Neural correlates of updating mental models in a picture morphing task

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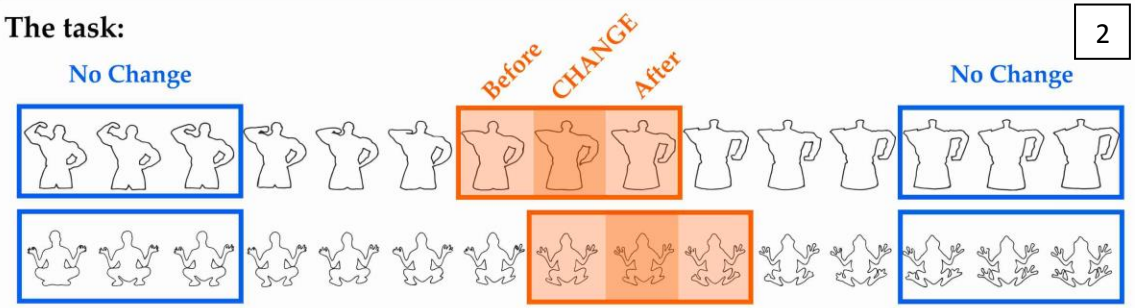
Background: 1

- Updating = changing our assumption about the environment based on information gathered from the environment
- Evidence from patient studies: right insula involved in updating (Danckert et al, 2012; Stöttinger et al, 2014)

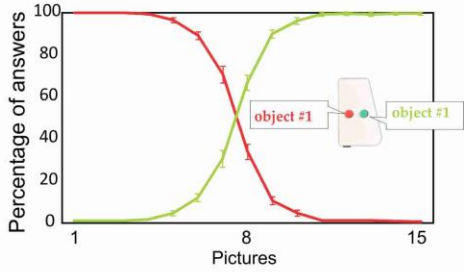
The task: 2



5 runs - 4 picture sets per run

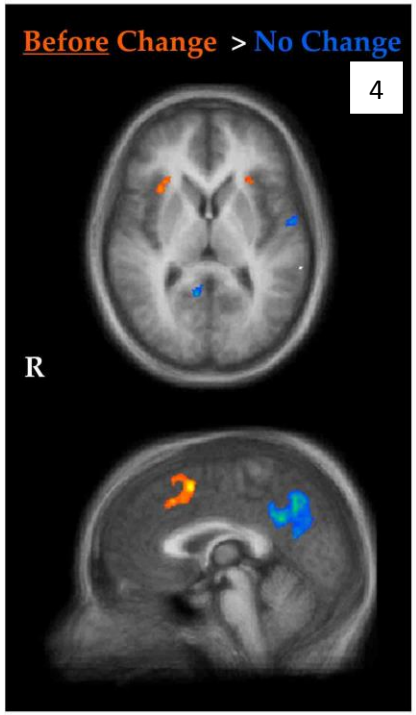
Instruction: press button 1 for 'seeing the first object', and button 2 for 'seeing the second object'.

