in the later studies before exploring the neurological basis of suicidality. One of the noteworthy insights from the prior literature was that the approach of studying the interaction of risk and protective factors is more effective in predicting suicidality than merely exploring the risk factors alone (Johnson et al., 2008; Joormann & Gotlib, 2010; Rajappa et al., 2012). The etiological explanations of suicide have moved away from the conventional risk factors to address how executive functions and emotion regulation abilities, as well as how individuals cope with situations, may interact with suicidality.

Based on the literature review in Chapter 1 it is posited that executive functions may still undergo development at the stage of young adulthood, this may hinder adaptive regulatory process and manifest in suicidality. Evidence for this has been put forth by Bredemeier and Miller (2015) who contend that individuals with deficits in executive functions, particularly shifting, may have more difficulty controlling thoughts about self-harm or switching to more positive or adaptive forms of coping in response to stress. They also explained that when an individual is suicidal, they may lack the cognitive flexibility needed to identify new solutions or coping strategies to deal with the stressors. Conversely, it is argued that individuals with functional cognitive abilities in the form of good working memory, planning, cognitive flexibility, and inhibition are better able to cope effectively with a stressor. For this reason, investigations on the cognitive, coping and emotional factors of the student population would help to understand how these variables interact with suicide behaviour. On the basis of key suicide models, Study 1 was conducted to see which cognitive factor(s) confer the most important predictors for suicidality.

This study adds to the existing research (Loyo, et al., 2013; Løvstad et al., 2016; Keilp et al., 2012; Richard-Devantoy & Courtet, 2016) as it examined the association between deficits in executive functions and increased suicidality by considering how students cope with stressors. Using a series of self-report questionnaires for measures of suicidality, coping, and executive functions (SBQ-R, COPE, and BRIEF-A respectively), it was predicted that increased suicide severity would be associated with greater perceived difficulties of executive functions and greater use of maladaptive form of coping.

In terms of the neurological investigation of suicidality, the literature suggests that asymmetrical frontal brain activation is linked to different degrees of affective disorder and different types of emotional states and responsivity. Among these findings, the alpha (α) frequency band is often used to investigate frontal asymmetry because it reflects a relaxed state of wakefulness (Allen et al., 2004). An increase in the alpha frequency band signifies a resting state with relatively low levels of cortical activity. Conversely, when the cortex is active such as when an individual is engaged in a cognitive task, the alpha frequency band detected is significantly reduced (Davidson, Jackson, & Larson, 2000). To measure frontal alpha asymmetry in the research of this thesis, the EEG was selected because it has been a common tool used to measure the correlates of relative hemispheric dominance (Tomarken et al., 1992; Tucker, 1981). Building upon the current scope of findings, frontal cortical activation was explored in relation to suicide and executive functions. This required examining frontal asymmetrical activation during resting state and task performance state. This final chapter will provide a summary of the findings in this thesis, and will discuss both the theoretical and the clinical implications of this work. Moreover, general limitations will be considered, and directions for future research will be outlined.

7.2 Summary of findings

Replicating some of the past literature (e.g., Burton et al., 2011; Doty, 2012; von Hecker et al., 2013; Imbir & Jarymowicz, 2013; Jollant et al., 2005; Richard-Devantoy & Courtet, 2016), it was found that difficulty in regulating their emotions, problems with initiation, and issues in organizing tasks are critical factors in the recurrence of suicide behaviour.

Results showed that impairment in multiple aspects of executive function may exacerbate problems regulating one's own emotions, thoughts, and actions, which ultimately increase suicidality. Regarding the association between executive functions, coping, and suicidality, it was found that an increased level of suicidality was associated with greater perceived difficulties in executive functions and increased use of avoidance coping, a coping strategy generally classified as maladaptive as it involves both thinking and having purposeful actions to avoid stressful situations (Carver et al., 1989; Endler, 1997). It reflects cognitive and behavioural attempts to avoid thinking about a stressor. These include venting of emotion, mental disengagement, alcohol-drug disengagement, behavioural disengagement, and humor. Some of the findings in this thesis were inconsistent to prior studies. For instance, past studies revealed that the increased use of emotion-focused and avoidant-focused coping were associated with higher levels of suicidality, whilst the increased use of problem-focused coping was associated with lower suicidality (e.g., Kirchner et al., 2011; Morris et al., 2014; Tang & Qin, 2015). However, Study 1 reported the opposite trend where an increased use of emotion-focused coping was associated with reduced levels of suicidality, whilst an increased use of problem-focused coping was not associated with reduced suicidality. It was reasoned that for student population emotion-focused coping could be an effective coping strategy that allows more emotional expression, thus promoting a positive social response (Stanton et al., 2000). Moreover, the use of emotional coping is also more effective for dealing with uncontrollable stressors versus controllable ones, it may help to alleviate distress temporarily without violating norms, which is crucial in Chinese culture (Matsumoto et al., 2008). With the unexpected finding that increased problem-focused coping did not correlate with reduced suicide behaviour, it was reasoned that the student sample who were young adults are yet to fully develop their executive functions. They may not have mastered their problem-focused coping strategies in order to tackle their challenging stressors. Therefore, it is possible that because participants may not be able to use this coping strategy effectively they disregard it as an option. This suggestion is substantiated by the findings on problem-focused coping and executive functions. For example, students who may not yet have developed their executive functions (as indexed by higher scoring of BRIEF-A) used problem-focused coping strategies to a lesser extent to tackle their challenging stressors. The results suggest that when individuals have more difficulties with their executive functions they may turn to use other copings strategies that are generally maladaptive (e.g. avoidance). The results of Study 1 confirm that the study of undergraduates reflects a crucial developmental stage when executive functions and coping skills are maturing and gaining importance as factors for their psychological health (Compas et al., 2001). This has raised the idea that as an individual's ability to master problem-focused coping effectively is dependent on their executive functions, this may increase suicide behaviour which is also linked to greater use of avoidance coping strategies. It is also noted that the study showed no evidence for cross-cultural difference in suicide behaviour. Given the non-significant difference in suicidality between UK and HK samples the remaining studies just used participants from HK.

Based on the findings of Study 1, critical risk factors of suicide were further considered in Study 2 in relation to the key suicidal models. In accordance with the Escape theory (Baumeister, 1990) and the Cry of Pain model (Williams & Pollock, 2000, 2001), avoidance coping was regarded as a form of motivation to escape. Rather than merely discussing the risk factors of suicide it was noted that addressing resilience factors against suicide is of comparable importance. Therefore, a key resilience factor was investigated based on the Schematic Appraisals Model of Suicide (SAMS; Johnson et al., 2008). This model specified that the use of reappraisal, which is to find positive attributions or interpretations of an event may serve as a resilience factor and protect against suicidal behaviour in light of a motivation to escape. To test the different predictions in relation to these three models Study 2 was conducted using self-report questionnaires to measure emotion regulation (cognitive reappraisal and expressive suppression), avoidance coping, and depression. Depression was investigated using self-report questionnaire (BDI-II) due to its high comorbidity with suicidality (Bostwick & Pankratz, 2000; Wang et al., 2007). The study sought to establish whether the separate constructs of cognitive reappraisal and avoidance coping would differentially impact suicidal behaviour and depression. The results echoed the results of Study 1 that suicidality was associated with increased use of avoidance coping. In addition, increased depression and reduced use of cognitive reappraisal correlated with increased suicidality. A non-significant relationship between expressive suppression and suicidality was explained by the distinctive characteristics of the Chinese culture, which accepts this method of regulating emotion. This argument was based on prior findings (Butler et al., 2007; Soto et al., 2011) which have also documented that emotional suppression was only associated with more negative emotions and adverse psychological functioning in European Americans but not in Asians.

With limitation of using self-report measures in Study 1 critical executive functions were explored experimentally in Study 3. Attention, inhibition, and working memory were measured using the emotional Stroop task, the Go/No-Go task, and the N-back task. An EEG was also used to investigate whether alpha frontal asymmetry could serve as a neurological indicator for characterizing high suicidality. It was predicted that there would be a difference in terms of cognitive task performance and EEG frontal asymmetry between high and low suicidality groups. However, contradictory to predictions, Study 3 did not show any difference across the different cognitive tasks between the high and low suicidality groups. There were also no group differences in EEG frontal asymmetry. The non-significant findings were explained by the mild severity of suicide behaviour reported in the high suicidality group of Study 3 since the high suicidality group report milder form of suicidality compared to the group in Study 1. In support of this suggestion, Study 1 has revealed significant difference in many aspects of executive functions (indexed by BRIEF-A) between the high and low suicidality groups but this was not replicated in study 3.

With ample investigations using Stroop tasks to explore suicidality and how attentional control relates to frontal asymmetry, Study 5 explored attentional control in suicide individuals to a greater extent. However, based on the emotional Stroop findings in Study 3, some methodological issues were highlighted. For example, the randomization of emotional trials in the Stroop design and the selection of stimuli used may impact the emotional Stroop effect. As it was unclear which type of stimuli can elicit a larger emotional Stroop effect, two pilot studies were conducted to select the most appropriate stimuli for the final Stroop investigation (Study 4a and 4b). Study 4a consisted of an emotional Stroop investigation that compared the emotional Stroop effects using words and faces. Consistent with past findings, participants took longer to respond to negative stimuli compared with neutral, but this effect did not vary according to the stimulus type (words or faces). In addition, the emotional Stroop effect was apparent in the emotional Stroop tasks using words and faces, it is suggested that the processing of faces is important on a social level, but it is also difficult to inhibit the automatic response of reading a word. The findings confirmed that word is the more appropriate type of stimulus for examining attentional control since it has been widely used in prior research.

Considering the distinctiveness of the sample who were all proficient Chinese-English bilinguals, it has initiated further investigation of how the use of language may impact the emotional Stroop effect for this population. Study 4b was conducted to determine whether to use Chinese (L1) and English (L2) words for the emotional Stroop task in Study 5. Past research suggests that the emotionality (difference in valence and arousal) of words has greater impact when presented in a bilingual's L1 compared with their L2. This is argued to be a consequence of automatic processing of emotional words in L1 compared with slower, semantic processing in L2. In Study 4b, all participants rated the valence and arousal of positive, neutral, and negative words presented in Chinese (L1) and English (L2). Contrary to predictions, perceived emotionality of the words was higher in L2, with positive words rated more positively and negative words rated more negatively when presented in English compared to Chinese. The findings suggest that English words did not have lower emotional impact than Chinese words. This confirms that English words are preferred over Chinese words for the emotional Stroop task in Study 5 despite all participants were proficient Chinese-English bilinguals.

In order to examine the impact of suicide behaviour in moderating frontal asymmetry to a greater extent, two models of frontal asymmetry were discussed. The dispositional model posits that individuals with rightward frontal activity measured at rest will correspond to greater disposition towards negative affect (e.g., depressive and suicidal traits) under all situational contexts. Whilst the capability model supports this, it argues that an individual's capability to respond in different situations is crucial, and therefore, it argues that the effect of suicidality on asymmetric frontal brain activation will be more apparent during emotionally demanding situations. Additional factors that were identified as having important role in suicide behaviour have been considered in the investigation. The variables identified as the strongest predictors for suicide behaviour were avoidance coping (from Study 1 and 2), cognitive reappraisal (from Study 2), and difficulty in attentional control (from Study 3).

To test frontal asymmetry in high and low suicidality groups, EEG measures were taken and compared during resting state and emotional Stroop task performance in Study 5. The high suicidality group reported less frequent use of cognitive reappraisal and had higher levels of depression. However, there was no significant difference in turns of emotional suppression and all other measures of coping strategies between high and low suicidality groups. Results revealed no frontal asymmetrical difference in suicidality during resting state, but the difference was significant during the emotional Stroop task (i.e. a cognitively demanding state). This gave support to the capability model, which proposes that measures taken when engaging in an emotionally challenging task provide a more powerful frontal asymmetrical marker for characterizing suicide behaviour when compared with measures taken during resting state. Recent models such as the asymmetric inhibition model have explained how difficulties in inhibitory control may be revealed by asymmetrical frontal cortical activity (Grimshaw & Carmel, 2014). They specify that the left dlPFC corresponds to inhibiting negative stimuli, and the right dlPFC corresponds to inhibiting positive stimuli. The postulation of this model also coincides with the dispositional model that individuals with negative affect (e.g., depressed and suicidal individuals) would correspond to rightward frontal cortical activity. As predicted, the EEG findings revealed a leftward frontal cortical activation during inhibition of negative stimuli; this indicates an increase in recruiting the left frontal regions during a task that requires inhibition of negative emotional stimuli. However, the opposite trend was not apparent when participants were inhibiting positive word stimuli; that is, there was no rightward frontal cortical activation during the performance of the emotional Stroop task of inhibiting positive words. The dissociated neurological patterns suggest that inhibition of stimuli is generally linked to greater activation of left frontal cortical activity regardless of the emotion of this stimuli. The results questioned whether the asymmetric inhibition model might be overly specific about inhibitory control with little consideration of the other aspects of executive functions. Moreover, it is questioned whether increasing cognitive demand to deal with emotional interference during a task, regardless of the emotional significance, has the potential to impact frontal asymmetry. In terms of the investigation of Stroop task performance, the main findings were twofold. First, the results revealed important differences between individuals with high and low levels of suicidality, with the high suicidality group taking longer to respond to word stimuli in the colour Stroop task. They also took longer in responding to the word *suicide* in the emotional Stroop task showing that they experienced greater interference by suicide-related information. However, there was no emotional Stroop effect, that is, emotional stimuli were not more difficult to inhibit (as measured by response time) compared to neutral stimuli.

7.3 Explaining the findings using models and theories

7.3.1 Avoidance coping and Cognitive Reappraisal

To understand why suicide behaviour arises, the Escape theory (Baumeister, 1990) was one of the earliest models for suicide. It posits that suicidal behaviour is regarded as a means of escaping painful self-awareness. This negative self-awareness often results from falling short of expectations in a stressful situation and then attributing the blame to one's own perceived incompetence and guilt. Similarly, the Cry of Pain model (Williams 1997, Williams & Pollock, 2001) specified that feelings of helplessness often lead to motivation to escape (or avoid) the situation through engaging in suicidal behaviour. Williams and Pollock (2001) proposed that the desire to escape must have two specific aspects, defeat and entrapment. When coupled with continuous feelings of loss and failure the individual becomes vulnerable to feelings of defeat. Unsuccessful attempts at solving their problems (e.g. repeated attempts at an exam without success) can then lead an individual to feel powerless in escaping from that situation (entrapment). It is apparent that both models emphasize the pivotal role of escape or avoidance in the progression of suicidality. Based on the current research which has examined avoidance in the form of avoidance coping in studies 1, 2, and 5, all the findings support the suicide models that individuals with high suicidality were more depressed and used avoidance coping more extensively as an escape or avoidance rather than directly trying to minimize or to tackle the stressor (e.g. via the use of problem-focused coping).

Aside from the study of risk factors, the resilience to suicide was explored in relation to the Schematic Appraisal Model of Suicide (SAMS; Johnson et al., 2008). The model consists of three interacting components; negative information processing biases, the presence of suicide schema, and an appraisal system. Johnson et al. (2010) suggest that positive self-appraisers are more able to adopt an optimistic perspective and are able reinterpret a stressful situation. These active efforts may provide resilience to suicidal behaviour compared to those with low levels of positive self-appraisal. This suggests that positive self-appraisal may act as a buffer against suicidality in the presence of environmental risk factors. Complementing the emphasis of reappraisal within the model, the findings in studies 2 and 5 confirm that cognitive reappraisal helps protect against the development of suicidal behaviours. In sum, the correlational analysis of the findings in this thesis revealed that a greater use of cognitive reappraisal and less use of avoidance coping strategy provide resilience against suicide behaviour.

7.3.2 Deficits of executive functions

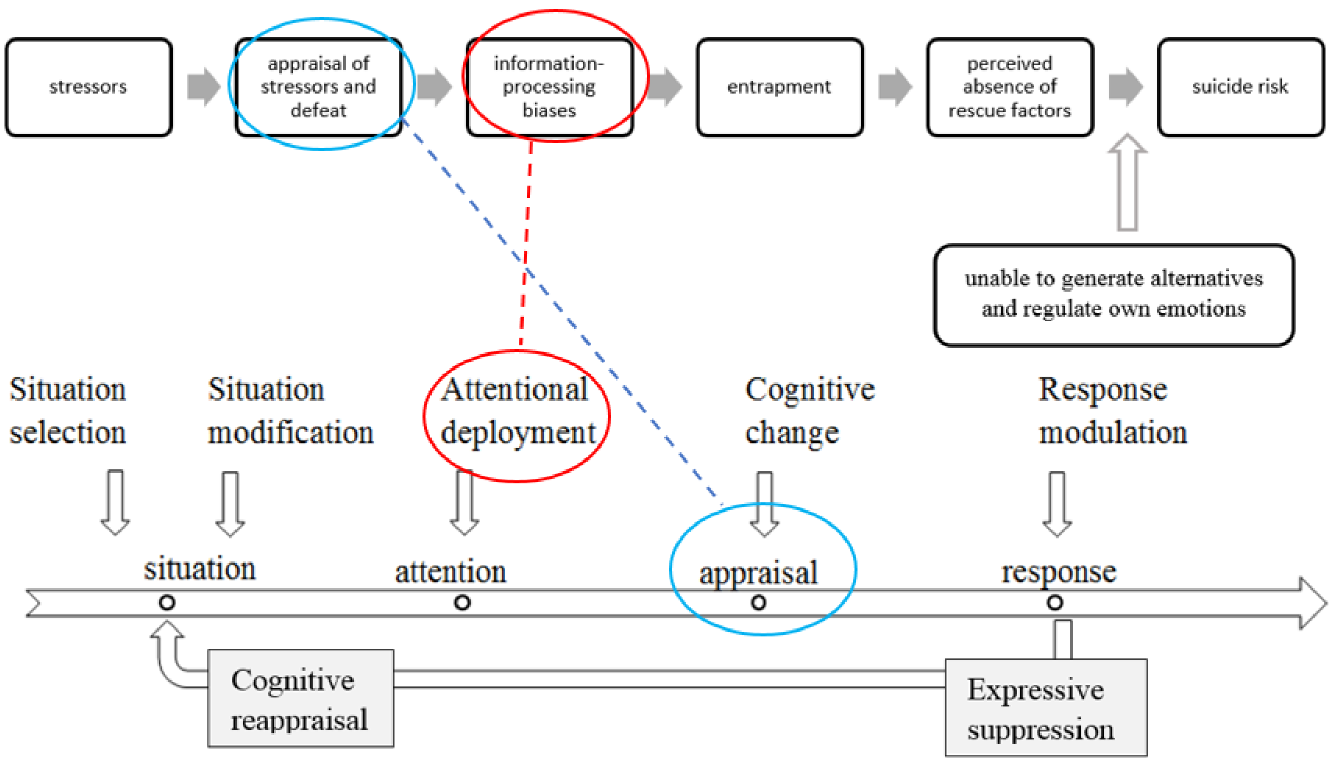
The Escape theory has also made a cognitive interpretation of suicide behaviour by specifying that individuals may try to escape the resultant negative affect of a distressing event by avoiding meaningful thoughts and engaging in cognitive deconstruction (e.g., having immediate or proximal goals, cognitive rigidity, and rejection of meaning). The critical step in the path of suicide progression is cognitive disinhibition, a component that characterizes the ability to inhibit thoughts but in the model, this is specifically related to suicidal thoughts. The Escape theory explains that disinhibition is critical because the inability to inhibit negative thoughts may lead individuals to have a strong desire to escape their own experience of negative affect by entering into a relatively numb, deconstructed state that immediately precedes an increased risk of attempting suicide (Baumeister, 1990; Kaplow et al., 2014). The results of Study 5 support the claim that the disinhibition feature is apparent in individuals with high suicidality as reflected by their poor performance in the colour Stroop task (measures inhibitory control). Additionally, the results from the emotional Stroop task also showed that the high suicidality group had increased difficulty inhibiting suicide-related stimuli (compared with neutral and other emotional stimuli). This may explain the increased risk of having further suicidal thoughts and behaviours. These cognitive aspects are also thought to be crucial in controlling and reducing suicidal behaviour (Carter & van Veen, 2007) since response inhibition can help individuals resist the urge to act impulsively, whilst interference control can help to inhibit irrelevant and intrusive thoughts such as self-harm (Diamond, 2013).

