Cognitive style:

A validation study using brain imaging and eye movements

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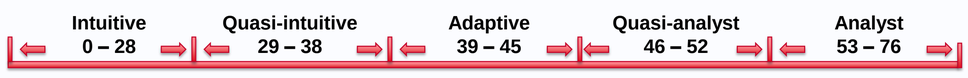
Introduction

Cognitive style refers to the manner in which individuals habitually gather, process and interpret information. Distinct from cognitive ability, style reflects generalized strategies for exploiting abilities and has been shown to influence the fundamental human processes of perception, decision making and learning. Thus, measuring cognitive style is important for understanding how individuals function in the broad contexts of work and education and assists in the development of an optimum 'fit' between individual and environment, maximizing the potential for success. Whilst self-report preference-based psychometric measures of style are favoured over time constrained task-based measures (e.g., field dependence/independence) on the basis that they are free from the influences of cognitive ability, such measures have been the subject of heavy criticism. One instrument emerging from such criticism as both sufficiently reliable and valid is the Cognitive Styles Index (CSI) (Allison & Hayes, 1996). The CSI measures style along the bipolar dimension of analysis-intuition. Analysts are characterised by sequential logical reasoning, whilst intuitives adopt a more innovative, creative and holistic approach. Such characteristic differences in approaches to cognitive processing offers the potential to further validate the CSI through examination of style-dependent functional brain activation and patterns of perceptual processing. Some evidence already exists indicating style-based individual differences in functional and neuroanatomical brain activation as well as visual search strategies. The present study attempts to capitalise on this, employing a mixed methods approach incorporating brain imaging, eye tracking and psychometric measures to explore psychobiological correlates of the analysis-intuition style dimension as measured by the CSI. Given the sequential nature of analytic processing, it is suggested that participants exhibiting a tendency towards an analytical style will exhibit a systematic (point-by-point) visual searching strategy, compared to holistic scanning strategies that may accompany intuitive style processing. Specifically, longer saccade size and frequent visual switches between images during comparative visual searching, together with shorter fixation durations, would be reflective of a more systematic, and analytic, strategy. Evidence suggesting prefrontal cortex (PFC) involvement in working memory and sustained attention supports the additional suggestion that any differences in haemodynamic responses in the PFC—measured using functional near-infrared spectroscopy (fNIRS)—can be attributed to differences in the levels of cognitive workload associated with analytical and intuitive processing.

Method

Functional near-infrared spectroscopy (a relatively novel and non-invasive brain imaging technique) and eye-tracking were used to record haemodynamic responses in the prefrontal cortex and visual search strategies in 34 participants whilst completing a comparative visual search (spot the difference) task. The task was not time limited and involved four practice and 20 randomized experimental trials (10 with and 10 without differences). On each trial participants were required to indicate whether they believed a difference did or did not exist between the two images. Following the visual search task participants completed the CSI. Changes in PFC oxygenated haemoglobin and visual search strategies were analysed according to preferred cognitive style groupings, analytic vs. intuitive. For the purpose of analysis 'pure' and 'quasi' cognitive style forms were combined to form two discrete style groups, intuitive and analysts; participants exhibiting an adaptive style were excluded.

COGNITIVE STYLE (CSI) GROUPINGS



Groups	Intuitives	Adaptives	Analysts
Nº of participants	9	5	20
CSI Mean (SD)	31.33 (6.20)	42.2 (1.79)	55.0 (7.93)

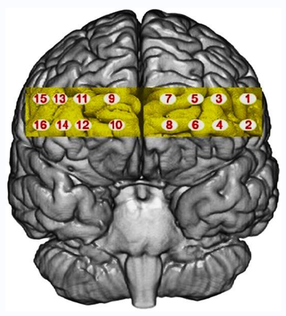
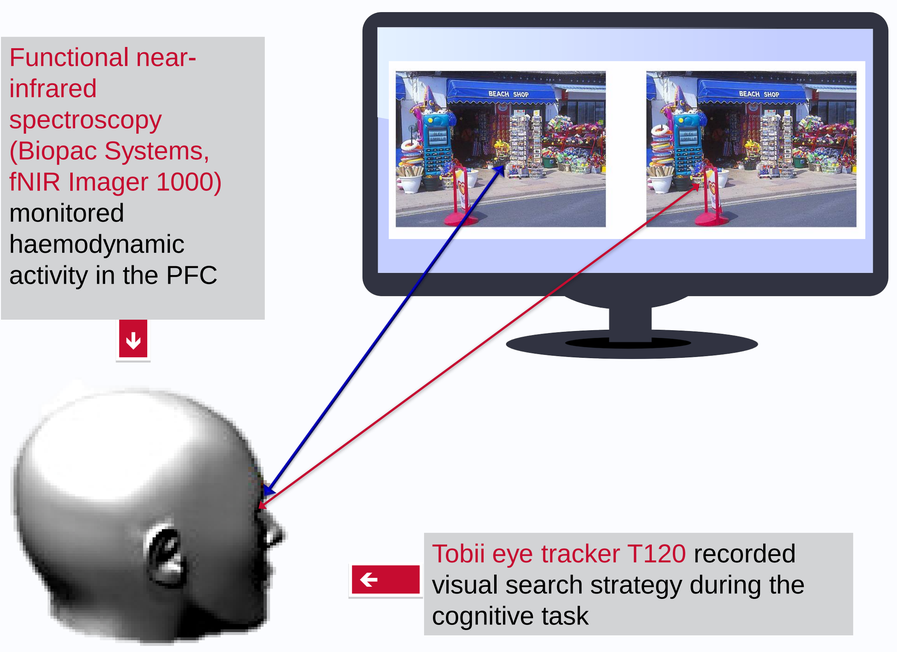


Fig 1. Location of the 16 fNIRS optodes over the PFC.



