Selecting between intelligent options

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Abstract: In this commentary we make two rejoinders to Jung & Haier (J&H). First, we highlight the response selection component in tasks as a confounding variable that may explain the parieto-frontal involvement in studies of human intelligence. Second, we suggest that efficient response selection may be an integral part of the definition of intelligence.

Jung & Haier (J&H) have reviewed 37 neuroimaging studies and concluded that the parietal cortex is part of a network associated with better performance in intelligence and reasoning tasks. Moreover, they have suggested that the interaction between the parietal cortex and the prefrontal regions supports the existence of a parieto-frontal integration theory (P-FIT) of intelligence. The meta-analysis approach that J&H have adopted is most welcome. However, we would like to point out that the activation of this same neuronal network is common to many mental operations that may not be related to intelligence. As there is therefore no unique relationship between the parieto-frontal network proposed and intelligence, we need to ask what other functions provide a competing fit.

J&H adopt the American Psychological Association (APA) definition of intelligence, according to which, "Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought" (target article, sect. 3, para. 1). A striking omission, or at least ambiguity, in this (most agreed upon) definition is the lack of a clear role for *response selection*. Response selection is interface between perception and action that allows one to choose the most adequate response among alternatives. Crucially, response selection in tasks recruits the parietal cortex, as well as the prefrontal lobe (Bunge 2004; Bunge et al. 2002b; Cohen Kadosh et al. 2007; Göbel et al. 2004; Jiang & Kanwisher 2003; Rosenthal et al. 2006). Moreover, it seems that a parieto-frontal network is activated under conflict situations and when response selection is required (e.g., Brass & von Cramon 2004; Cohen Kadosh et al. 2007; Rushworth et al. 2001; Zysset et al. 2001). In terms of the definition of intelligence adopted in the target article, one could rewrite that in order to "adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought" one must *respond effectively to the environment, learn which responses to (not) use again, and overcome obstacles by taking action.* Indeed, the greater number of behavioural alternatives an intelligence can generate, the more important is the role of selection between possibilities.

In general, the neuroimaging studies reviewed by J&H did not control for a response selection component in their measurement. Hence, the correlation between IQ and the parieto-frontal network, as assessed by structural changes (e.g., voxel based morphometry [VBM], diffusion tensor imaging [DTI]) or functional neuroimaging (PET, fMRI), may suffer from confounding of IQ and response selection. If IQ and response selection tap different mental processes, future studies aimed at revealing the brain mechanisms underlying IQ should take into account this possibility in order to unconfound response selection and IQ – if indeed one thinks it desirable to take action out of intelligence.

We would argue that it is possible and desirable that response selection should be regarded as an integral part of intelligence. Indeed, most of the tests, assumed to measure intelligence, request that the participants choose among alternatives and take into consideration the number of correct answers and speed of processing in calculating one's IQ score. Moreover, at least in Western culture, the ability to quickly choose a correct response is a virtue that can help in various areas such as driving, shopping (very important), and other tasks which enhance life. Having response selection as an important component of intelligence would necessitate casting a different eye over the finding that a parieto-frontal network appears to be related to intelligence. It is important to establish, for example, whether these structures are involved in IQ only because of the response selection component of IQ tasks or also because of other aspects of IQ. Moreover, it would be interesting to find out how much of the variance in IQ is contributed by the various components. This could help us understand the relationship between the parieto-frontal role in IQ and the role of the parieto-frontal network in human mental experience in general.

The argument made by J&H is therefore, in our view, limited in two ways. We can either conclude that the network outlined is no more than an amalgam of areas involved in many task components that may be related to intelligence in some way. Or we may conclude that the network lacks specificity because an important component of intelligent *behaviour* is not taken into account.

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