An information processing bias has also been identified as a crucial factor in suicide according to the Cry of Pain model; this is similar to cognitive inhibition as both can affect the way individual views the world, which impacts further suicide progression. The model describes an information processing bias as an orientation of one’s attention to a particular feature or class of features in the environment. For instance, a negative attentional bias may ultimately result in an increasing tendency to focus on negative stimuli in the environment. This is likely to increase perceptions of defeat, and feelings that a situation is inescapable and that rescue will not be forthcoming. This attentional bias was investigated through a series of Stroop investigations (in Study 3, 4a and 5), but found no emotional Stroop effect in Study 3 and 5. The absence of emotional Stroop effect represent a deviation from the mainstream of literature (e.g., Beall & Herbert; 2008; Epp et al., 2012; Öhman et al., 2001; Pratto & John, 1991; Williams et al., 1996). However, the emotional Stroop findings from Study 5 revealed an attentional bias towards suicide-related information in individuals with high suicidality, which added support to the suggestion that a very specific information processing bias is apparent in individuals with high levels of suicidality. This also complements the process model of emotion regulation (Gross, 1998; Gross & Thompson, 2007) whereby attentional deployment was one of the earlier stage of the entire emotion generative process whereby emotions could be regulated. As outlined, emotion regulation at an earlier stage (also known as the antecedent emotion regulation strategy) is beneficial to ameliorating negative emotions and the current findings lend support that high level of suicidality is associated with difficulty of attentional control, an indirect indication of attentional deployment fails.

Summarizing the results in accordance with the Cry of Pain model and the Process model of emotion regulation (see Figure 7.1), it is suggested that they are generally consistent with the appraisal and information processing bias proposed by these models and provide empirical support towards the influence of these variables in impacting suicide behaviour. The SAMS in particular explains how information processing bias links to increased suicidality. It is postulated that in long term when negative information increases, is elaborated, and becomes easily accessible, a suicide schema is formed. This is a semantic network comprising various stimuli, possible responses, and emotionally stored information related to suicide (Johnson et al., 2008; Panagioti et al., 2014). The suicide schema may influence individuals as it biases them to process more negative rather than positive information. This may enhance emotionally congruent information processing and retrieval of more mood-congruent memories related to suicide.

Figure 7.1 showing the appraisal and information processing bias between two models

The Cry of Pain model specifying the key elements; appraisal and information-processing bias



The Process model of emotion regulation specifying the key elements: attentional deployment and appraisal

7.3.3 Frontal asymmetry

Building upon the existing literature relating to frontal asymmetry, which is heavily focused on clinical populations with executive dysfunction, the current thesis has examined the neural correlates of suicide in a student population who have been underrepresented in the literature. Considering the findings that have shown significant differences in frontal asymmetry between individuals with various degrees of suicidality (Jollant et al., 2005; 2011; Pan et al., 2011), it is noted that these studies were largely conducted using the most advanced and conventional neuroimaging techniques such as fMRI. This could be a limitation whereby their clinical use has historically been limited to medical evaluation. Conversely, the EEG Emotiv used in the current investigation of this thesis is comparatively low-cost and is more easily accessible. It is highly portable and can allow collection in many places outside of the laboratory.

Despite the absence of any frontal asymmetrical difference between individuals with high and low levels of suicidality reported in Study 3, the careful consideration of participant sample and experimental stimuli (for the emotional Stroop task) helped to improve the EEG investigation in Study 5. With these improvements, Study 5 found frontal asymmetrical differences between high and the low suicidality groups during an emotional Stroop task whereby individuals with high suicidality exhibited less leftward frontal cortical activity. Importantly, this suggests that situational context is an important factor for moderating frontal alpha asymmetry thus gives support to the capability model but not the dispositional model. The results show that when using alpha symmetry as a marker for suicide the situational context needs to be considered.

Relating frontal cortical asymmetry to inhibitory control, the EEG findings in Study 5 revealed a shift towards leftward frontal cortical activation during inhibition of negative word stimuli in the emotional Stroop task, but unexpectedly, inhibition of positive word stimuli did not elicit rightward frontal cortical activation. This means that the results only provided partial support for the asymmetric inhibition model (Grimshaw & Carmel, 2014). Based on this investigation, it was also postulated that frontal asymmetry may reflect individual differences in the ability to recruit different frontal brain regions to manage inhibitory control. In Study 5, it was found that when participants were asked to perform an emotional Stroop task that required inhibition of negative information, the low suicidality group exhibited relative leftward frontal cortical activation whilst the opposite was found in the high suicidality group; that is, they exhibited relatively less leftward frontal cortical activation during inhibition.

The present findings complement the explanation of Grimshaw and Carmel (2014) of the inhibitory difficulties apparent in depressed individuals. They argued that the neurological difference shows depressed individuals are unable to utilize the parts of the brain responsible for inhibition (i.e. the left PFC), particularly the inhibition of negative information. Indeed, the relationship between inhibitory deficits with frontal asymmetry has also been substantiated by other studies showing that failure to recruit the left dlPFC when presented with irrelevant negative information is associated with depression (Herrington et al., 2010; Joormann & Gotlib, 2007) and trait negative affect (Crocker et al., 2012). Grimshaw and Carmel (2014) explained that the resulting asymmetrical difference may impede the ability to inhibit negative irrelevant stimuli, resulting in more emotional distraction. The EEG findings in Study 5 confirms that the Stroop task requires increasing cognitive resources relative to the resting state.

Similar to the current findings, Compton et al. (2003) documented that the recruitment of the left (relative to the right) frontal brain regions is especially important for dealing with the increased cognitive demand associated with inhibiting information that is incongruent or negative in nature. Compton et al. (2003) argued that all distracters are difficult to inhibit, regardless of their precise emotional content (i.e. either positive or negative). They suggest that frontal asymmetry may reflect a general cognitive control mechanism rather than specific inhibition of different types of emotional information. This means that tasks that require greater inhibitory control such as the colour Stroop and an emotional Stroop task will correspond to individual differences in frontal asymmetry depending on the level of cognitive demands the task exerted.

Deficits in these neural interactions related to attentional control may impede an individual's ability to deal with emotional disturbances and solve problems, and they may increase other symptoms that are commonly found in suicidal patients (e.g. feelings of hopelessness; Desmyter et al., 2011; Jollant et al., 2011). Taken together, the neurological findings from the current research indicate that neural measures using a cheaper system such as the EEG Emotiv still reveals frontal asymmetrical patterns apparent in a population with mild level of suicidality (the majority of participants in the high suicidality were only having suicide ideation but had no history of past attempt). This easily accessible tool has the potential to give wider application from the findings thus serves as promising indicator for characterizing suicide behaviour.

7.4 Limitations and recommendations for future research

The results of the work in this thesis must be weighed in light of their limitations. These include issues regarding the experimental designs used for investigating the cognitive and neural indicators of suicide risk and the current sample population.

7.4.1 Methodological considerations

Regarding the validity and reliability of the cognitive measures in this thesis, some scholars have previously critiqued the generalizability of the self-report measures of executive functions as they often fail to capture the precise cognitive deficits in a real-world setting (Barkley, 2012; Manchester et al., 2004). This raises the possibility that the use of the BRIEF-A did not capture measures of executive functions effectively. Therefore Study 4 and 5 have addressed this limitation by measuring executive functions objectively using cognitive task performance. Aside from the use of ERQ to assess emotion regulation, which has repeatedly been challenged for its limitations, future studies could explore other ways of measuring emotion regulation objectively in similar ways as how executive functions were measured in the current investigation. For example, Jackson, Burghy, Hanna, Larson, and Davidson (2000) and Jackson et al. (2003) have measured emotion regulation via startle eye blink response. The startle response is regarded as a physiological measure of implicit emotional regulation. In an attempt to downregulate negative emotions in the presence of negative emotional stimuli, participants will show smaller blink magnitudes (and smaller eye muscle activity) to negative images (Vrana, Spence, & Lang, 1988). Conversely, instructions to enhance negative emotion (indicating less intention to regulate emotions) or when attempting to decrease emotion to positive images leads to larger startle eye blink magnitudes due to the aversive nature of the startle reflex.

In the Jackson et al. (2003) study, the relationship between asymmetric prefrontal activation and emotion regulation was explored with participants viewing emotionally arousing and neutral visual stimuli. The startle eye blink response and EEG activity were recorded. Results showed that following the offset of negative stimuli, greater intention to downregulate negative emotions (indexed by attenuated startle magnitude) corresponded with relative left-sided frontal cortical activation. The results provided support for the role of the PFC activation for emotion regulation processes. In the future, rather than using self-report measures of emotion regulation (e.g. ERQ), the use of physiological measures of emotion regulation may be a better method to testify the emotion regulation in real-time behaviour in relation to frontal asymmetrical activation in suicide population.

Based on the comparison of valence ratings of words used for emotional Stroop tasks in Study 3 and 4a, it is highlighted that the selection of stimuli based on valence, and possibly arousal, are important factors that could have significant impact on the results (e.g. emotional Stroop effect). For the other two cognitive tasks that were not further explored in the final study, it is noted that they were suitable ways of measuring inhibition and working memory. However, the research of this thesis did not further explore these executive functions but has instead narrowed down to examining attentional control. This is because based on the proposal of key models of suicide and substantial research using Stroop studies, attentional bias/deployment plays a pivotal role in suicide progression. Indeed, it is noted that followed from the careful selection of participant sample and experimental designs from Study 4a and 4b, these two Go/No-Go and N-back could have been useful test to examine the cognitive difference of individuals with high and low levels of suicide risk.

7.4.2 Sample issues

As outlined in the introductory chapter, suicide is prevalent in the student population, and the primary aim of this investigation was to find ways of identifying at risk individuals early in the suicide path. Based on the comparative findings of Study 1 with related studies, the prevalence of suicide behaviour reported by students (22.6% reported high level of suicidality) was higher than the prevalence in the Tang and Qin (2015) study (16.39% of university students reported the presence of suicide ideation). Nonetheless, studies in this thesis reveal that the severity of suicide behaviour was still comparatively low. The comparative statistics indicated that the high suicidality group reported higher degree of suicidality (SBQ-R score of 10.10) in Study 1 than in Study 3 (SBQ-R score of 8.31) and reflects that most who reported suicide behaviour were only reporting the milder forms such as having suicide ideation but no plans or attempts. For example, 7.63% of participants reported having past history of suicide attempts in Study 1, 11.54% in Study 5 but none in Study 3 had history of suicide attempts. Whilst these figures help to confirm that the aim of targeting individuals with mild severity of suicidality has been achieved, it may also explain some of the non-significant findings in Study 3. The argument receives support from the findings whereby the high suicidality group in Study 1 reported having increased difficulties in executive functions (as indexed by BRIEF-A) but this was not apparent in Study 3. When the high suicide group was carefully selected in Study 5, results indicated that emotional Stroop effect for the word *suicide* served as useful indicator for characterizing suicide behaviour. The results of these studies imply that those who already have plans and even have a suicide attempt may perform significantly worse on Stroop tasks but individuals who are only engaged in suicide ideation may not be significantly different to the low suicidality group.

Due to the absence of the emotional Stroop effect in Study 3, the use of stimuli in Study 5 was carefully selected using studies 4a and 4b. Despite this, the absence of an emotional Stroop effect was still reported in Study 5. Whilst the emotional Stroop effect has been consistently reported in past literature, the present findings revealed that as the investigations of this thesis have used bilinguals this may differ from previous studies that have used monolinguals instead. One argument is that the participants who are proficient bilinguals may have cognitive advantage and were better able to manage interference from the emotional stimuli during the task. They may confer some cognitive advantages when performing some of the tasks that demand attentional control. There is empirical evidence that bilinguals are distinguished from others because their L1 and L2 remain highly active during language comprehension and production (Marian & Kaushanskaya, 2008). With these two simultaneously active language systems, bilinguals must master their cognitive control by selecting the appropriate language at a particular time, inhibiting the inappropriate one, and managing the conflict between the two (Sabourin & Vinerte, 2014).

The impact of bilingualism on attentional control has previously been investigated using the Stroop task. Costa, Fuentes, Vivas, and Sebastian-Galles (2010) used a numerical version of the Stroop task. This is because they were concerned over the use of classic colour Stroop paradigm with linguistic material, and there is a possibility that the bilingual advantage reported in the past (e.g. Bialystok et al., 2008) only reveals a better control of linguistic representations rather than a cognitive advantage in inhibitory control. This was examined with the comparison of task performance between Catalan-Spanish bilingual undergraduates with Spanish monolingual undergraduates. The results were twofold: first, there was a reduced Stroop interference effect in bilinguals compared with monolinguals. This confirms that there is bilingual advantage in resolving conflict produced by irrelevant information (e.g., Bialystok et al., 2004; Costa et al., 2008). Second, bilinguals responded faster than monolinguals across all experimental conditions, which indicates that bilingual advantage in the monitoring processes is also relevant in tasks that involve different types of stimuli (Hernández et al., 2010). This bilingual advantage was evident from the superiority in colour Stroop task performance that measures task switching and attentional control of bilingual participants compared to their monolingual counterparts (Prior & MacWhinney, 2010).

Despite the supporting evidence for a cognitive advantage in bilinguals, the current work still reveals that individuals with high suicidality have impairments in inhibitory control. However, the study results are limited in their applicability to only university students with milder form of suicidality. From the cognitive findings in the comparison of bilinguals and monolinguals, there is also neurological evidence to suggest that bilinguals’ cognitive advantages go beyond just language advantages (Bialystok, Craik, & Luk; 2008 2012; Costa et al., 2008; Hernández et al., 2010). For example, fMRI studies reveal different frontal cortical activation in bilingual relative to monolingual participants, especially in the region of the left PFC (Bialystok et al., 2006). With the comparison of Spanish monolinguals and Catalan-Spanish bilinguals using ERP and fMRI, Rodriguez-Fornells et al. (2002) observed neurological difference when bilinguals and monolinguals performed inhibitory task. Interestingly, activation of the left PFC was only evident during task performance in bilinguals but not monolinguals. This substantiated the evidence that monolinguals and bilinguals recruited different neural networks for both congruent and incongruent trials. Importantly, greater activity in the PFC was related to smaller time costs for incongruent trials. Bialystok et al. (2012) explained this is because bilinguals relied more on the left frontal region in face of cognitive demand to switch between responses associated with a bivalent stimulus. They also concluded that the bilingual nature of participants may give them cognitive advantage beyond language, that is, a better ability in dealing with interference such as in a Stroop task.

Another noteworthy point to make on the sample selection in this investigation is that the current research has adopted a convenience sampling where participants voluntarily participated in response to a request from a seminar workshop within the university. This means that it is likely to reflect a particular interest in participating in a study focusing on suicide and psychological health. In addition, all students participating in the studies of this thesis have attended university, creating a fairly high-functioning sample of young adults. Consequently, the current findings may not generalize to other populations.

Limitations of the study primarily reflect the specific nature of the sample, which also represents one of the study’s greatest strengths. The sample was predominantly university students studying Psychology in a university in HK; all of them were proficient bilinguals and it is reasoned that they may have better executive functioning compared with their non-academic peers who are not bilinguals. Nevertheless, the research still revealed difficulties in many aspects of executive functions in relation to suicide behaviour. With this pattern, given the proposed high levels of executive functions in the chosen sample who are bilinguals, the effects of suicide would be more apparent in a different sample who are non-academic peers and are monolinguals.

7.4.3 Other factors for influencing suicide

The present study primarily investigated the cognitive and neural risk factors as potential indicators for characterizing suicide behaviour. The findings of this research have supported the proposal of appraisal and information processing bias in suicide progression posited by the main models studied, however, other key elements have not been examined. These include the direct measures of defeat, entrap, and escape, which have been highlighted by different key models. Further research with other perspectives is needed to reach the overall aim of gaining more knowledge about the reasons why students engage in suicide behaviour. It should be noted that because this research did not include any direct measure of these key variables due to the high number of coping and emotion regulation variables that need to be examined, the present findings can only indirectly support the importance of these factors in relation to the different models discussed. Future research could investigate critical components in the Cry of Pain model such as entrapment, defeat, and resilience.

Coping and ERQ-R were chosen in the current investigation as some of these aspects such as avoidance coping and cognitive reappraisal fit well with the elements in the suicide models. Nevertheless, the current investigation on executive functions was a first reasonable step in increasing knowledge of the various models of suicide behaviour from a neurological and cognitive perspective. Future studies further investigating these models should include direct measures of defeat and entrapment and this could help to evaluate the importance of these variables in the progression of suicidality.

Findings in Study 5 showed that the alpha asymmetry could indeed serve as a promising neurological indicator for characterizing suicide behaviour. This confirmed that individual differences were strong enough to exceed limitations such as the sensitivities of EEG measures (Turner et al., 2017). The replicability of findings using the EEG Emotiv has also given the opportunities for moving EEG out of the specialized, custom-built laboratories that are limited by using expensive neuroimaging tools. It means that EEG measures can be collected even in a more naturalistic setting such as a counsellor's room in a school. This could have useful application for educators who intend to implement quick and reliable method of identifying at risk individuals in schools.

