Changes in brain functional connectivity underlying the Space-Number Association (SNA)

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1. Objectives

Whether the semantic representation of numbers is endowed with an inherent spatial component is one of the core questions in studies of math cognition. Using a Go-NoGo Implicit Association Task (IAT), we recently demonstrated that a significant and reliable space-number association (SNA) is only observed when number-magnitude codes and spatial codes are used jointly to select a response ("Joint Code" task; Pinto et al., 2021). In the present fMRI study we investigated the neural correlates of the SNA.

2. Materials

fMRI scans and behavioural performance were acquired from twenty-six healthy participants (19 females, 7 females), who performed two different Go/No-Go tasks defined as "Single Code" (SC) and "Joint Code" (JC).

3. Methods

In the SC, participants had to discriminate the left/right direction of horizontal arrows without discriminating the small/large magnitude of alternating Arabic numbers, or vice-versa. In JC, participants were asked to discriminate both the direction of arrow targets and the magnitude of Arabic numbers. In different blocks, spatial and magnitude response codes were Congruent (Go to left arrows and small numbers) or Incongruent (Go to left arrows and large numbers). Faster RTs in the Congruent condition point out the SNA. fMRI images were used for analyses of ROI-to-ROI functional connectivity (gPPI, McLaren et al., 2012; DCM/PEB, Zeidman et al., 2019).

4. Results

The SNA was only present only in the JC. gPPI analysis identified one cluster of increased connectivity in the JC > SC contrast, during the presentation of incongruent trials. This cluster included connections between the left/right intraparietal sulcus (IPS, Ba7/Ba40) and the anterior cingulate cortex (ACC, Ba32). Further analysis with DCM-PEB disclosed the strength and direction of these cingulate-parietal connections and also revealed the presence of lateral connectivity between left and right IPS during incongruent trials in the SC.

5. Discussion

These fMRI results show that the SNA depends on a modified functional interaction among structures underlying the conflict monitoring of different response codes when these are used jointly rather than in isolation. Increased connectivity between the left and right IPS during the SC could be linked to the inhibition of one out of the two different codes during performance.

6. Conclusions

The SNA is not automatic and depends on high-order control mechanisms regulating the use of response codes.

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