Results

VISUAL SEARCH STRATEGIES

Correlational analyses examined relationships between CSI scores and variables of interest including number of saccades, length of saccade, fixation duration and the proportion of switches between the two images.

Fig 2. The gaze plot on the left illustrates the point-by-point search strategy of a participant scoring highly within the analytic range (CSI score of 70). The scan path portrayed on the right is a representative example of the holistic scanning strategy adopted by a participant scoring within the intuitive range (CSI score of 27).

- A moderate negative correlation was found between CSI score and the number of saccade eye movements ***r* (23)= -.402, p=0.047.**
- There was also a moderate positive correlation between saccade length and CSI scores ***r* (23)= .367, p= .036, one-tailed.**
- Fixation duration showed a small negative correlation with CSI scores that approached significance ***r* (23)= -.2.67, p= .098, one-tailed.**
- The proportion of switches between images showed a small positive correlation with CSI scores which again approached significance ***r* (23)= 2.92, p= .078, one-tailed.**

In summary, there seems to be associations between level of analytical processing style and visual search strategies. Higher CSI scores were associated with fewer saccades and longer saccade length during the comparative visual search task. This longer saccade length alludes to the use of more targeted search strategies as the gaze path stretches to the corresponding point on the comparative image. Whilst neither fixation duration nor the proportion of switches between images reached statistical significance the direction of the correlations are indicative of greater use of comparative search strategy for those scoring higher for analytic style.

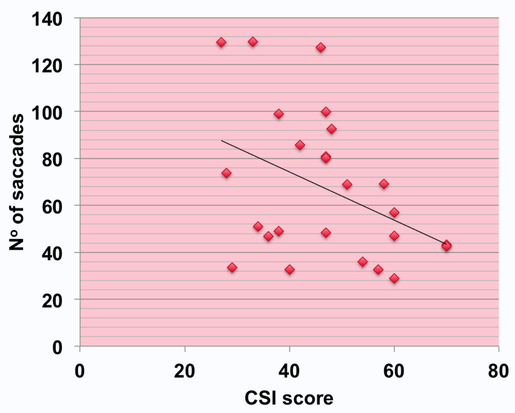


Fig. 3. Scatterplot showing the correlation between CSI score and number of saccades

fNIRS

Examination of changes in oxygenated haemoglobin in the PFC allowed for comparison of brain activation between analytic and intuitive groups.
Analysis took the form of independent samples t-tests for each of the individual voxels.

- Group comparisons revealed a greater increase in levels of oxygenated haemoglobin [voxel 11] in the analytic group compared to the intuitive group, and the difference approached significance, **t(18)= 1.970, p= .064.**

Results revealed a greater increase in haemodynamic activity in the PFC during the comparative visual search task for the analytic group when compared to the intuitive group. Whilst group differences in increased haemodynamic activity did not reach significance, findings are suggestive of an increase in cognitive workload for those exhibiting an analytic style.

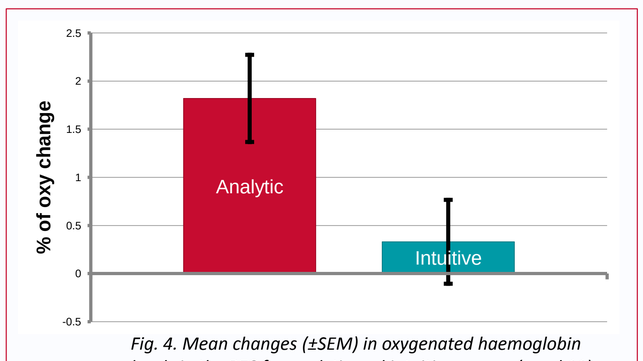


Fig. 4. Mean changes (±SEM) in oxygenated haemoglobin levels in the PFC for analytic and intuitive groups (voxel 11)

Discussion

The observed systematic visual search strategy together with the uplift in haemodynamic response suggests that analysts engaged more cognitive resources during the experimental task. These initial findings support the stated research predictions and thus warrant further exploration. Further analysis will include examination of response times and accuracy levels to establish the relative effectiveness of the strategies adopted by analytic and intuitive cognitive style groups. Analysing the application of visual search strategy across the time course of a trial would also provide insight into the flexibility of cognitive strategies, particularly when proving unsuccessful, and how these relate to subsequent haemodymanic changes. Additionally, increasing the sample size in order to increase the number of participants within the intuitive group will provide greater confidence in the power of the analysis. The observed variation in visual search strategies and differences in haemodynamic responses between the cognitive style groupings offers [neurocognitive] evidence supporting the conceptualisation of cognitive style along an intuitive-analytic dimension and the validity of the CSI as a measure of cognitive style.

References

- Allinson, C., & Hayes, J. (1996). The cognitive style index. *Journal of Management studies*, *33*(1), 119-135

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