The studies reported in this thesis are the first that have taken a cognitive and neurologically driven approach with the intention of finding markers for individuals with high suicidality. As such, the findings can only represent a starting point for further research. There are areas upon which future research could expand. For example, the studies conducted in this thesis support the validity of the proposed resilience and risk factors; however, future research could investigate whether cognitive reappraisal and avoidance coping moderate suicidality when these are measured as real-time behaviours such as by asking participants to use appraisal or avoidance in a task whilst EEG measures are taken. There has been research using emotional stimuli in the cognitive task to examine the approach withdrawal model in relation to frontal asymmetry (Lang, 1995). On the basis of the appetitive and defensive systems, the study has implemented aggressive and aversive stimuli to represent approach and withdrawal related behaviour. An appetitive system motivates life sustaining and reproductive (e.g. approach) related behaviours and responses in order to benefit from potentially advantageous situations. It is often associated with positive subjective feelings (e.g., enthusiasm or sexual arousal). In contrast, a defensive system motivates protective behavioural and physiological responses (e.g. withdrawal) in order to avoid harm or overcome threat. It is typically associated with negative subjective feelings (e.g. fear or disgust). On the basis of these descriptions, aversive and aggressive stimuli may be better than the current use of generally positive and negative stimuli, which elicit neither aversive nor aggressive emotions.

Although the current objective of this thesis was to explore the neural correlates of mildly suicidal individuals, it is unknown how suicidal individuals with or without past history of suicide attempt may differ in this perspective. Therefore, further studies are needed to investigate the effects of suicide severity on frontal asymmetry. For example, many past studies discussed in this thesis including Keilp et al. (2008; 2013) have previously compared different groups of suicidal individuals (with or without history of attempt, or depressed with or without suicide). Future research could investigate resilience to suicide in a wider range of suicidality with categorization of participant group to suicidality, self-harm, past suicide attempter to further differentiate suicidal individuals on the basis of their suicide severity. Findings from such studies are needed to disentangle whether the present effects of suicide behaviour on attentional bias or other executive function deficits are less apparent in suicidal individuals who use more reappraisal. As it stands, the current research in this thesis was restricted to only the milder form of suicide behaviour, which may limit transferability of findings to other populations.

7.5 Implications

7.5.1 Frontal asymmetrical measures as prediction and intervention for suicidality

The findings of this thesis show promising indication that there could be neurological markers for characterizing suicide behaviour. Consistently, Johnston et al. (2017) have recently implemented the use of neuroimaging data to help identifying those most at risk of suicide. They explored brain development in young adults using MRI who were either past suicide attempters (n=26) or without suicide attempt (n=42). As the frontal-limbic system (the neural connection between the frontal region and the limbic system that regulates emotion and impulses) is still under development at this stage, the neurological data may provide an explanation as to how suicidal thoughts and behaviours arise (Hathaway, 2017). In the MRI findings, past suicide attempters exhibited relatively lower activity (in both the left and right) in the frontal-limbic system, and had less white matter volume (the wiring that provides connections between these brain areas) compared with healthy controls. The findings also suggested that the frontal cortex of suicide attempters was less functional in regulating neural activity, which may result in increased sensitivity to emotional pain (due to lesser ability to regulate emotions by the limbic system), difficulties in generating alternate solutions to suicide, and greater risk of having suicidal impulses (Johnston et al., 2017). Subsequently, neurological deficits in the frontal cortex could reveal the extents of suicidality one is suffering from.

Similar to the results of Study 5, Johnston et al. (2017) suggested that the neurological findings may serve as a new method to assist towards suicide prevention; it may also help clinicians to develop new strategies to minimize risk factors and therapies designed to strengthen vulnerable brain circuits. For example, recent research has found a non-invasive method that fits well in the criteria, namely transcranial direct current stimulation (tDCS; Boggio Rocha, da Silva, Fregni & Fregni., 2008). This is a method whereby a weak electrical current (1 to 4 mA) is passed over the scalp using electrodes. The current can stimulate the cortical activity of the corresponding region (Silva et al., 2017). This intervention does not merely elicit action potentials, but it is thought to manipulate neuronal activity and enhance neuroplasticity. The use of tDCS has shown some promising results for the treatment of depression (Knotkova et al., 2012; Rigonatti et al., 2008). Following just two weeks of tDCS treatment depressives showed a significant decrease in the severity of symptoms reported. In addition, tDCS stimulation has obtained some positive results showing improvement in cognitive performance after repeated usage. These include enhanced performance in impulse control, working memory, attention, and inhibitory control in healthy participants (Boggio et al., 2008). This shows that tDCS may be used as a form of intervention that could improve cognitive and emotional aspects at the same time.

As it was unclear from previous studies what specifically mediates the effects of tDCS on learning and performance of these tasks, Coffman, Trumbo, and Clark (2012) included an Attentional Network Test[27] (ANT) in their study to identify the extent to which attention is modified by tDCS applied to the inferior frontal cortex. They examined how tDCS stimulation improves learning and performance in the task by comparing the response times for three forms of attentions: alerting, orienting, and executive network. These executive function aspects were assessed by task performance in the ANT which consists of a cued reaction time task (Posner, 1980) and a flanker task (Eriksen & Eriksen, 1974). Efficiency of three attention networks are assessed by measuring how response times can be affected by alerting cues (assessing the alerting network), spatial cues (assessing the orienting network), and flankers (assessing the executive network). Nineteen participants received tDCS (either of a low (0.1 mA) or high (2.0 mA) stimulation) and completed the ANT before and after training (baseline-test). Results indicated that tDCS was effective in improving attention measures following just 30 minutes of receiving tDCS. The improvement was most significant on measures of all attentional measures, particularly measures for the alerting and executive network. This is important since the current findings of the thesis specified that difficulties in attentional control was one key factor identified for the manifestation of suicide behaviour. Having an intervention that targets at frontal cortical activity as well as attention control may seem ideal, however, it is noteworthy that improved responses to the alerting cues in the Coffman et al. (2012) study was only found following stimulation over the location of F10, which in an area in front of the temporal lobe but below the F4 (the PFC). This is different to the proposal of this thesis which stated that left (not right) frontal activation is

[27] The Attentional Network Task (ANT) was developed to assess the operation of three attentional networks in participants: alerting, orienting, and executive control (Petersen & Posner, 2012). The task requires participants to indicate with a speeded button press response whether a centrally presented arrow points to the left or to the right.

crucial in executing inhibitory responses in a cognitive task. Although the use of tDCS has shown some promising results for the treatment of depression (Knotkova et al., 2012; Rigonatti et al., 2008), its effectiveness for treating individuals with high levels of suicidality remains speculative and warrants further investigation. In acknowledging that the difficulty in recruiting left frontal activities might have been an underlying cause for impaired inhibitory control found in suicidal individuals, this has led to the idea that interventions that target the correction of such brain lateralization may shed light on treating suicidal individuals.

7.5.2 Impairment of attentional control as prediction and intervention for suicidality

Past studies such as those of Cha et al. (2010) and Jung and Jeglic (2016) show that the specific Stroop interference effect (attentional bias towards disorder-related cues) is consistently found in the suicidal population and this may be particularly useful for clinicians to predict, above and beyond other clinical predictors (e.g., depression, past history of attempt), those individuals who go on to make a suicide attempt. Although the effect of suicidality on the emotional Stroop effect in the current research may have been less robust compared with to Cha et al. who used a clinical population, there was still an indication that students with high level of suicidality exhibited the specific Stroop effect. This was evident as individuals with high suicidality exhibited a specific bias towards the word *suicide*. This could be particularly useful in situations where individuals with suicide behaviours deny their suicide tendency through self-report questionnaires. As outlined in previous chapters, those who experience suicide behaviour may avoid discussing this with others, and sharing feelings and thoughts can often trigger feelings of stigmatization. This can also lead to difficulties in predicting suicidality because assessments are largely based on clinical interviews and self-report measures (Wilson, 2009). However, the research of this thesis has highlighted the usefulness of using emotional Stroop task as an alternative for predicting suicide, a method that does not require self-disclosure of individual.

Together with some of the adjunctive therapies (e.g. meditation, cognitive therapy, and neurofeedback training) that aim to help patients by strengthening the attentional control processes and reducing negativity bias, the Stroop effect has recently been implemented to provide objective measures for monitoring therapeutic effectiveness of interventions (Malinowski, Moore, Mead & Gruber, 2017). For example, the effectiveness of mindfulness meditation intervention on cognitive processing was assessed using performance in a Stroop task. In a study by Malinowski et al. (2017), participants were randomly allocated to the mindfulness training group or to an active control group. In the mindfulness group participants were instructed to conduct 10 minutes of mindfulness practice five times per week. To match the mindfulness training condition as closely as possible, participants in the active control group took part in a brain training that involved active, effortful cognitive processes. This included doing arithmetic calculation that required effortful cognitive processing and activated a wide range of frontal and parietal brain regions implicated in attention. Improvement sin attentional control was shown by better performance in a counting Stroop task (lower response times across all trials). This task differs to the one used in the current research as it was a combination of a counting Stroop task and an emotional Stroop task. In each trial a word stimulus (a word of either ONE, TWO, THREE or FOUR) was presented in either in congruent or incongruent condition. Participants are instructed to indicate how many words are presented on the screen by button press (between one and four words). In an incongruent condition for example, the word “TWO” would be presented three times. Participants have to inhibit the word and respond to the number of words. This means that to complete this task, executive control is essential in the response conflict condition (i.e. when the meaning of a presented number word conflicts with the number of words that are presented and need to be responded to). Results showed greater improvement in attentional control can help to give objective indicator in terms of the therapeutic effectiveness of meditation training compared to the active control group

As outlined in the earlier chapters, clinicians and educators struggle to find effective ways to reduce the prevalence of suicide. Nonetheless, given that specific attentional bias towards suicide related information is shown to be a promising marker characterizing suicide behaviours, interventions that aim to alter the extent of such bias may prove to be a useful strategy to alter the information processing bias of suicidal individuals. In addition, since improvement of attention control was shown to have a pivotal role in the regulation of emotions, it is suggested that interventions that aim to improve specific bias such as suicide-related information may be an effective way to alleviate the recurrence of the symptoms in suicidal individuals. With the argument that attentional control is important, recent research shows that attention biases to emotional information can be trained and untrained in individuals with affective disorders using attention bias modification (ABM; Boffo, Willermenm Pronk, Wiers & Dom, 2017; Ferrari, Becker, Smit, Rinck & Spijker, 2016). As with training to divert attention away from negative stimuli, Ferrari et al. (2016) have introduced the use of ABM training as a cost-effective intervention for depressed patients alongside their usual care including taking medication and CBT interventions. Acknowledging that the extent of negativity bias noted in depressed individuals contributes to development and maintenance of depression, the ABM intervention was reported to help reduce the negativity bias in depressed patients and therefore have a therapeutic value.

Although the research in ABM is quite recent and existing evidence of its effectiveness on suicidal individuals is lacking, its effectiveness in clinical samples has shown some promising results. For example, depressed individuals are characterized by increased avoidance behaviour, an enhanced sensitivity (bias) to negative cues and punishment, and reduced attention to positive and rewarding stimuli (see also Pizzagalli et al., 2011), and ABM training has been implemented to help this these patients. Wells and Beevers, (2010) conducted a study involving 126 patients diagnosed with depression, they were randomly allocated to a positive training (towards positive and away from negative stimuli), a placebo (i.e. sham ABM) training, or a control condition (continuous attentional bias assessment). The effectiveness of ABM intervention was evaluated at 1, 6, and 12 months. The results consistently showed the ABM to be successful in reducing symptoms of depression after as little as four weeks of training.

More recently Ferrari et al. (2016) assessed the outcome of training through the measures of mood response to stress, depressive symptoms, and cognitive abilities (i.e., measures of attentional bias for verbal stimuli, cognitive control, and positive mental imagery). Similar to the use of the Stroop performance as outcome measures for meditation in Malinowski et al. (2017) study, the colour Stroop task and the emotional Stroop task (both similar to the tasks used in Study 5) were used as the outcome measures of the training to monitor the changes in attentional control and attention bias. Ferrari et al. (2016) again showed that a dot-probe-based ABM training away from negative and towards positive pictures was therapeutically effective compared with a placebo (i.e., sham ABM). The results showed success of ABM training in reducing depressive symptoms and negativity bias after two weeks of the intervention, it also showed that the Stroop task can be used to monitor effectiveness of interventions and objectively measure cognitive improvements of patients.

Further to the evidence of how ABM training can be useful to depressed patients, Boffo et al. (2017) implemented ABM training for addictive gamblers who suffered from a cognitive bias towards salient gambling cues in the environment. All participants were randomly assigned to one of four experimental conditions (attentional or approach bias training, or the placebo version of the two conditions) and completed six sessions of training. The attentional bias training consisted of an adapted version of the Visual Probe Task (Boffo et al., 2017). Participants were trained to direct their attention away from gambling cues and towards neutral cues by exposing them only to non-gambling trials. In the placebo condition participants are presented with 50% gambling and 50% non-gambling trials (as in the assessment version). The approach bias training contained a modified Approach-Avoidance Task (Boffo et al., 2017), including a zooming feature of a gambling-related picture (e.g. a pack of playing cards) or a control picture (e.g. a stack of books). A zooming feature is that pressing a push button will minimize the picture whilst pressing a pull button to enlarge the picture on the screen. The task was a computerized speeded reaction-time task in which participants are asked to react or to ignore the stimulus presentation content (gambling-related pictures). In the active training version, participants are trained to avoid gambling cues. In the placebo version both stimulus categories are presented equally often in both formats and participants were not given specific instructions. The post-intervention, 1-month, and 3-month follow-up assessments examined changes in gambling behaviour, with frequency and expenditure as primary outcomes, and depressive symptoms and gambling-related attentional and approach biases as secondary outcomes. Results showed that the ABM intervention successfully reverted the automatic cognitive biases previously found in these addictive gamblers. With the advantage that the ABM intervention can be administered online, this provides a promising yet relatively low-cost addition to conventional treatments. Considering the studies of Boffo et al. (2017) and Ferrari et al. (2016) together, support is gained for the use of ABM intervention on reverting the existing cognitive bias in individuals, whether it is depression- or gambling-related. In this perspective, the intervention has potential to revert the attentional bias apparent in suicide population and to help towards reducing suicidality. This training can be implemented to suicidal individuals by altering these images to suicide-related ones (a picture of someone cutting him/herself).

7.5.3 Implementing resilience into suicide prevention programs

Similar to the concept of how a negative bias can be reduced by ABM intervention, Wadlinger and Isaacowitz (2008) contended that individuals can be trained to redirect attention towards positive information. This is important because while reducing negative thoughts may be adequate to reduce suicide behaviour, there is a necessity to build resilience for suicidal individuals in the form of increasing their ability for positive appraisal. Whilst diverting suicidal individuals away from the negative (or suicide-related) information is a critical first step, one must not neglect the importance to enhance resilience to future suicide behaviour. It is suggested that interventions that enhance positive thinking and reappraisal in individuals would be an effective strategy for building resilience. This is based on the evidence that the use of positive reappraisal serves as an effective way to reduce suicidality, and it may be useful to incorporate this technique into future resilience-building interventions.

Based on the findings of the current research of this thesis, the use of Positive Psychotherapy (PPT) may be one potential for encouraging the use of cognitive reappraisal and positive thinking. It aims to increase positive emotion, engagement, and meaning by reinterpreting problems in a positive way, and then build on them (Seligman et al., 2006). Syzdek, Addis, and Martell (2010) documented that PPT serves as a promising intervention to increase positive cognitions, feelings, and behaviour in depressed patients. Through numerous sessions, depressed individuals can be reinforced to attend to more positive information and adapt more strategies such as positive appraisal. A meta-analysis of this PPT intervention has found promising results with significant decreases in depressive symptoms reported (Sin & Lyubomirsky, 2009) and effective reduction of relapse (Fava & Ruini, 2003).

Consistently, Wadlinger and Isaacowitz (2008) reported that following a brief session of PPT intervention, inhibition for negative stimuli in a subsequent visual stress task was found to be significantly improved in non-depressed university participants. Further, preliminary evidence suggests that increasing activation of positive material in working memory may also enhance positive affect, reduce emotional regulation deficits, and emotional cognitive biases that characterize depressive disorders. Though there has not been much empirical work conducted on this topic, the remarkable improvement in enhancing positive affect suggests that this intervention could be one alternative treatment for suicide behaviour. Although these results have yet to be replicated in suicidal individuals, these interventions have the potential to not only reduce an individual's vulnerability to suicidality, but also protect them from susceptibility to other emotional disturbances by helping or encouraging them to think more positively in the face of the normal adversities of life.

7.5.4 Accounting for executive functioning abilities into suicide prevention programs

The findings of the current research suggest that the use of cognitive reappraisal and reduced use of avoidance coping are important variables in reducing suicide behaviour. Importantly the findings show that the use of these coping and emotion regulation are dependent on one's executive functions, a cognitive factor that prevention programs have not paid much attention to when developing their programs. Take The Problem solving Skills Training and Mentorship Programme organized by the CSRP as examples, these prevention programs which were described in Chapter 1 outlined the aim of strengthening the knowledge and skills of suicidal individuals ("Mentorship Programme for Adolescents - Centre for Suicide Research and Prevention", 2017). It also aims to encourage students to solve problems on their own with support from mentors. Nevertheless, when encouraging students to solve problems it is crucial that any possible cognitive deficits apparent in students should be accounted for as this may considerably affect their ability to generate solutions to solve problems.

Reflecting on the current suicide prevention programs that have been described in previous chapters, the Samaritans has offered the Youth programmes to enhance peer support networking when facing emotional distress ("Youth Programme – Samaritans Hong Kong", 2017), there is also a safety management technique (Jobes, 2006; Rudd, 2006) to enhance ability to cope with difficult situations. Nevertheless, these programs target the development of more emotion regulation and coping strategies without the consideration of executive functioning deficits. With the association between selection of coping and the extent of cognitive difficulties (as indexed by scoring of BRIEF-A in Study 1), it is essential that the aforementioned prevention programs should take account of cognitive factors when aiming to improve coping and emotion regulation skills. As suggested by Bredemeier and Miller (2015), executive functions are still undergoing development at the stage of young adulthood and this may hinder adaptive regulatory processes and lead to suicidality. To account for executive function deficits in suicidal individuals, it is suggested that the programs can implement the use of tCDS or ABM intervention.

7.6 **CONCLUSION**

Extended from the existing scope of literature, the current investigation aimed to investigate the cognitive and neurological factors that could best predict suicide behaviour. Whilst most of the past studies focus on clinical population the scarcity of studies using a non-clinical sample (e.g. Herrington et al., 2010) has attracted attentions as to whether frontal asymmetrical finding in clinically depressed population (Allen et al., 1993; Urry et al., 2004) could be replicated in a non-clinical population. Through the series of studies in this thesis, the findings have indicated that measures of frontal asymmetry are sensitive to many factors the state of the participants (resting versus task performing states). These factors will all need to be accounted for should the alpha asymmetric index be used as a neurological marker for suicide traits in the future. Although the findings reveal that obtaining cognitive and neurological differences between the high and low suicidality group were less pronounced in this non-clinical population, there is still indication that some specific difference is noted that may be helpful in characterizing high suicide risk. From a neurobiological view, one main finding is that individuals with high suicidality exhibit rightward frontal asymmetry. This suggests that an inefficient neural network within the frontal cortex might be a signature marker for suicide behaviour. Another main finding is that individuals with high levels of suicidality have distinctive deficits in executive functions such as difficulties in attentional control.

The work presented in this thesis has provided strong evidence for the continuation of neurological research in the suicidal population. It seems clear that in terms of behavioural and emotional responses to deal with stressors, students should not try to avoid the problems by avoidance coping and should be encouraged to use more reappraisal strategies; this would help them to cope better and have healthier psychological outcomes in reducing the risk of suicide. Based on the current findings, these might be easier to state than to carry out since the ability to utilize adaptive coping strategies and emotion regulations is somewhat limited to individuals with well-functioning executive controls only. For those who are disadvantaged by having impairments with attentional control or difficulties with recruiting the essential brain regions to carry out work, they may be predisposed to an increased risk of suicide. Nevertheless, interventions are presently available that could alter these neurological and cognitive differences, and this may help the vulnerable group to be protected from the emotional disturbance in advance. From the supporting evidence, it is evident that executive functions, frontal asymmetry and emotion regulations may all be used to identify individuals at risk of suicide in non-clinical population and this should be accounted for in future treatment and prevention programmes. It was concluded that as the neurological mechanism of resilience research is currently in the stage of early investigation, the present research should be regarded as only a starting point for further work.

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APPENDICES

Appendix 1 - Questionnaires used in the studies

1.1 Suicide Behaviour Questionnaire (SBQ)

SBQ-R Suicide Behaviors Questionnaire-Revised

Patient Name ______________________________ Date of Visit ______________

Instructions: Please check the number beside the statement or phrase that best applies to you.

1. Have you ever thought about or attempted to kill yourself? (check one only)

- ☐ 1. Never
- ☐ 2. It was just a brief passing thought
- ☐ 3a. I have had a plan at least once to kill myself but did not try to do it
- ☐ 3b. I have had a plan at least once to kill myself and really wanted to die
- ☐ 4a. I have attempted to kill myself, but did not want to die
- ☐ 4b. I have attempted to kill myself, and really hoped to die

2. How often have you thought about killing yourself in the past year? (check one only)

- ☐ 1. Never
- ☐ 2. Rarely (1 time)
- ☐ 3. Sometimes (2 times)
- ☐ 4. Often (3-4 times)
- ☐ 5. Very Often (5 or more times)

3. Have you ever told someone that you were going to commit suicide, or that you might do it? (check one only)

- ☐ 1. No
- ☐ 2a. Yes, at one time, but did not really want to die
- ☐ 2b. Yes, at one time, and really wanted to die
- ☐ 3a. Yes, more than once, but did not want to do it
- ☐ 3b. Yes, more than once, and really wanted to do it

4. How likely is it that you will attempt suicide someday? (check one only)

- ☐ 0. Never
- ☐ 1. No chance at all
- ☐ 2. Rather unlikely
- ☐ 3. Unlikely
- ☐ 4. Likely
- ☐ 5. Rather likely
- ☐ 6. Very likely

The Suicide Behaviors Questionnaire-Revised (SBQ-R) - Overview

The SBQ-R has 4 items, each tapping a different dimension of suicidality:[1]

- Item 1 taps into lifetime suicide ideation and/or suicide attempt.
- Item 2 assesses the frequency of suicidal ideation over the past twelve months.
- Item 3 assesses the threat of suicide attempt.
- Item 4 evaluates self-reported likelihood of suicidal behavior in the future.

Clinical Utility

Due to the wording of the four SBQ-R items, a broad range of information is obtained in a very brief administration. Responses can be used to identify at-risk individuals and specific risk behaviors.

Scoring

See scoring guideline on following page.

Psychometric Properties[1]

	Cutoff score	Sensitivity	Specificity
Adult General Population	≥7	93%	95%
Adult Psychiatric Inpatients	≥8	80%	91%

SBQ-R - Scoring

Item 1: taps into *lifetime* suicide ideation and/or suicide attempts			
Selected response 1	Non-Suicidal subgroup	1 point	
Selected response 2	Suicide Risk Ideation subgroup	2 points	
Selected response 3a or 3b	Suicide Plan subgroup	3 points	
Selected response 4a or 4b	Suicide Attempt subgroup	4 points	________ **Total Points**

Item 2: assesses the *frequency* of suicidal *ideation* over the past 12 months			
Selected Response:	Never	1 point	
	Rarely (1 time)	2 points	
	Sometimes (2 times)	3 points	
	Often (3-4 times)	4 points	
	Very Often (5 or more times)	5 points	________ **Total Points**

Item 3: taps into the *threat* of suicide *attempt*		
Selected response 1	1 point	
Selected response 2a or 2b	2 points	
Selected response 3a or 3b	3 points	________ **Total Points**

Item 4: evaluates *self-reported likelihood* of suicidal behavior in the future			
Selected Response:	Never	0 points	
	No chance at all	1 point	
	Rather unlikely	2 points	
	Unlikely	3 points	
	Likely	4 points	
	Rather Likely	5 points	
	Very Likely	6 points	________ **Total Points**

Sum all the scores circled/checked by the respondents.
The total score should range from 3-18.

________ **Total Score**

AUC = Area Under the Receiver Operating Characteristic Curve; the area measures discrimination, that is, the ability of the test to correctly classify those with and without the risk. [.90-1.0 = Excellent; .80-.90 = Good; .70-.80 = Fair; .60-.70 = Poor]

	Sensitivity	Specificity	PPV	AUC
Item 1: a cutoff score of ≥ 2				
• Validation Reference: Adult Inpatient	0.80	0.97	.95	0.92
• Validation Reference: Undergraduate College	1.00	1.00	1.00	1.00
Total SBQ-R : a cutoff score of ≥7				
• Validation Reference: Undergraduate College	0.93	0.95	0.70	0.96
Total SBQ-R: a cutoff score of ≥ 8				
• Validation Reference: Adult Inpatient	0.80	0.91	0.87	0.89

1.2 BRIEF-A Questionnaire

Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A) Questionnaire

Participant Number:
Date:
Gender: Male Female
Age:
Date of Birth:
Years of Education:
Level of education: Less than High School
High School
College
Master's Degree
Doctorate
Other

During the past month, how often has each of the following behaviors been a *problem*?

N=Never S=Sometimes O=Often

1	I have angry outbursts	N	S	O
2	I make careless errors when completing tasks	N	S	O
3	I am disorganized	N	S	O
4	I have trouble concentrating on tasks (such as chores, reading or work)	N	S	O
5	I tap my fingers or bounce my legs	N	S	O
6	I need to be reminded to begin a task even when I am willing	N	S	O
7	I have a messy closet	N	S	O
8	I have trouble changing from one activity or task to another	N	S	O
9	I get overwhelmed by large tasks	N	S	O
10	I forget my name	N	S	O
11	I have trouble with jobs or tasks that have more than one step	N	S	O
12	I overreact emotionally	N	S	O
13	I don't notice when I cause others to feel bad or get mad until its too late	N	S	O
14	I have trouble getting ready for the day	N	S	O
15	I have trouble prioritizing activities	N	S	O
16	I have trouble sitting still	N	S	O
17	I forget what am I doing in the middle of things	N	S	O
18	I don't check my work for mistakes	N	S	O
19	I have emotional outbursts for little reason	N	S	O
20	I lie around the house a lot	N	S	O
21	I start tasks (such as cooking, projects) without the right materials	N	S	O
22	I have trouble accepting different ways to solve problems with work, friends, or tasks	N	S	O
23	I talk at the wrong time	N	S	O
24	I misjudge how difficult or easy tasks will be	N	S	O
25	I have problems getting started on my own	N	S	O
26	I have trouble staying on the same topic when I am talking	N	S	O
27	I get tired	N	S	O
28	I react more emotionally to situations than my friends	N	S	O
29	I have problems waiting for my turn	N	S	O
30	people say that I am disorganized	N	S	O
31	I lose things (such as keys, money, wallet, homework, etc.)	N	S	O
32	I have trouble thinking of a different way to solve a problem when I am stuck	N	S	O
33	I overreact to small problems	N	S	O
34	I don't plan ahead for future activities	N	S	O
35	I have a short attention span	N	S	O

36	I make inappropriate sexual comments	N	S	O
37	when people seem upset with me, I don't understant why	N	S	O
38	I have trouble counting to three	N	S	O
39	I have unrealistic goals	N	S	O
40	I leave the bathroom a mess	N	S	O
41	I make careless mistakes	N	S	O
42	I get emotionally upset easily	N	S	O
43	I make decisions that get me into trouble (legally, financially, socially)	N	S	O
44	I am bothered with having to deal with changes	N	S	O
45	I have difficulty getting excited about things	N	S	O
46	I forget instructions easily	N	S	O
47	I have good ideas but I cannot get them on paper	N	S	O
48	I make mistakes	N	S	O
49	I have trouble getting started on tasks	N	S	O
50	I say things without thinking	N	S	O
51	my anger is intense but ends quickly	N	S	O
52	I have trouble finishing tasks (such a s chores, work)	N	S	O
53	I start things at the last minute (such as assignments,chores, tasks)	N	S	O
54	I have difficulty finishing a task on my own	N	S	O
55	people say that I am easily distracted	N	S	O
56	I have trouble remembering things, even for a few minutes (such as directions, phone numbers)	N	S	O
57	people say I am too emotional	N	S	O
58	I rush through things	N	S	O
59	I get annoyed	N	S	O
60	I leave my room or home a mess	N	S	O
61	I get disturbed by unexpected changes in my daily routine	N	S	O
62	I have trouble coming up with ideas for what to do with my free time	N	S	O
63	I don't plan ahead for tasks	N	S	O
64	people say that I don't think before acting	N	S	O
65	I have trouble finding things in my room, closet, or desk	N	S	O
66	I have problems organizing activities	N	S	O

67	after having a problem I don't get over it easily	N	S	O
68	I have trouble doing more than one thing at a time	N	S	O
69	my mood changes frequently	N	S	O
70	I don't think about consequences before doing something	N	S	O
71	I have trouble organizing work	N	S	O
72	I get upset quickly or easily over little things	N	S	O
73	I am impulsive	N	S	O
74	I don't pick up after myself	N	S	O
75	I have problems completing my work	N	S	O

1.3 COPE inventory

COPE Inventory

We are interested in how people respond when they confront difficult or stressful events in their lives. There are lots of ways to try to deal with stress. This questionnaire asks you to indicate what you generally do and feel when you experience stressful events. Obviously, different events bring out somewhat different responses, but think about what you usually do when you are under a lot of stress.

Then respond to each of the following items by blackening one number on your answer sheet for each, using the response choices listed just below. Please try to respond to each item separately in your mind from each other item. Choose your answers thoughtfully, and make your answers as true FOR YOU as you can. Please answer every item. There are no "right" or "wrong" answers, so choose the most accurate answer for YOU--not what you think "most people" would say or do. Indicate what YOU usually do when YOU experience a stressful event.

1 = I usually don't do this at all
2 = I usually do this a little bit
3 = I usually do this a medium amount
4 = I usually do this a lot

1. I try to grow as a person as a result of the experience.
2. I turn to work or other substitute activities to take my mind off things.
3. I get upset and let my emotions out.
4. I try to get advice from someone about what to do.
5. I concentrate my efforts on doing something about it.
6. I say to myself "this isn't real."
7. I put my trust in God.
8. I laugh about the situation.
9. I admit to myself that I can't deal with it, and quit trying.
10. I restrain myself from doing anything too quickly.
11. I discuss my feelings with someone.
12. I use alcohol or drugs to make myself feel better.
13. I get used to the idea that it happened.
14. I talk to someone to find out more about the situation.
15. I keep myself from getting distracted by other thoughts or activities.
16. I daydream about things other than this.
17. I get upset, and am really aware of it.
18. I seek God's help.
19. I make a plan of action.
20. I make jokes about it.
21. I accept that this has happened and that it can't be changed.
22. I hold off doing anything about it until the situation permits.
23. I try to get emotional support from friends or relatives.
24. I just give up trying to reach my goal.
25. I take additional action to try to get rid of the problem.
26. I try to lose myself for a while by drinking alcohol or taking drugs.
27. I refuse to believe that it has happened.
28. I let my feelings out.
29. I try to see it in a different light, to make it seem more positive.
30. I talk to someone who could do something concrete about the problem.
31. I sleep more than usual.
32. I try to come up with a strategy about what to do.
33. I focus on dealing with this problem, and if necessary let other things slide a little.
34. I get sympathy and understanding from someone.
35. I drink alcohol or take drugs, in order to think about it less.
36. I kid around about it.
37. I give up the attempt to get what I want.
38. I look for something good in what is happening.
39. I think about how I might best handle the problem.
40. I pretend that it hasn't really happened.

1.4 Emotion regulation questionnaire

Emotion Regulation Questionnaire (ERQ)
Gross & John
9/03

The Emotion Regulation Questionnaire is designed to assess individual differences in the habitual use of two emotion regulation strategies: cognitive reappraisal and expressive suppression.

Citation

Gross, J.J., & John, O.P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. Journal of Personality and Social Psychology, 85, 348-362.

Instructions and Items

We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1-----------------2-----------------3-----------------4-----------------5-----------------6-----------------7
strongly disagree | **neutral** | **strongly agree**

1. ____ When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about.*
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less *negative* emotion (such as sadness or anger), I *change what I'm thinking about.*
4. ____ When I am feeling *positive* emotions, I am careful not to express them.
5. ____ When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.
6. ____ I control my emotions by *not expressing them.*
7. ____ When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.
8. ____ I control my emotions by *changing the way I think* about the situation I'm in.
9. ____ When I am feeling *negative* emotions, I make sure not to express them.
10. ____ When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

Note

Do not change item order, as items 1 and 3 at the beginning of the questionnaire define the terms "positive emotion" and "negative emotion".

Scoring (no reversals)

Reappraisal Items: 1, 3, 5, 7, 8, 10; Suppression Items: 2, 4, 6, 9.

1.5 COPE-R Questionnaire

We are interested in how people respond when they confront difficult or stressful events in their lives. There are lots of ways to try to deal with stress. This questionnaire asks you to indicate what you generally do and feel when you experience stressful events. Obviously, different events bring out somewhat different responses, but think about what you usually do when you are under a lot of stress.

Then respond to each of the following items by blackening one number on your answer sheet for each, using the response choices listed just below. Please try to respond to each item separately in your mind from each other item. Choose your answers thoughtfully, and make your answers as true FOR YOU as you can. Please answer every item. There are no "right" or "wrong" answers, so choose the most accurate answer for YOU--not what you think "most people" would say or do. Indicate what YOU usually do when YOU experience a stressful event.

1 = I usually don't do this at all
2 = I usually do this a little bit
3 = I usually do this a medium amount
4 = I usually do this a lot

1. I pretend that it hasn't really happened
2. I look for something good in what is happening
3. I try hard to prevent other things from interfering with my efforts at dealing with this
4. I try to get emotional support from friends or relatives
5. I think hard about what steps to take
6. I relive the problem by dwelling on it all the time
7. I try to identify something else I care about
8. I brood over my problem nonstop
9. I take direct action to get around the problem
10. I take time to express my emotions
11. I just think about my problem constantly
12. I refuse to believe that it has happened
13. I accuse someone of causing my misfortune
14. I let my emotions show
15. I try to let out my feelings
16. I blame someone or something for what happened to me
17. I concentrate my efforts on doing something about it
18. I talk to someone about how I feel
19. I work on staying positive even when things look bad
20. I try to forget the whole thing
21. I see that I am at the root of the problem
22. I return in my head again and again to what is troubling me
23. I criticize or lecture myself
24. I blame myself
25. I accept the reality of the fact that it happened
26. I admit to myself that I can't deal with it, and quit trying
27. I get used to the idea that it happened
28. I discuss my feelings with someone
29. I try to come up with a strategy about what to do
30. I allow myself to show how I feel about things
31. I take additional action to try to get rid of the problem
32. I give up the attempt to get what I want
33. I do what has to be done, one step at a time

34. I try to be optimistic in spite of what happened
35. I try to see it in a different light, to make it seem more
36. I say to myself ‘‘this isn’t real.’’
37. I work on feeling positive no matter what
38. I realize I brought the problem on myself
39. I make a plan of action
40. I talk to someone to find out more about the situation

1.6 Beck's Depression Inventory-II

This depression inventory can be self-scored. The scoring scale is at the end of the questionnaire.

1.
0 I do not feel sad.
1 I feel sad
2 I am sad all the time and I can't snap out of it.
3 I am so sad and unhappy that I can't stand it.

2.
0 I am not particularly discouraged about the future.
1 I feel discouraged about the future.
2 I feel I have nothing to look forward to.
3 I feel the future is hopeless and that things cannot improve.

3.
0 I do not feel like a failure.
1 I feel I have failed more than the average person.
2 As I look back on my life, all I can see is a lot of failures.
3 I feel I am a complete failure as a person.

4.
0 I get as much satisfaction out of things as I used to.
1 I don't enjoy things the way I used to.
2 I don't get real satisfaction out of anything anymore.
3 I am dissatisfied or bored with everything.

5.
0 I don't feel particularly guilty
1 I feel guilty a good part of the time.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

6.
0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

7.
0 I don't feel disappointed in myself.
1 I am disappointed in myself.
2 I am disgusted with myself.
3 I hate myself.

8.
0 I don't feel I am any worse than anybody else.
1 I am critical of myself for my weaknesses or mistakes.
2 I blame myself all the time for my faults.
3 I blame myself for everything bad that happens.

9.
0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.
10.
0 I don't cry any more than usual.
1 I cry more now than I used to.
2 I cry all the time now.
3 I used to be able to cry, but now I can't cry even though I want to.

11.
0 I am no more irritated by things than I ever was.
1 I am slightly more irritated now than usual.
2 I am quite annoyed or irritated a good deal of the time.
3 I feel irritated all the time.

12.
0 I have not lost interest in other people.
1 I am less interested in other people than I used to be.
2 I have lost most of my interest in other people.
3 I have lost all of my interest in other people.

13.
0 I make decisions about as well as I ever could.
1 I put off making decisions more than I used to.
2 I have greater difficulty in making decisions more than I used to.
3 I can't make decisions at all anymore.

14.
0 I don't feel that I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel there are permanent changes in my appearance that make me look unattractive
3 I believe that I look ugly.

15.
0 I can work about as well as before.
1 It takes an extra effort to get started at doing something.
2 I have to push myself very hard to do anything.
3 I can't do any work at all.

16.
0 I can sleep as well as usual.
1 I don't sleep as well as I used to.
2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
3 I wake up several hours earlier than I used to and cannot get back to sleep.

17.

0 I don't get more tired than usual.
1 I get tired more easily than I used to.
2 I get tired from doing almost anything.
3 I am too tired to do anything.

18.
0 My appetite is no worse than usual.
1 My appetite is not as good as it used to be.
2 My appetite is much worse now.
3 I have no appetite at all anymore.

19.
0 I haven't lost much weight, if any, lately.
1 I have lost more than five pounds.
2 I have lost more than ten pounds.
3 I have lost more than fifteen pounds.

20.
0 I am no more worried about my health than usual.
1 I am worried about physical problems like aches, pains, upset stomach, or constipation.
2 I am very worried about physical problems and it's hard to think of much else.
3 I am so worried about my physical problems that I cannot think of anything else.

21.
0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I have almost no interest in sex.
3 I have lost interest in sex completely.

Appendix 2 Participant Information Sheets
2.1 Participant Information Sheet for study 1

Study Title: Cross-Cultural Study of the Risk Factors of Suicide Ideation in University Students

Invitation paragraph:
I, Elsie Ong, PhD student at University of Salford, would like to invite you to take part in my research study. Before you decide whether to take part you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or you would like more information. Take time to decide whether or not to take part.

What is the purpose of the study?
The research aims to examine the relationship between coping, well-being and cognitive abilities among University students in the United Kingdom and Hong Kong. The research consists of several questionnaires.

Why have I been invited?
If you are a full-time student aged 18-24, studying in Open University, HK or the University of Salford, UK, you are eligible to participate in this study.

Do I have to take part?
Participation is voluntary and it is your decision whether you would like to take part or not. Please take at least 24 hours to decide if you would like to take part. By completing the consent form and returning them

you are consenting to take part in this study and you are consenting for your data to be used in this study. Even if you do decide to take part you are free to withdraw from the study at any time without stating providing a reason or explanation.

What will happen to me if I take part?
If you decide to take part you will be given a time, date, and location for the study. When you attend for the study, you will be asked to complete 5 questionnaires that measure well-being, coping, cognitive ability, suicidal thoughts, and general demographics.

Following the completion of questionnaires, you will receive debriefing and contact details for counselling and well-being services both from the university and external agencies. In addition, if you are identified as having high suicide thoughts you may be contacted by researcher via email to provide further support services.

Expenses and payments?
No gifts, vouchers, expenses or payments will be given to participants. Participation is completely on a voluntary basis.

What will I have to do?
You will be asked to complete a series of questionnaires that will take no more than 40 minutes.

What are the possible disadvantages and risks of taking part?
This study involves completing questionnaires in relation to how you are feeling, how you cope in stressful situations, and whether you have experienced suicidal thoughts previously. Some people may feel uncomfortable answering the questions. If you are at all concerned about this please contact the researcher, Elsie Ong, who will be happy to give you further information or direct you to professional services (e.g. on-call counsellors are available within the University institute). Other than that, no form of risk, discomfort or inconvenience is involved in this research for participants.

What are the possible benefits of taking part?
Your contribution will be useful in studying the cultural differences between UK and HK students in their coping strategies and well-being as well as suicide ideation.

What if there is a problem?
Should you have any questions or queries regarding this study, please feel free to call Elsie Ong (the researcher) at (HK office no. +852 31209707) or by email *eong@ouhk.edu.hk* who will try her best to answer your questions. If you wish to have further information, you may contact the Research Supervisors: Dr Peter Eachus *P.Eachus@salford.ac.uk* (UK), Dr Catherine Thompson *c.thompson@salford.ac.uk* (UK), or Dr Andrew Tang by email *acwtang@ouhk.edu.hk* (HK)

(For UK students) - If this information has caused you any emotional distress or discomfort, you may contact our well-being advisor (UOS) on 0161 2957008 or email our student life advisor on advice@salford.ac.uk. Alternatively you can approach an external service such as MIND on http://www.mindinsalford.org.uk/. (For Hong Kong students) - If this information has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute, Mr. Henry Lee hhwlee@ouhk.edu.hk and Miss Joyce Li mhli@ouhk.edu.hk

Will my taking part in the study be kept confidential?
This study is anonymous and you will be provided with a participant number that will identify you in the study. All data collected will be only used for research purposes and would be kept confidential by storing it in a USB memory stick with password. After the completion of this study, all data collected will be deleted. All the questionnaires will be kept in a locked drawer which is only assessed by the researcher. You will be asked to provide your name and email address as part of the study and this will be linked to your participant number in a separate document, however this will not be paired with your questionnaire responses. The purpose of asking for this information is to ensure that any participants who identify as

being high in suicidal thoughts can be contacted after the study to ensure they receive the support they require. It is your choice to provide your name and email address, but please note that if you do not provide this information we cannot contact you should we wish to advise you of the support services which may be of some use.

What will happen if I don't carry on with the study?
You can withdraw from the research at anytime you want without stating a reason. All your data collected will be destroyed and all your information will be removed from the study files. If you would like to withdraw from the study after you have completed the questionnaires please email the researcher with your participant number.

What will happen to the results of the research study?
If you would like to know the results of this study, you may make a request to the researcher after completion and leave your contact information. Participants will not be identified in any report or publication and the data will only be used within this research.

Who is organizing or sponsoring the research?
University of Salford, School of Health Sciences

Further information and contact details:

For Further information, please contact the researcher
Miss Elsie Ong – eong@ouhk.edu.hk
OR
Research supervisors
Dr Peter Eachus P.Eachus@salford.ac.uk
Dr Catherine Thompson c.thompson@salford.ac.uk
Dr Andrew Tang acwtang@ouhk.edu.hk

2.2 Participant Information sheet for study 2

Study Title: Neurocognitive basis of emotion regulation as a predictor of suicide ideation

Invitation paragraph:
I am a PhD student at the University of Salford and I would like to invite you to take part in my research study. Before you decide whether to take part you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. You can ask questions at any time if anything you read is not clear or you would like more information. Please take at least 24 hours to decide whether or not to take part.

What is the purpose of the study?
The research aims to examine the relationship between depression, emotion regulation, cognitive function and suicidal thoughts. The study consists of using several self-report questionnaires.

Why have I been invited?
If you are a full-time student aged 18 or above with English proficiency and computer literate, you are eligible to participate in this study. Although this study investigates the relationship between depression, emotion regulation, and suicidal thoughts you do not need to have experienced, or be experiencing suicidal thoughts to take part.

Do I have to take part?
Participation is voluntary and it is your decision whether you would like to take part or not. Please take at least 24 hours to decide if you would like to take part. By agreeing to participate and by completing the

consent form you are consenting to take part in this study and you are consenting for your data to be used in this study. Even if you do decide to take part you are free to withdraw from the study at any time without providing a reason or explanation.

What will happen to me if I take part?
If you decide to take part you will be given a time, date, and location for the study. When you attend for the study, you will be asked to complete questionnaires in a computer lab in OUHK LiPACE that measure emotion regulation, emotional state, suicidal thoughts, and general demographics (e.g. provide your age and gender). Following the completion of the study, you will receive debriefing and contact details for counselling and well-being services both from the university and external agencies. After participating in this study, you will also have the opportunity to take part in pilot study 2. In addition, you may or may not be contacted about the main experimental study and if you are identified as having high suicidal thoughts you may be contacted by the researcher via email to provide further support services.

Expenses and payments?
No gifts, vouchers, expenses or payments will be given to participants. Participation is completely on a voluntary basis.

What will I have to do?
You will be asked to complete a series of self-report questionnaires. The procedure will take approximately 30 minutes in total.

What are the possible disadvantages and risks of taking part?
This study involves some questionnaires in relation to how you cope in stressful situations, and whether you have experienced suicidal thoughts previously. Some people may experience physical and psychological discomfort when answering those questions on a Likert scales. If you are at all concerned about this please contact the researcher, xxx, who will be happy to give you further information or direct you to professional services (e.g. on-call counsellors are available within the University institute). Other than that, no form of risk, discomfort or inconvenience is involved in this research for participants.

What are the possible benefits of taking part?
Your contribution will be useful in studying the link between emotion regulation and depression measures as well as suicide ideation.

What if there is a problem?
Should you have any questions or queries regarding this study, please feel free to call xxx (the researcher) at (office no. xxx) or by email *xxx* who will try her best to answer your questions. If you wish to have further information, you may contact the Research Supervisors: xxx

If this information has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute xxx

If you remain unhappy and wish to complain formally you can do this by contacting the Research and Innovation Manager in the College of Health and Social Care at the University of Salford:
Anish Kurien - a.kurien@salford.ac.uk (0161 2955276)

Will my taking part in the study be kept confidential?
This study is anonymous and you will be provided with a participant number that will identify you in the study. All data collected will be only used for research purposes and will be kept confidential by storing it on a USB memory stick with password. All the questionnaires will be kept in a locked drawer that is only accessed by the researcher. You will be asked to provide your name and email address as part of the study and this will be linked to your participant number in a separate document, however this will not be paired with your questionnaire responses. The purpose of asking for this information is to ensure that any participants who identify as being high in suicidal thoughts can be contacted after the study to ensure they receive the support they require. It is your choice to provide your name and email address, but please note

that if you do not provide this information we cannot contact you should we need to advise you of the support services which may be of some use.

What will happen if I don't carry on with the study?
You can withdraw from the research at anytime without stating a reason. All your data collected will be destroyed and all your information will be removed from the study files. If you would like to withdraw from the study after you have completed the study please email the researcher with your participant number.

What will happen to the results of the research study?
If you would like to know the results of this study, you may make a request to the researcher after completion and leave your contact information. Participants will not be identified in any report or publication and the data will retain for a minimum of three years as they will be used for this research and for further publication purpose.

Who is organising or sponsoring the research?
University of Salford, School of Health Sciences

Further information and contact details:

For Further information, please contact the researcher

Miss Elsie Ong – eong@ouhk.edu.hk
OR
Research supervisors
Dr Peter Eachus P.Eachus@salford.ac.uk
Dr Catherine Thompson c.thompson@salford.ac.uk
Dr Andrew Tang acwtang@ouhk.edu.hk

2.3 Participant Information sheet for study 3

Study Title: Neurocognitive basis of emotion regulation as a predictor of suicide ideation

Invitation paragraph:
I am a PhD student at the University of Salford and I would like to invite you to take part in my research study. Before you decide whether to take part you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. You can ask questions at any time if anything you read is not clear or you would like more information. Please take at least 24 hours to decide whether or not to take part.

What is the purpose of the study?
The research aims to contrasts a range of different computerized tasks aim to measure inhibitory control. The research consists one classic Stroop tasks and two forms of emotional Stroop tasks.

Why have I been invited?
If you are a full-time student aged 18 or above with English proficiency and computer literate, you are eligible to participate in this study.

Do I have to take part?
Participation is voluntary and it is your decision whether you would like to take part or not. Please take at least 24 hours to decide if you would like to take part. By agreeing to participate and by completing the

consent form you are consenting to take part in this study and you are consenting for your data to be used in this study. Even if you do decide to take part you are free to withdraw from the study at any time without providing a reason or explanation.

What will happen to me if I take part?
If you decide to take part you will be given a time, date, and location for the study. When you attend for the study, you will be asked to take part in computerised tasks in a computer lab in OUHK LiPACE that require you to respond to words and images presented on the screen. Some of the stimuli are emotional but you will be provided with examples of the stimuli prior to the study.

Following the completion of the study, you will receive debriefing and you may be contacted by the researcher via email in the future.

Expenses and payments?
No gifts, vouchers, expenses or payments will be given to participants. Participation is completely on a voluntary basis.

What will I have to do?
You will be asked to complete a series of computerized tasks and questionnaires. During this time, an EEG headset will be attached to your scalp to measure brain waves pattern. The experiment will take no more than 1 hour in total.

What are the possible disadvantages and risks of taking part?
This study involves completing a series of computerized tasks. |It is unlikely that you may experience any physical and psychological discomfort during the experiment. However, if you are at all concerned about this please contact the researcher, xxx, who will be happy to give you further information or direct you to professional services (e.g. on-call counsellors are available within the University institute). Other than that, no form of risk, discomfort or inconvenience is involved in this research for participants.

What are the possible benefits of taking part?
Your contribution will be useful in studying the link between emotion regulation and cognitive performance as well as suicide ideation.

What if there is a problem?
Should you have any questions or queries regarding this study, please feel free to call xxx (the researcher) at (office no. xxx) or by email *xxx* who will try her best to answer your questions. If you wish to have further information, you may contact the Research Supervisors: xxx

If this information has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute xxx

If you remain unhappy and wish to complain formally you can do this by contacting the Research and Innovation Manager in the College of Health and Social Care at the University of Salford:
Anish Kurien - a.kurien@salford.ac.uk (0161 2955276)

Will my taking part in the study be kept confidential?
This study is anonymous and you will be provided with a participant number that will identify you in the study. All data collected will be in the form of electronic data and will only be used for research purposes. Data will be kept confidential by storing it on a USB memory stick with password. You will be asked to provide your name and email address as part of the study and this will be linked to your participant number in a separate document, however this will not be paired with your questionnaire responses (in pilot study 1). The purpose of asking for this information is to ensure that any participants who identify as being high in suicidal thoughts can be contacted after the study to ensure they receive the support they require. It is your choice to provide your name and email address, but please note that if you do not provide this information we cannot contact you should we need to advise you of the support services which may be of some use.

What will happen if I don't carry on with the study?
You can withdraw from the research at anytime without stating a reason. All your data collected will be destroyed and all your information will be removed from the study files. If you would like to withdraw from the study after you have completed the study please email the researcher with your participant number.

What will happen to the results of the research study?
If you would like to know the results of this study, you may make a request to the researcher after completion and leave your contact information. Participants will not be identified in any report or publication and the data will retain for a minimum of three years as they will be used for this research and for further publication purpose.

Who is organising or sponsoring the research?
University of Salford, School of Health Sciences

Further information and contact details:

For Further information, please contact the researcher
Miss Elsie Ong – eong@ouhk.edu.hk
OR
Research supervisors
Dr Peter Eachus P.Eachus@salford.ac.uk
Dr Catherine Thompson c.thompson@salford.ac.uk
Dr Andrew Tang acwtang@ouhk.edu.hk

2.4 Participant Information sheet for study 4A and 4B

Study Title: Emotional processing of information

Invitation paragraph:
I am a PhD student at the University of Salford and I would like to invite you to take part in my research study. Before you decide whether to take part you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. You can ask questions at any time if anything you read is not clear or you would like more information. Please take at least 24 hours to decide whether or not to take part.

What is the purpose of the study?
The research aims to examine how individuals process information with different types of emotions.

Why have I been invited?
If you are a full-time student aged 18 or above with English proficiency and computer literate, you are eligible to participate in this study.

Do I have to take part?
Participation is voluntary and it is your decision whether you would like to take part or not. Please take at least 24 hours to decide if you would like to take part. By agreeing to participate and by completing the consent form you are consenting to take part in this study and you are consenting for your data to be used in this study. Even if you do decide to take part you are free to withdraw from the study at any time without providing a reason or explanation.

What will happen to me if I take part?
If you decide to take part you will be given a time, date, and location for the study. When you attend for the study, you will be asked to take part in computerised tasks in a computer lab in OUHK LiPACE that

require you to respond to words and images presented on the screen. Some of the stimuli are emotional but you will be provided with examples of the stimuli prior to the study.

Following the completion of the study, you will receive debriefing and you may be contacted by the researcher via email in the future.

Expenses and payments?
No gifts, vouchers, expenses or payments will be given to participants. Participation is completely on a voluntary basis.

What will I have to do?
You will be asked to complete a series of computerized tasks and questionnaires. During this time, an EEG headset will be attached to your scalp to measure brain waves pattern. The experiment will take no more than 1 hour in total.

What are the possible disadvantages and risks of taking part?
This study involves completing a computerized task and completing some questionnaires. It is unlikely that you may experience any physical and psychological discomfort during the experiment. However, if you are at all concerned about this please contact the researcher, xxx, who will be happy to give you further information or direct you to professional services (e.g. on-call counsellors are available within the University institute). Other than that, no form of risk, discomfort or inconvenience is involved in this research for participants.

What are the possible benefits of taking part?
Your contribution will be useful in studying the link between emotion regulation and cognitive performance as well as suicide ideation.

What if there is a problem?
Should you have any questions or queries regarding this study, please feel free to call xxx (the researcher) at (office no. xxx) or by email *xxx* who will try her best to answer your questions. If you wish to have further information, you may contact the Research Supervisors: xxx

If this information has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute xxx

If you remain unhappy and wish to complain formally you can do this by contacting the Research and Innovation Manager in the College of Health and Social Care at the University of Salford:
Anish Kurien - a.kurien@salford.ac.uk (0161 2955276)

Will my taking part in the study be kept confidential?
This study is anonymous and you will be provided with a participant number that will identify you in the study. All data collected will be in the form of electronic data and will only be used for research purposes. Data will be kept confidential by storing it on a USB memory stick with password. You will be asked to provide your name and email address as part of the study and this will be linked to your participant number in a separate document, however this will not be paired with your questionnaire responses (in pilot study 1). The purpose of asking for this information is to ensure that any participants who identify as being high in suicidal thoughts can be contacted after the study to ensure they receive the support they require. It is your choice to provide your name and email address, but please note that if you do not provide this information we cannot contact you should we need to advise you of the support services which may be of some use.

What will happen if I don't carry on with the study?
You can withdraw from the research at anytime without stating a reason. All your data collected will be destroyed and all your information will be removed from the study files. If you would like to withdraw from the study after you have completed the study please email the researcher with your participant number.

What will happen to the results of the research study?
If you would like to know the results of this study, you may make a request to the researcher after completion and leave your contact information. Participants will not be identified in any report or publication and the data will retain for a minimum of three years as they will be used for this research and for further publication purpose.

Who is organising or sponsoring the research?
University of Salford, School of Health Sciences

Further information and contact details:

For Further information, please contact the researcher
Miss Elsie Ong – eong@ouhk.edu.hk
OR
Research supervisors
Dr Peter Eachus P.Eachus@salford.ac.uk
Dr Catherine Thompson c.thompson@salford.ac.uk
Dr Andrew Tang acwtang@ouhk.edu.hk

2.5 Participant Information sheet for Study 5

Study Title: Neurocognitive basis of emotion regulation as a predictor of suicide ideation

Invitation paragraph:
I am a PhD student at the University of Salford and I would like to invite you to take part in my research study. Before you decide whether to take part you need to understand why the research is being done and what it would involve for you. Please take time to read the following information carefully You can ask questions at any time if anything you read is not clear or you would like more information. Please take at least 24 hours to decide whether or not to take part.

What is the purpose of the study?
The research aims to examine the relationship between emotion regulation, cognitive function and suicidal thoughts. The research consists of an experimental study with the use of several computerized tasks and neurological measurements using EEG.

Why have I been invited?
If you are a full-time student aged 18 or above with English proficiency and computer literate, you are eligible to participate in this study. Although this study investigates the relationship between brain activity, emotion regulation, and suicidal thoughts you do not need to have experienced, or be experiencing suicidal thoughts to take part.

Do I have to take part?
Participation is voluntary and it is your decision whether you would like to take part or not. Please take at least 24 hours to decide if you would like to take part. By agreeing to participate and by completing the consent form you are consenting to take part in this study and you are consenting for your data to be used in this study. Even if you do decide to take part you are free to withdraw from the study at any time without providing a reason or explanation.

What will happen to me if I take part?
If you decide to take part you will be given a time, date, and location for the study. When you attend for the study, you will be asked to complete questionnaires that measure your current emotional states and general

demographics (e.g. provide your age and gender). You will also take part in different computerised tasks that measure inhibition in a computer lab in OUHK LiPACE that require you to respond to words and images presented on the screen. Some of the stimuli are emotional but you will be provided with examples of the stimuli prior to the study. Whilst you complete the computer tasks there will be an EEG headset placed on your head to measure brain waves changes. The headset simply attaches to your head and is completely non-invasive.

Following the completion of the study, you will receive debriefing and contact details for counselling and well-being services both from the university and external agencies. In addition, if you are identified as having high suicidal thoughts you may be contacted by the researcher via email to provide further support services.

Expenses and payments?
No gifts, vouchers, expenses or payments will be given to participants. Participation is completely on a voluntary basis.

What will I have to do?
You will be asked to complete a series of computerized tasks and questionnaires. During this time, an EEG headset will be attached to your scalp to measure brain waves pattern. The experiment will take approximately 30minutes in total.

What are the possible disadvantages and risks of taking part?
This study involves completing a series of computerized tasks and some questionnaires in relation to your cognitive performance, how you cope in stressful situations, and whether you have experienced suicidal thoughts previously. Some people may experience physical and psychological discomfort during the experiment. If you are at all concerned about this please contact the researcher, xxx, who will be happy to give you further information or direct you to professional services (e.g. on-call counsellors are available within the University institute). Other than that, no form of risk, discomfort or inconvenience is involved in this research for participants.

What are the possible benefits of taking part?
Your contribution will be useful in studying the link between emotion regulation and cognitive performance as well as suicide ideation.

What if there is a problem?
Should you have any questions or queries regarding this study, please feel free to call xxx (the researcher) at (office no. xxx) or by email *xxx* who will try her best to answer your questions. If you wish to have further information, you may contact the Research Supervisors: xxx

If this information has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute xxx

If you remain unhappy and wish to complain formally you can do this by contacting the Research and Innovation Manager in the College of Health and Social Care at the University of Salford:
Anish Kurien - a.kurien@salford.ac.uk (0161 2955276)

Will my taking part in the study be kept confidential?
This study is anonymous and you will be provided with a participant number that will identify you in the study. All data collected will be only used for research purposes and will be kept confidential by storing it on a USB memory stick with password. All the questionnaires will be kept in a locked drawer that is only accessed by the researcher. You will be asked to provide your name and email address as part of the study and this will be linked to your participant number in a separate document, however this will not be paired with your questionnaire responses. The purpose of asking for this information is to ensure that any participants who identify as being high in suicidal thoughts can be contacted after the study to ensure they receive the support they require. It is your choice to provide your name and email address, but please note

that if you do not provide this information we cannot contact you should we need to advise you of the support services which may be of some use.

What will happen if I don't carry on with the study?
You can withdraw from the research at anytime without stating a reason. All your data collected will be destroyed and all your information will be removed from the study files. If you would like to withdraw from the study after you have completed the study please email the researcher with your participant number.

What will happen to the results of the research study?
If you would like to know the results of this study, you may make a request to the researcher after completion and leave your contact information. Participants will not be identified in any report or publication and the data will retain for a minimum of three years as they will be used for this research and for further publication purpose.

Who is organising or sponsoring the research?
University of Salford, School of Health Sciences

Further information and contact details:

For Further information, please contact the researcher
Miss Elsie Ong – eong@ouhk.edu.hk
OR
Research supervisors
Dr Peter Eachus P.Eachus@salford.ac.uk
Dr Catherine Thompson c.thompson@salford.ac.uk
Dr Andrew Tang acwtang@ouhk.edu.hk

Appendix 3 - example consent form

Research Participant Consent Form

Title of Project: Cross-Cultural Study of the Risk Factors of Suicide Ideation in University Students
Ethics Ref No:
Name of Researcher: Elsie Li Chen Ong

(Delete as appropriate)

➢ I confirm that I have read and understood the information sheet for the above study (version x- date) and what my contribution will be.	**Yes**	**No**
➢ I have been given the opportunity to ask questions (face to face, via telephone and e-mail)	**Yes**	**No**
➢ I agree to take part in the study	**Yes**	**No**

- This study measures suicide ideation. If I am scored as having high suicide ideation, I agree to be contacted by researcher after the study. If you do not agree to be contacted you can still take part in the study, however it is important that you understand that you will only be contacted if you consent to this.

Yes	No

- I understand that my participation is voluntary and that I can withdraw from the research at any time **without giving any reason**

Yes	No

- I understand how the researcher will use my responses, who will see them and how the data will be stored.

Yes	No

- **I agree to take part in the above study**

Yes	No

Name of participant ………………………………………………………………………

Signature ……………………………………………………………………………

Date ……………………………….

Name of researcher taking consent …ELSIE LI CHEN ONG…………………

Researcher's e-mail address ……eong@ouhk.edu.hk………………………

<u>Appendix 4 Debriefing sheets</u>
<u>4.1 Debriefing for Study 1 and 2</u>

Debriefing Information

<u>General Information</u>
Your participation is greatly appreciated and will help psychologists to better understand the relationship between coping style, Executive Function, well-being and suicide ideation. If you would like to receive a report of this research when it is completed (or a summary of the findings), please contact me at Miss Elsie Ong – eong@ouhk.edu.hk or Dr Andrew Tang acwtang@ouhk.edu.hk

<u>Safety</u>
If the study has caused you any emotional distress or discomfort, you may contact our well-being advisor (UOS) on 01612957008 (email: well-being@salford.ac.uk), or email our student life advisor on advice@salford.ac.uk. Alternatively you can approach out of University service like MIND on http://www.mindinsalford.org.uk/ . For Hong Kong participants, students can contact our on-call counselors within the University institute, Mr. Henry Lee hhwlee@ouhk.edu.hk and Miss Joyce Li mhli@ouhk.edu.hk are also available within the University institute.

<u>Confidentiality</u>

All information collected in this study is anonymous and confidential, we do not aim to identify anyone's responses in the data archive. Instead, this research will only be focused on examining general patterns that emerge when the data are aggregated together.

Please do not disclose research procedures and hypotheses to anyone who might participate in this study between now and the end of data collection, as this could affect the results of the study.

Thank you for your participation!

5.2 Debriefing for study 3 and 5

Debriefing Information

Objectives of this study

This study aims to explore the underlying mechanisms that may help to explain the neurological interactions between critical Executive function and coping. The way in which suicidal thoughts and coping may alter brain wave patterns in the left and right hemispheres was measured using EEG. The findings will extend the current understanding of how people with different coping styles differentiate in their cognitive task performance and frontal brain activity. We expect that the knowledge gained from this study will contribute towards enhancing adaptive coping and reducing suicide ideation.

General Information

Your participation is greatly appreciated and will help psychologists to better understand the relationship between coping strategies, cognitive function, and suicide ideation. If you would like to receive a report of this research when it is completed (or a summary of the findings), please contact me (Ms Elsie Ong) at eong@ouhk.edu.hk or Dr Andrew Tang acwtang@ouhk.edu.hk

Safety

If the study has caused you any emotional distress or discomfort, you may contact our on-call counsellors within the University institute; Mr. Henry Lee hhwlee@ouhk.edu.hk (2768-6856) and Miss Joyce Li mhli@ouhk.edu.hk.

Please do not disclose research procedures and hypotheses to anyone who might participate in this study between now and the end of data collection, as this could affect the results of the study.

Thank you for your participation!

4.2 Debriefing for Study 4a and 4b

Debriefing Information

General Information

Your participation is greatly appreciated and will help psychologists to better understand the processing of word versus faces, and Chinese words versus English words. If you would like to receive a report of this research when it is completed (or a summary of the findings), please contact me at Miss Elsie Ong – eong@ouhk.edu.hk or Dr Andrew Tang acwtang@ouhk.edu.hk

Safety

If the study has caused you any emotional distress or discomfort, you may contact our well-being advisor (UOS) on 01612957008 (email: well-being@salford.ac.uk), or email our student life advisor on advice@salford.ac.uk. Alternatively you can approach out of University service like MIND on http://www.mindinsalford.org.uk/ . For Hong Kong participants, students can contact our on-call counselors within the University institute, Mr. Henry Lee hhwlee@ouhk.edu.hk and Miss Joyce Li mhli@ouhk.edu.hk are also available within the University institute.

Confidentiality

All information collected in this study is anonymous and confidential, we do not aim to identify anyone's responses in the data archive. Instead, this research will only be focused on examining general patterns that emerge when the data are aggregated together.

Please do not disclose research procedures and hypotheses to anyone who might participate in this study between now and the end of data collection, as this could affect the results of the study.

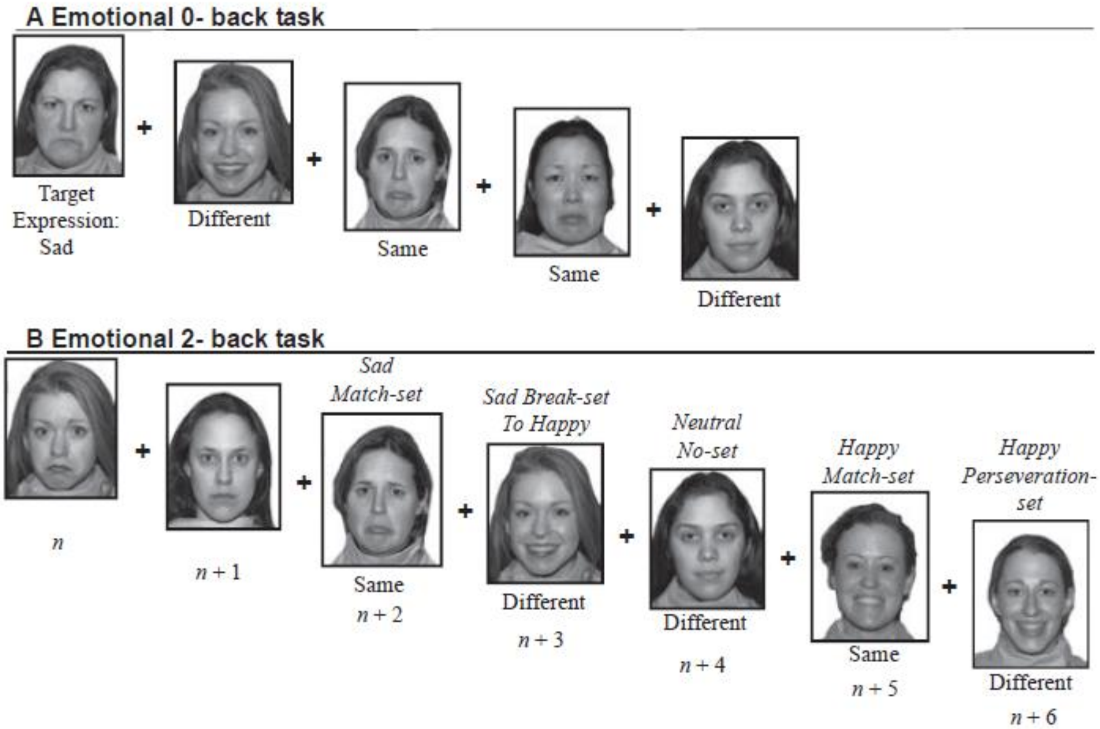
Thank you for your participation!

Appendix 5 - Stimuli used in the experiments
5.1 – Study 3 words used in the emotional Stroop task

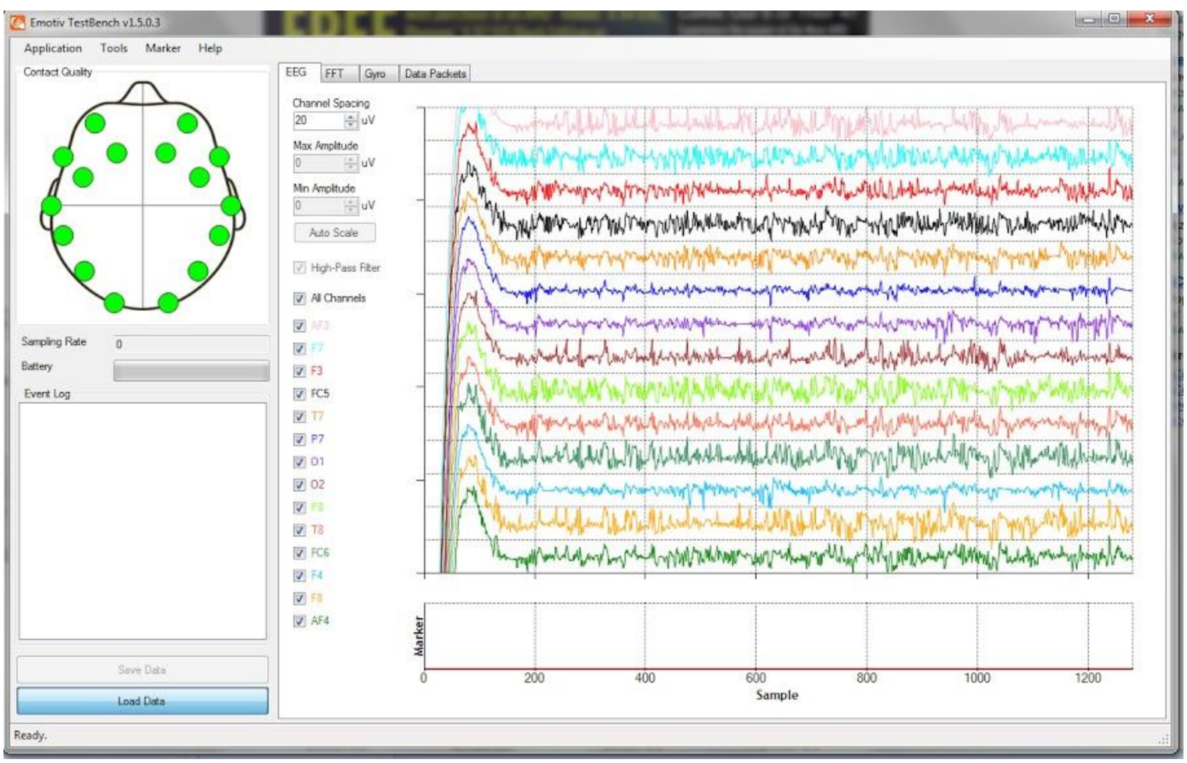
Negative	**Neutral**	**ositive**
terrible	carpet	graduate
loneliness	basket	house
infection	machine	good
burn	bottle	friend
pain	hawk	money
hurt	handle	triumphant
sick	moral	lucky
victim	industry	girl
accident	jungle	delight
buried	theory	wish
cancer	manner	idea
war	foam	achieve
seasick	cork	respect
crash	habit	music
negative	horse	satisfy
serious	hotel	joy
unfaithful	person	christmas
sad	power	game
reject	letter	baby
alone	avenue	family
failure	hospital	love
helpless	board	pleasure
hate	farm	joke
anger	poster	hope
illness	spray	beauty
unhappy	nature	positive
drown	elevator	cake
vomit	bench	miracle
mad	mind	proud
gun	rough	champion
divorce	lamb	sweetheart
abuse	highway	spirit
bankrupt	material	birthday
toothache	chair	knowledge
fat	news	honor

devil	content	god
lost	bus	present
fear	ankle	passion
corpse	month	cash
depression	detail	romantic
headache	event	ecstasy
misery	square	beach
trouble	fabric	interest
stress	church	diamond
stupid	corner	rainbow
cruel	excuse	strong
afraid	clock	holiday
dead	ink	diploma
slave	leaflet	cheers
fire	market	free
murder	city	sun
coffin	field	humor
rude	book	progress
funeral	option	mother
prison	rock	comedy
punishment	gender	pretty
mistake	elbow	luxury
bomb	hairpin	laughter
violence	office	party
poison	door	peace
depress	lamp	angel
betray	moment	kind
distress	method	hug
disaster	curtain	sex

5.2 The trial procedure used in 0-back and the 2-back tasks adapted from the figure in Levens and Gotlib (2010)



5.3 An example of the Raw EEG data in study 3 and 5



5.4 Words used for Study 4b

Negative words	Neutral words	Positive words
nightmare	foam	achieve
seasick	carpet	respect
crash	habit	music
suicide	horse	satisfy
hurt	handle	young
sick	table	lucky
victim	industry	girl
killer	boxer	delight
ugly	jungle	wish
failure	vest	love
jail	corner	heal
pain	excuse	joy
anger	poster	hope
illness	spray	beauty
unhappy	nature	positive
drown	seat	sun
vomit	bench	miracle
mad	mind	proud
gun	rough	circus
useless	time	city
abuse	highway	spirit
bankrupt	milk	birthday
insult	chair	knowledge
cancer	news	holiday
slave	content	idea
fire	bus	cheers
fear	ankle	free
coffin	field	humor
rude	book	progress
funeral	option	mother
prison	rock	win
gloom	gender	cash
mistake	elbow	luxury
bomb	hairpin	laughter
violence	office	party
poison	door	peace
depress	lamp	angel
betray	moment	kind
distress	method	hug
disaster	fire	sex

5.5- Study 5. Words used for Study 5 (Emotional Stroop task)

Negative words	Neutral words	Positive words
terrible	carpet	graduate
jail	basket	heal
infect	machine	pretty
burn	bottle	friend
pain	hawk	money
hurt	handle	young
sick	table	lucky
victim	industry	girl
killer	boxer	delight
ugly	jungle	wish
cancer	manner	idea
nightmare	foam	achieve
seasick	cork	respect
crash	habit	music
suicide	horse	satisfy
serious	hotel	joy
hell	person	christmas
sad	power	game
reject	letter	baby
alone	avenue	family
failure	vest	love
helpless	board	pleasure
hate	farm	joke
anger	poster	hope
illness	spray	beauty
unhappy	nature	positive
drown	seat	cake
vomit	bench	miracle
mad	mind	proud
gun	rough	circus
divorce	time	city
abuse	highway	spirit
bankrupt	milk	birthday
insult	chair	reward
fat	news	honor
devil	content	god
lost	bus	present
fear	ankle	passion
corpse	month	comedy
useless	detail	romantic
headache	event	holiday
misery	square	kiss
trouble	fabric	interest
stress	church	diamond

stupid	corner	rainbow
cruel	excuse	strong
afraid	clock	kiss
dead	ink	diploma
slave	leaflet	cheers
fire	market	free
murder	city	sun
coffin	field	humor
rude	book	progress
funeral	option	mother
prison	rock	win
gloom	gender	cash
mistake	elbow	luxury
bomb	hairpin	laughter
violence	office	party
poison	door	peace
depress	lamp	angel
betray	moment	kind
distress	method	hug
disaster	fire	sex

Appendix 6 – Statistics

6.1 Study 1. Data output

6.1.1 Mann Whitney test on difference in suicidality between the UK and HK

Test Statistics[a]

	SBQ TOTAL
Mann-Whitney U	1868.500
Wilcoxon W	4283.500
Z	-1.601
Asymp. Sig. (2-tailed)	.109

6.1.2 Mann Whitney test on difference in coping between the UK and HK

Test Statistics[a]

	positive growth	mental disengageme nt	focus emotion	instru social support	Suppression	emotional soc support	active coping
Mann-Whitney U	1834.500	2091.000	1793.500	2065.500	1715.500	2148.000	2160.000
Wilcoxon W	3914.500	4171.000	4208.500	4145.500	3795.500	4563.000	4240.000
Z	-1.696	-.530	-1.875	-.646	-2.245	-.271	-.218
Asymp. Sig. (2-tailed)	.090	.596	.061	.518	.025	.786	.827

Test Statistics[a]

	substance use	denial	religious coping	humour	acceptance	Beh disengage	planning	restraint
Mann-Whitney U	2131.000	1460.500	1689.500	1780.500	1890.000	1468.500	2160.000	1560.000
Wilcoxon W	4546.000	3540.500	3769.500	3860.500	3970.000	3548.500	4240.000	3640.000
Z	-.399	-3.399	-2.402	-1.937	-1.447	-3.356	-.218	-2.950
Asymp. Sig. (2-tailed)	.690	.001	.016	.053	.148	.001	.827	.003

6.1.3 Correlational analyses of suicide and executive functions

Correlations

			SBQ TOTAL	B emotional control	B task monitor	B organisation	B working memory	B inhibit	B initiate	B shift	B planning	B self monitor
Spearman's rho	SBQ TOTAL	Correlation Coefficient	1.000	.386**	.240**	.329**	.228**	.316**	.365**	.315**	.292**	.164
		Sig. (2-tailed)	.	.000	.005	.000	.008	.000	.000	.000	.001	.059
		N	133	133	133	133	133	133	133	133	133	133
	B emotional control	Correlation Coefficient	.386**	1.000	.416**	.445**	.516**	.561**	.535**	.641**	.451**	.436**
		Sig. (2-tailed)	.000	.	.000	.000	.000	.000	.000	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B task monitor	Correlation Coefficient	.240**	.416**	1.000	.602**	.659**	.585**	.717**	.589**	.741**	.682**
		Sig. (2-tailed)	.005	.000	.	.000	.000	.000	.000	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B organisation	Correlation Coefficient	.329**	.445**	.602**	1.000	.557**	.556**	.607**	.531**	.697**	.536**
		Sig. (2-tailed)	.000	.000	.000	.	.000	.000	.000	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B working memory	Correlation Coefficient	.228**	.516**	.659**	.557**	1.000	.609**	.642**	.700**	.713**	.567**
		Sig. (2-tailed)	.008	.000	.000	.000	.	.000	.000	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B inhibit	Correlation Coefficient	.316**	.561**	.585**	.556**	.609**	1.000	.642**	.578**	.683**	.615**
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.	.000	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B initiate	Correlation Coefficient	.365**	.535**	.717**	.607**	.642**	.642**	1.000	.580**	.755**	.589**
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B shift	Correlation Coefficient	.315**	.641**	.589**	.531**	.700**	.578**	.580**	1.000	.644**	.527**
		Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.	.000	.000
		N	133	133	133	133	133	133	133	133	133	133
	B planning	Correlation Coefficient	.292**	.451**	.741**	.697**	.713**	.683**	.755**	.644**	1.000	.627**
		Sig. (2-tailed)	.001	.000	.000	.000	.000	.000	.000	.000	.	.000
		N	133	133	133	133	133	133	133	133	133	133
	B self monitor	Correlation Coefficient	.164	.436**	.682**	.536**	.567**	.615**	.589**	.527**	.627**	1.000
		Sig. (2-tailed)	.059	.000	.000	.000	.000	.000	.000	.000	.000	.
		N	133	133	133	133	133	133	133	133	133	133

**. Correlation is significant at the 0.01 level (2-tailed).

6.1.4 Multiple Regression of executive functions and suicidality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.509[a]	.259	.211	2.721

a. Predictors: (Constant), B planning, B emotional control, B organisation , B inhibit, B working memory, B task monitor, B shift, B initiate

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	321.243	8	40.155	5.424	.000[b]
	Residual	918.065	124	7.404		
	Total	1239.308	132			

a. Dependent Variable: SBQ TOTAL
b. Predictors: (Constant), B planning, B emotional control, B organisation , B inhibit, B working memory, B task monitor, B shift, B initiate

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.818	1.093		.749	.456
	B emotional control	.155	.065	.276	2.396	.018
	B task monitor	-.318	.168	-.275	-1.895	.060
	B organisation	.221	.088	.299	2.525	.013
	B working memory	-.055	.111	-.069	-.492	.624
	B inhibit	.038	.103	.045	.366	.715

	B initiate	.284	.120	.345	2.358	.020
	B shift	.082	.153	.076	.539	.591
	B planning	-.142	.121	-.209	-1.177	.241

a. Dependent Variable: SBQ TOTAL

6.1.6 Correlational analyses of suicide and coping

Correlations

			SBQ TOTAL	C positive growth	C mental disengagement	C focus emotion	C instru social support	C active coping	C denial	C religious coping	C humour	C Beh disengage	C restraint	C emotional soc support	C substance use	C acceptance	C Suppression	C planning
Spearman's rho	SBQ TOTAL	Correlation Coefficient	1.000	-.066	.318**	.290**	.031	-.023	.171*	-.249**	.050	.157	.157	.032	.364**	.029	.095	-.032
		Sig. (2-tailed)	.	.447	.000	.001	.723	.794	.050	.004	.568	.071	.072	.711	.000	.744	.277	.710
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C positive growth	Correlation Coefficient	-.066	1.000	.185*	.171*	.501**	.668**	.157	.338**	.401**	.126	.417**	.370**	.110	.513**	.386**	.618**
		Sig. (2-tailed)	.447	.	.033	.048	.000	.000	.071	.000	.000	.149	.000	.000	.205	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C mental disengagement	Correlation Coefficient	.318**	.185*	1.000	.312**	.275**	.076	.426**	-.019	.264**	.420**	.240**	.190*	.435**	.248**	.350**	.079
		Sig. (2-tailed)	.000	.033	.	.000	.001	.384	.000	.831	.002	.000	.005	.029	.000	.004	.000	.363
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C focus emotion	Correlation Coefficient	.290**	.171*	.312**	1.000	.409**	.208*	.285**	.067	.145	.327**	.200*	.524**	.342**	.158	.207*	.126
		Sig. (2-tailed)	.001	.048	.000	.	.000	.016	.001	.443	.097	.000	.021	.000	.000	.069	.017	.147
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C instru social support	Correlation Coefficient	.031	.501**	.275**	.409**	1.000	.556**	.288**	.162	.300**	.140	.325**	.719**	.184*	.433**	.437**	.480**
		Sig. (2-tailed)	.723	.000	.001	.000	.	.000	.001	.063	.000	.108	.000	.000	.034	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C active coping	Correlation Coefficient	-.023	.668**	.076	.208*	.556**	1.000	.081	.234**	.304**	-.009	.410**	.444**	.012	.512**	.491**	.734**
		Sig. (2-tailed)	.794	.000	.384	.016	.000	.	.354	.007	.000	.916	.000	.000	.888	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C denial	Correlation Coefficient	.171*	.157	.426**	.285**	.288**	.081	1.000	.194*	.388**	.492**	.264**	.241**	.265**	.215*	.282**	.009
		Sig. (2-tailed)	.050	.071	.000	.001	.001	.354	.	.025	.000	.000	.002	.005	.002	.013	.001	.916
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C religious coping	Correlation Coefficient	-.249**	.338**	-.019	.067	.162	.234**	.194*	1.000	.219*	.219*	.211*	.095	-.007	.142	.105	.256**
		Sig. (2-tailed)	.004	.000	.831	.443	.063	.007	.025	.	.011	.011	.015	.277	.934	.103	.229	.003
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C humour	Correlation Coefficient	.050	.401**	.264**	.145	.300**	.304**	.388**	.219*	1.000	.344**	.324**	.201*	.245**	.350**	.301**	.300**
		Sig. (2-tailed)	.568	.000	.002	.097	.000	.000	.000	.011	.	.000	.000	.020	.005	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C Beh disengage	Correlation Coefficient	.157	.126	.420**	.327**	.140	-.009	.492**	.219*	.344**	1.000	.384**	.121	.246**	.183*	.181*	-.071
		Sig. (2-tailed)	.071	.149	.000	.000	.108	.916	.000	.011	.000	.	.000	.166	.004	.035	.037	.415
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C restraint	Correlation Coefficient	.157	.417**	.240**	.200*	.325**	.410**	.264**	.211*	.324**	.384**	1.000	.244**	.023	.415**	.340**	.442**
		Sig. (2-tailed)	.072	.000	.005	.021	.000	.000	.002	.015	.000	.000	.	.005	.789	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C emotional soc support	Correlation Coefficient	.032	.370**	.190*	.524**	.719**	.444**	.241**	.095	.201*	.121	.244**	1.000	.167	.338**	.340**	.415**
		Sig. (2-tailed)	.711	.000	.029	.000	.000	.000	.005	.277	.020	.166	.005	.	.054	.000	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C substance use	Correlation Coefficient	.364**	.110	.435**	.342**	.184*	.012	.265**	-.007	.245**	.246**	.023	.167	1.000	.180*	.149	-.028
		Sig. (2-tailed)	.000	.205	.000	.000	.034	.888	.002	.934	.005	.004	.789	.054	.	.039	.087	.746
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C acceptance	Correlation Coefficient	.029	.513**	.248**	.158	.433**	.512**	.215*	.142	.350**	.183*	.415**	.338**	.180*	1.000	.433**	.467**
		Sig. (2-tailed)	.744	.000	.004	.069	.000	.000	.013	.103	.000	.035	.000	.000	.039	.	.000	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C Suppression	Correlation Coefficient	.095	.386**	.350**	.207*	.437**	.491**	.282**	.105	.301**	.181*	.340**	.340**	.149	.433**	1.000	.475**
		Sig. (2-tailed)	.277	.000	.000	.017	.000	.000	.001	.229	.000	.037	.000	.000	.087	.000	.	.000
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
	C planning	Correlation Coefficient	-.032	.618**	.079	.126	.480**	.734**	.009	.256**	.300**	-.071	.442**	.415**	-.028	.467**	.475**	1.000
		Sig. (2-tailed)	.710	.000	.363	.147	.000	.000	.916	.003	.000	.415	.000	.000	.746	.000	.000	.
		N	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

6.1.6 ***Multiple Regression of suicidality and coping***

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.630[a]	.397	.320	2.528

a. Predictors: (Constant), C planning, C substance use, C Beh disengage, C religious coping, C focus emotion, C denial , C humour, C mental disengagement, C emotional soc support, C acceptance, C restraint, C Suppression, C positive growth, C instru social support, C active coping

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	491.873	15	32.792	5.133	.000[b]
	Residual	747.435	117	6.388		
	Total	1239.308	132			

a. Dependent Variable: SBQ TOTAL

b. Predictors: (Constant), C planning, C substance use, C Beh disengage, C religious coping, C focus emotion, C denial , C humour, C mental disengagement, C emotional soc support, C acceptance, C restraint, C Suppression, C positive growth, C instru social support, C active coping

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	3.155	.915		3.449	.001
	C positive growth	-.304	.142	-.337	-2.146	.034
	C mental disengagement	.149	.107	.159	1.392	.167
	C focus emotion	.234	.086	.285	2.719	.008
	C instru social support	-.077	.131	-.089	-.584	.560
	C active coping	.125	.169	.126	.741	.460
	C denial	.180	.121	.153	1.490	.139
	C religious coping	-.134	.061	-.183	-2.189	.031
	C humour	.008	.086	.009	.093	.926
	C Beh disengage	-.054	.123	-.050	-.442	.659
	C restraint	.234	.139	.212	1.691	.093
	C emotional soc support	-.152	.104	-.196	-1.460	.147
	C substance use	.340	.093	.330	3.644	.000
	C acceptance	-.311	.127	-.317	-2.440	.016
	C Suppression	.152	.144	.140	1.051	.295
	C planning	.087	.159	.093	.546	.586

a. Dependent Variable: SBQ TOTAL

6.1.7 Step Regression of executive functions, coping and suicidality

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.418[a]	.175	.169	2.794
2	.507[b]	.257	.246	2.661
3	.552[c]	.342	.321	2.624

a. Predictors: (Constant), B emotional control
b. Predictors: (Constant), B emotional control, C substance use
c. Predictors: (Constant), B emotional control, C substance use, B organisation

6.2 Study 2 data output

6.2.1 Correlations between suicidal behaviour, emotion regulation, and coping

	1	2	3	4	5	6	7	8
1. Suicidal behaviour	1.00							
2. Cognitive reappraisal	-.34**	1.00						
3. Expressive suppression	.001	.13	1.00					
4. Avoidance coping	.25**	.00	.26**	1.00				
5. Self-punishment coping	.17	-.05	.24**	.44**	1.00			
6. Accommodation coping	-.20*	.26**	-.12	-.05	.01	1.00		
7. Approach coping	-.09	.23*	.01	.16	.33**	.45**	1.00	
8. Self-help coping	-.23*	.21*	-.42**	-.00	-.03	.36**	.31**	1.00

* Correlation is significant at the .05 level
** Correlation is significant at the .01 level

6.2.2 Multiple-regression to explore the extent to which the aspects of emotion regulation and coping can predict suicidal behaviour

Predictors	*b*	SE (B)	*t*
Cognitive reappraisal	-.179	-.343	-4.058**
Avoidance coping	.214	.275	3.366**
Accommodation coping	-.076	-.102	-1.097
Self-help coping	-.085	-.148	-1.611

** p < .001

6.3 Study 3 data output
6.3.1 Mann-Whitney for self-report measures

Test Statistics[a]

	depression	MI	BRI	GEC	adaptive	maladaptive
Mann-Whitney U	87.000	161.000	155.000	153.000	134.500	108.000
Wilcoxon W	318.000	392.000	386.000	384.000	270.500	339.000
Z	-2.488	-.215	-.400	-.460	-1.028	-1.843
Asymp. Sig. (2-tailed)	.013	.830	.689	.645	.304	.065
Exact Sig. [2*(1-tailed Sig.)]	.012[b]	.844[b]	.705[b]	.660[b]	.308[b]	.068[b]

6.3.2 emotional Stroop task RT

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
word_nature	Sphericity Assumed	613.952	2	306.976	.279	.757
	Greenhouse-Geisser	613.952	1.909	321.650	.279	.747
	Huynh-Feldt	613.952	2.000	306.976	.279	.757
	Lower-bound	613.952	1.000	613.952	.279	.600
word_nature * suicidegroup	Sphericity Assumed	2636.734	2	1318.367	1.200	.307
	Greenhouse-Geisser	2636.734	1.909	1381.387	1.200	.306
	Huynh-Feldt	2636.734	2.000	1318.367	1.200	.307
	Lower-bound	2636.734	1.000	2636.734	1.200	.281
Error(word_nature)	Sphericity Assumed	76894.541	70	1098.493		
	Greenhouse-Geisser	76894.541	66.807	1151.003		
	Huynh-Feldt	76894.541	70.000	1098.493		
	Lower-bound	76894.541	35.000	2196.987		

Tests of Within-Subjects Contrasts

Source	word_nature	Type III Sum of Squares	df	Mean Square	F	Sig.
word_nature	Level 1 vs. Level 3	1124.852	1	1124.852	.421	.520
	Level 2 vs. Level 3	653.354	1	653.354	.321	.575
word_nature * suicidegroup	Level 1 vs. Level 3	148.432	1	148.432	.056	.815
	Level 2 vs. Level 3	3125.545	1	3125.545	1.534	.224
Error(word_nature)	Level 1 vs. Level 3	93417.724	35	2669.078		
	Level 2 vs. Level 3	71319.572	35	2037.702		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	11085551.695	1	11085551.695	1583.806	.000
Suicidegroup	62.456	1	62.456	.009	.925
Error	244975.905	35	6999.312		

6.3.3 Go/No go task Accuracy

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
emotion	Sphericity Assumed	64.297	1	64.297	2.005	.166
	Greenhouse-Geisser	64.297	1.000	64.297	2.005	.166
	Huynh-Feldt	64.297	1.000	64.297	2.005	.166
	Lower-bound	64.297	1.000	64.297	2.005	.166
emotion * suicidegroup	Sphericity Assumed	2.536	1	2.536	.079	.780
	Greenhouse-Geisser	2.536	1.000	2.536	.079	.780
	Huynh-Feldt	2.536	1.000	2.536	.079	.780
	Lower-bound	2.536	1.000	2.536	.079	.780
Error (emotion)	Sphericity Assumed	1122.374	35	32.068		
	Greenhouse-Geisser	1122.374	35.000	32.068		
	Huynh-Feldt	1122.374	35.000	32.068		
	Lower-bound	1122.374	35.000	32.068		
gonogo	Sphericity Assumed	6169.578	1	6169.578	57.014	.000
	Greenhouse-Geisser	6169.578	1.000	6169.578	57.014	.000
	Huynh-Feldt	6169.578	1.000	6169.578	57.014	.000
	Lower-bound	6169.578	1.000	6169.578	57.014	.000
gonogo * suicidegroup	Sphericity Assumed	14.519	1	14.519	.134	.716
	Greenhouse-Geisser	14.519	1.000	14.519	.134	.716
	Huynh-Feldt	14.519	1.000	14.519	.134	.716
	Lower-bound	14.519	1.000	14.519	.134	.716
Error (gonogo)	Sphericity Assumed	3787.433	35	108.212		
	Greenhouse-Geisser	3787.433	35.000	108.212		
	Huynh-Feldt	3787.433	35.000	108.212		
	Lower-bound	3787.433	35.000	108.212		
emotion * gonogo	Sphericity Assumed	15.800	1	15.800	.780	.383
	Greenhouse-Geisser	15.800	1.000	15.800	.780	.383
	Huynh-Feldt	15.800	1.000	15.800	.780	.383
	Lower-bound	15.800	1.000	15.800	.780	.383
emotion * gonogo * suicidegroup	Sphericity Assumed	.291	1	.291	.014	.905
	Greenhouse-Geisser	.291	1.000	.291	.014	.905
	Huynh-Feldt	.291	1.000	.291	.014	.905
	Lower-bound	.291	1.000	.291	.014	.905
Error(emotion*gonogo)	Sphericity Assumed	709.040	35	20.258		
	Greenhouse-Geisser	709.040	35.000	20.258		
	Huynh-Feldt	709.040	35.000	20.258		
	Lower-bound	709.040	35.000	20.258		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1172202.562	1	1172202.562	8102.777	.000
suicidegroup	4.336	1	4.336	.030	.864
Error	5063.337	35	144.667		

6.3.4 Go/No go task RT

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
emotion	Sphericity Assumed	788.691	1	788.691	2.513	.122
	Greenhouse-Geisser	788.691	1.000	788.691	2.513	.122
	Huynh-Feldt	788.691	1.000	788.691	2.513	.122
	Lower-bound	788.691	1.000	788.691	2.513	.122
emotion * suicidegroup	Sphericity Assumed	126.560	1	126.560	.403	.530
	Greenhouse-Geisser	126.560	1.000	126.560	.403	.530
	Huynh-Feldt	126.560	1.000	126.560	.403	.530
	Lower-bound	126.560	1.000	126.560	.403	.530
Error(emotion)	Sphericity Assumed	10986.173	35	313.891		
	Greenhouse-Geisser	10986.173	35.000	313.891		
	Huynh-Feldt	10986.173	35.000	313.891		
	Lower-bound	10986.173	35.000	313.891		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	9306559.227	1	9306559.227	3459.762	.000
suicidegroup	864.447	1	864.447	.321	.574
Error	94147.966	35	2689.942		

6.3.5 0-back task accuracy

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
valence	Sphericity Assumed	711.620	2	355.810	5.215	.008
	Greenhouse-Geisser	711.620	1.550	459.135	5.215	.014
	Huynh-Feldt	711.620	1.711	416.018	5.215	.011
	Lower-bound	711.620	1.000	711.620	5.215	.029
valence * depression	Sphericity Assumed	29.878	2	14.939	.219	.804
	Greenhouse-Geisser	29.878	1.550	19.277	.219	.747
	Huynh-Feldt	29.878	1.711	17.467	.219	.770

	Lower-bound	29.878	1.000	29.878	.219	.643
valence * suicidegroup	Sphericity Assumed	335.449	2	167.724	2.458	.093
	Greenhouse-Geisser	335.449	1.550	216.431	2.458	.108
	Huynh-Feldt	335.449	1.711	196.106	2.458	.103
	Lower-bound	335.449	1.000	335.449	2.458	.126
Error(valence)	Sphericity Assumed	4503.042	66	68.228		
	Greenhouse-Geisser	4503.042	51.147	88.041		
	Huynh-Feldt	4503.042	56.448	79.773		
	Lower-bound	4503.042	33.000	136.456		

Tests of Within-Subjects Contrasts

Source	valence	Type III Sum of Squares	df	Mean Square	F	Sig.
valence	Level 1 vs. Level 3	779.074	1	779.074	5.523	.025
	Level 2 vs. Level 3	64.387	1	64.387	.326	.572
valence * depression	Level 1 vs. Level 3	4.822	1	4.822	.034	.854
	Level 2 vs. Level 3	28.311	1	28.311	.143	.708
valence * suicidegroup	Level 1 vs. Level 3	60.059	1	60.059	.426	.519
	Level 2 vs. Level 3	639.020	1	639.020	3.232	.081
Error(valence)	Level 1 vs. Level 3	4655.189	33	141.066		
	Level 2 vs. Level 3	6524.335	33	197.707		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	72840.628	1	72840.628	3740.259	.000
depression	18.024	1	18.024	.925	.343
suicidegroup	14.721	1	14.721	.756	.391
Error	642.667	33	19.475		

6.3.6 2-back task accuracy

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
emotion	Sphericity Assumed	168.538	2	84.269	2.168	.132
	Greenhouse-Geisser	168.538	1.974	85.396	2.168	.133
	Huynh-Feldt	168.538	2.000	84.269	2.168	.132
	Lower-bound	168.538	1.000	168.538	2.168	.162
emotion * suicidegroup	Sphericity Assumed	21.784	2	10.892	.280	.758
	Greenhouse-Geisser	21.784	1.974	11.038	.280	.755
	Huynh-Feldt	21.784	2.000	10.892	.280	.758
	Lower-bound	21.784	1.000	21.784	.280	.604
Error(emotion)	Sphericity Assumed	1165.915	30	38.864		
	Greenhouse-Geisser	1165.915	29.604	39.384		
	Huynh-Feldt	1165.915	30.000	38.864		
	Lower-bound	1165.915	15.000	77.728		

Tests of Within-Subjects Contrasts

Source	emotion	Type III Sum of Squares	df	Mean Square	F	Sig.

emotion	Level 1 vs. Level 3	142.653	1	142.653	2.023	.175
	Level 2 vs. Level 3	325.707	1	325.707	4.247	.057
emotion * suicidegroup	Level 1 vs. Level 3	37.576	1	37.576	.533	.477
	Level 2 vs. Level 3	26.884	1	26.884	.351	.563
Error(emotion)	Level 1 vs. Level 3	1057.673	15	70.512		
	Level 2 vs. Level 3	1150.402	15	76.693		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	51205.569	1	51205.569	2320.352	.000
suicidegroup	22.219	1	22.219	1.007	.332
Error	331.020	15	22.068		

6.3.7 frontal asymmetry data

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
state	Sphericity Assumed	3.641E-5	1	3.641E-5	.001	.982
	Greenhouse-Geisser	3.641E-5	1.000	3.641E-5	.001	.982
	Huynh-Feldt	3.641E-5	1.000	3.641E-5	.001	.982
	Lower-bound	3.641E-5	1.000	3.641E-5	.001	.982
state * suicidegroup	Sphericity Assumed	.006	1	.006	.083	.775
	Greenhouse-Geisser	.006	1.000	.006	.083	.775
	Huynh-Feldt	.006	1.000	.006	.083	.775
	Lower-bound	.006	1.000	.006	.083	.775
Error(state)	Sphericity Assumed	2.383	34	.070		
	Greenhouse-Geisser	2.383	34.000	.070		
	Huynh-Feldt	2.383	34.000	.070		
	Lower-bound	2.383	34.000	.070		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	3.232	1	3.232	19.033	.000
Suicide group	.003	1	.003	.020	.889
Error	5.944	35	.170		

Pairwise Comparisons

(I) suicide group	(J) suicide group	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
yes	no SI	.014	.097	.889	-.183	.210

no SI	yes	-.014	.097	.889	-.210	.183

Based on estimated marginal means
a. Adjustment for multiple comparisons: Bonferroni.

6.4 Study 4a and 4b data output
6.4.1 Stroop stud performance using words or faces

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
stimuli	Sphericity Assumed	.209	1	.209	13.881	.001
	Greenhouse-Geisser	.209	1.000	.209	13.881	.001
	Huynh-Feldt	.209	1.000	.209	13.881	.001
	Lower-bound	.209	1.000	.209	13.881	.001
Error(stimuli)	Sphericity Assumed	.346	23	.015		
	Greenhouse-Geisser	.346	23.000	.015		
	Huynh-Feldt	.346	23.000	.015		
	Lower-bound	.346	23.000	.015		
emotion	Sphericity Assumed	.021	2	.010	3.474	.039
	Greenhouse-Geisser	.021	1.670	.013	3.474	.049
	Huynh-Feldt	.021	1.785	.012	3.474	.045
	Lower-bound	.021	1.000	.021	3.474	.075
Error(emotion)	Sphericity Assumed	.139	46	.003		
	Greenhouse-Geisser	.139	38.406	.004		
	Huynh-Feldt	.139	41.057	.003		
	Lower-bound	.139	23.000	.006		
stimuli * emotion	Sphericity Assumed	.005	2	.003	1.050	.358
	Greenhouse-Geisser	.005	1.907	.003	1.050	.356
	Huynh-Feldt	.005	2.000	.003	1.050	.358
	Lower-bound	.005	1.000	.005	1.050	.316
Error(stimuli*emotion)	Sphericity Assumed	.112	46	.002		
	Greenhouse-Geisser	.112	43.855	.003		
	Huynh-Feldt	.112	46.000	.002		
	Lower-bound	.112	23.000	.005		

Tests of Within-Subjects Contrasts

Source	stimuli	emotion	Type III Sum of Squares	df	F	Sig.	Mean Square
stimuli	Linear		.070	1	13.881	.001	.070
Error(stimuli)	Linear		.115	23			.005
emotion		Level 1 vs. Level 3	4.033E-5	1	.006	.939	4.033E-5
		Level 2 vs. Level 3	.033	1	4.088	.055	.033
Error(emotion)		Level 1 vs. Level 3	.154	23			.007
		Level 2 vs. Level 3	.183	23			.008
stimuli * emotion	Linear	Level 1 vs. Level 3	.004	1	.729	.402	.004
		Level 2 vs. Level 3	.010	1	1.733	.201	.010
Error(stimuli*emotion)	Linear	Level 1 vs. Level 3	.111	23			.005
		Level 2 vs. Level 3	.135	23			.006

6.4.2 Valence comparison for Chinese versus English words

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
language	Sphericity Assumed	.026	1	.026	.022	.883
	Greenhouse-Geisser	.026	1.000	.026	.022	.883
	Huynh-Feldt	.026	1.000	.026	.022	.883
	Lower-bound	.026	1.000	.026	.022	.883
Error (language)	Sphericity Assumed	68.546	57	1.203		
	Greenhouse-Geisser	68.546	57.000	1.203		
	Huynh-Feldt	68.546	57.000	1.203		
	Lower-bound	68.546	57.000	1.203		
emotion	Sphericity Assumed	529.756	2	264.878	121.572	.000
	Greenhouse-Geisser	529.756	1.341	395.110	121.572	.000
	Huynh-Feldt	529.756	1.361	389.173	121.572	.000
	Lower-bound	529.756	1.000	529.756	121.572	.000
Error (emotion)	Sphericity Assumed	248.381	114	2.179		
	Greenhouse-Geisser	248.381	76.425	3.250		
	Huynh-Feldt	248.381	77.590	3.201		
	Lower-bound	248.381	57.000	4.358		
language * emotion	Sphericity Assumed	69.375	2	34.688	15.725	.000
	Greenhouse-Geisser	69.375	1.170	59.315	15.725	.000
	Huynh-Feldt	69.375	1.179	58.831	15.725	.000
	Lower-bound	69.375	1.000	69.375	15.725	.000
Error(language*emotion)	Sphericity Assumed	251.473	114	2.206		
	Greenhouse-Geisser	251.473	66.668	3.772		
	Huynh-Feldt	251.473	67.217	3.741		
	Lower-bound	251.473	57.000	4.412		

6.4.3 Arousal comparison for Chinese versus English words

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
language	Sphericity Assumed	4.973	1	4.973	2.327	.133
	Greenhouse-Geisser	4.973	1.000	4.973	2.327	.133
	Huynh-Feldt	4.973	1.000	4.973	2.327	.133
	Lower-bound	4.973	1.000	4.973	2.327	.133
Error(language)	Sphericity Assumed	121.805	57	2.137		
	Greenhouse-Geisser	121.805	57.000	2.137		
	Huynh-Feldt	121.805	57.000	2.137		
	Lower-bound	121.805	57.000	2.137		
emotion	Sphericity Assumed	272.034	2	136.017	41.488	.000
	Greenhouse-Geisser	272.034	1.539	176.779	41.488	.000
	Huynh-Feldt	272.034	1.573	172.915	41.488	.000
	Lower-bound	272.034	1.000	272.034	41.488	.000
Error(emotion)	Sphericity Assumed	373.743	114	3.278		
	Greenhouse-Geisser	373.743	87.714	4.261		
	Huynh-Feldt	373.743	89.674	4.168		
	Lower-bound	373.743	57.000	6.557		
language * emotion	Sphericity Assumed	106.184	2	53.092	37.811	.000
	Greenhouse-Geisser	106.184	1.353	78.459	37.811	.000
	Huynh-Feldt	106.184	1.375	77.243	37.811	.000

	Lower-bound	106.184	1.000	106.184	37.811	.000
Error (language*emotion)	Sphericity Assumed	160.071	114	1.404		
	Greenhouse-Geisser	160.071	77.142	2.075		
	Huynh-Feldt	160.071	78.356	2.043		
	Lower-bound	160.071	57.000	2.808		

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	language	emotion	Type III Sum of Squares	df	Mean Square	F	Sig.
language	Linear		4.973	1	4.973	2.327	.133
Error(language)	Linear		121.805	57	2.137		
emotion		Linear	27.793	1	27.793	8.545	.005
		Quadratic	244.240	1	244.240	73.920	.000
Error(emotion)		Linear	185.408	57	3.253		
		Quadratic	188.335	57	3.304		
language * emotion	Linear	Linear	62.483	1	62.483	34.204	.000
		Quadratic	43.700	1	43.700	44.525	.000
Error (language*emotion)	Linear	Linear	104.128	57	1.827		
		Quadratic	55.944	57	.981		

6.5- Study 5 data output

6.5.1 Mann Whitney tests of the self-report measures

Mann Whitney tests

	AVOIDANCE_COPE	SELF PUNISHMENT_COPE	ACCOMODATION_COPE	APPROACH_COPE	SELF-HELP COPE
Mann-Whitney U	320.500	208.500	302.500	248.000	287.000
Wilcoxon W	573.500	461.500	555.500	501.000	752.000
Z	-.178	-2.264	-.513	-1.526	-.801
Asymp. Sig. (2-tailed)	.859	.024	.608	.127	.423

	COG APPRAISAL	EXP SUPPRESSION	depression	SBQ
Mann-Whitney U	223.500	267.000	106.000	.000
Wilcoxon W	476.500	520.000	571.000	465.000
Z	-1.983	-1.176	-4.158	-6.162
Asymp. Sig. (2-tailed)	.047	.239	.000	.000

6.5.2 Response times of CST

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
cong	Sphericity Assumed	557520.420	1	557520.420	127.853	.000	.719
	Greenhouse-Geisser	557520.420	1.000	557520.420	127.853	.000	.719
	Huynh-Feldt	557520.420	1.000	557520.420	127.853	.000	.719
	Lower-bound	557520.420	1.000	557520.420	127.853	.000	.719
cong *	Sphericity Assumed	20080.493	1	20080.493	4.605	.037	.084

SUICIDE_group	Greenhouse-Geisser	20080.493	1.000	20080.493	4.605	.037	.084
	Huynh-Feldt	20080.493	1.000	20080.493	4.605	.037	.084
	Lower-bound	20080.493	1.000	20080.493	4.605	.037	.084
Error (cong)	Sphericity Assumed	218031.561	50	4360.631			
	Greenhouse-Geisser	218031.561	50.000	4360.631			
	Huynh-Feldt	218031.561	50.000	4360.631			
	Lower-bound	218031.561	50.000	4360.631			

Tests of Within-Subjects Contrasts

Source	cong	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
cong	Linear	557520.420	1	557520.420	127.853	.000	.719
cong * SUICIDE_group	Linear	20080.493	1	20080.493	4.605	.037	.084
Error (cong)	Linear	218031.561	50	4360.631			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	63334531.069	1	63334531.069	2285.443	.000	.979
SUICIDE_group	801311.380	1	801311.380	28.916	.000	.366
Error	1385607.581	50	27712.152			

6.5.3 Response times of emotional Stroop task

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
emotion	Sphericity Assumed	14479.141	2	7239.571	1.824	.167	.035
	Greenhouse-Geisser	14479.141	1.844	7853.222	1.824	.170	.035
	Huynh-Feldt	14479.141	1.949	7427.677	1.824	.168	.035
	Lower-bound	14479.141	1.000	14479.141	1.824	.183	.035
emotion * suicide_GP	Sphericity Assumed	4827.044	2	2413.522	.608	.546	.012
	Greenhouse-Geisser	4827.044	1.844	2618.100	.608	.534	.012
	Huynh-Feldt	4827.044	1.949	2476.233	.608	.542	.012
	Lower-bound	4827.044	1.000	4827.044	.608	.439	.012
Error(emotion)	Sphericity Assumed	396958.455	100	3969.585			
	Greenhouse-Geisser	396958.455	92.186	4306.060			
	Huynh-Feldt	396958.455	97.467	4072.727			
	Lower-bound	396958.455	50.000	7939.169			

Tests of Within-Subjects Contrasts

Source	emotion	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
emotion	Level 1 vs. Level 3	2315.417	1	2315.417	.333	.566	.007
	Level 2 vs. Level 3	13759.018	1	13759.018	1.343	.252	.026
emotion * suicide_GP	Level 1 vs. Level 3	7046.687	1	7046.687	1.014	.319	.020
	Level 2 vs. Level 3	7429.384	1	7429.384	.725	.398	.014
Error(emotion)	Level 1 vs. Level 3	347340.705	50	6946.814			

Level 2 vs. Level 3	512161.344	50	10243.227			

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	20643064.334	1	20643064.334	2429.990	.000	.980
suicide_GP	95995.749	1	95995.749	11.300	.001	.184
Error	424756.170	50	8495.123			

6.5.4 Response times of emotional Stroop task (the word 'suicide)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
word SUICDE RT	Equal variances assumed	.035	.852	2.171	50	.035	73.4227	33.8255
	Equal variances not assumed			2.142	43.105	.038	73.4227	34.2743

6.5.5 Frontal asymmetry resting

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
EO EEG	Equal variances assumed	.651	.423	-2.633	50	.011
	Equal variances not assumed			-2.753	49.970	.008
EC EEG	Equal variances assumed	.034	.854	-1.497	50	.141
	Equal variances not assumed			-1.447	39.244	.156

6.5.6 Frontal asymmetry CST

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
CST EEG	Equal variances assumed	.132	.718	-.580	50	.564
	Equal variances not assumed			-.626	48.032	.534

6.5.7 Frontal asymmetry of emotional Stroop task

Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
emotion	Sphericity Assumed	2.099	2	1.050	13.730	.000	.215
	Greenhouse-Geisser	2.099	1.358	1.546	13.730	.000	.215
	Huynh-Feldt	2.099	1.411	1.488	13.730	.000	.215
	Lower-bound	2.099	1.000	2.099	13.730	.001	.215
emotion * suicide_GP	Sphericity Assumed	.469	2	.235	3.068	.051	.058
	Greenhouse-Geisser	.469	1.358	.345	3.068	.072	.058
	Huynh-Feldt	.469	1.411	.332	3.068	.070	.058
	Lower-bound	.469	1.000	.469	3.068	.086	.058
Error(emotion)	Sphericity Assumed	7.645	100	.076			
	Greenhouse-Geisser	7.645	67.909	.113			
	Huynh-Feldt	7.645	70.542	.108			
	Lower-bound	7.645	50.000	.153			

Tests of Within-Subjects Contrasts

Source	emotion	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
emotion	Level 1 vs. Level 3	2.254	1	2.254	12.852	.001	.204
	Level 2 vs. Level 3	3.836	1	3.836	16.632	.000	.250
emotion * suicide_GP	Level 1 vs. Level 3	.908	1	.908	5.179	.027	.094
	Level 2 vs. Level 3	.393	1	.393	1.703	.198	.033
Error(emotion)	Level 1 vs. Level 3	8.768	50	.175			
	Level 2 vs. Level 3	11.531	50	.231			