Behavioral Results: 3



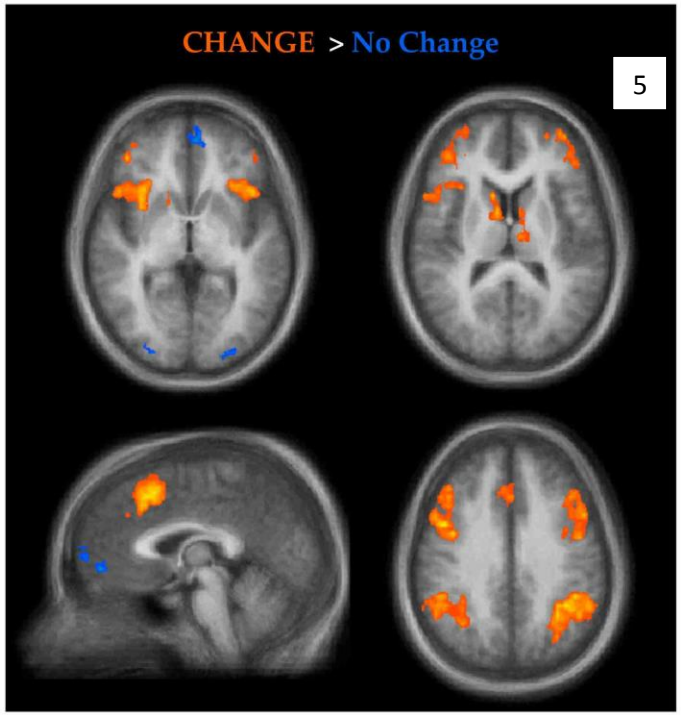
Averaged over all 20 picture sets

Before Change > No Change 4



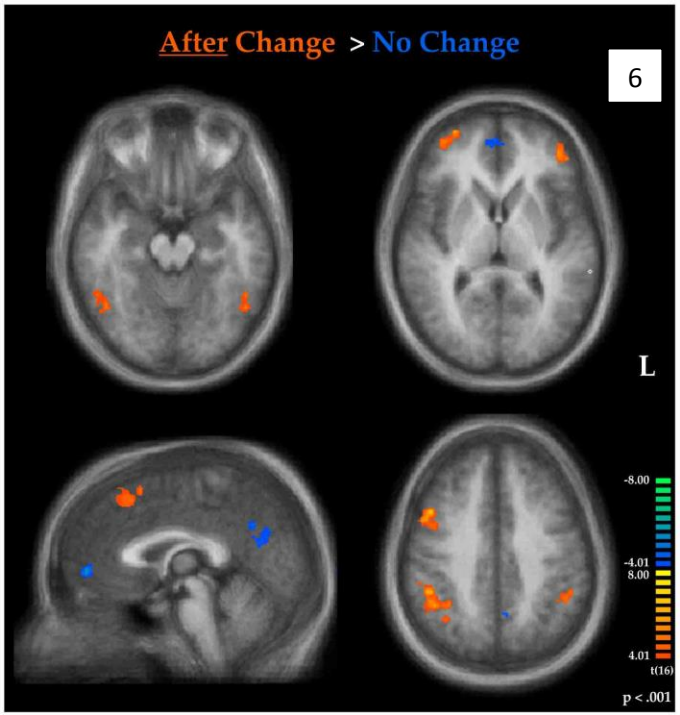
Preparation to switch:
Anterior Insula & Mid Frontal

CHANGE > No Change 5



Moment of switch/ recognition:
Anterior Insula, Mid Frontal, Caudate, Thalamus, Inferior Frontal & Inferior Parietal Cortex

After Change > No Change 6



Response evaluation:
Cerebellum, Fusiform gyrus, Inferior Frontal, Inferior Parietal, Medial Frontal Cortex

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1: In our lab we are interested in the behavioral and neural correlates of building and updating mental models of the environment. Mental models encapsulate beliefs about the rules that govern our environment and allow us to generate expectations regarding the consequences of specific actions. When new observations do not match those expectations, we must either abandon or update our model (Danckert, Stöttinger, Quehl, Anderson, 2012; Stöttinger et al, 2014a; 2014b). In different studies we demonstrated that focal brain injury selectively and differentially impaired updating. Damage to the insula – in particular on the right– results in a generic deficit in updating across different tasks (Danckert et al., 2012; Stöttinger et al, 2014b; Sepahvand et al, 2014).

2: To explore in more detail the neural networks involved in updating we developed a quick and easy task to assess how and when people update perceptual representations of ambiguous stimuli. In this task line drawings of pictures of common objects morphed over 15 iterations into a completely different object (Stöttinger et al, submitted; all picture sets can be downloaded at: http://brittlab4.uwaterloo.ca/dokuwiki/doku.php?id=elisabeth_stoettinger:start. Normative data are reported in a method paper currently under review).
In a fMRI experiment a total of seventeen neurologically healthy participants saw 20 picture morphing sets. Participants were asked to press one button for 'seeing the first object'. As soon as they saw the second object they were instructed to press a second button.

3: Participants on average reported the second object between picture 6 and picture 8 (Mean = 7.07, SD = .56). Neither gender [$t(15) = .11$, $p > .90$) nor age [Kendall's $\tau = -.11$, $p > .55$] had a significant influence on when participants reported the second object.

4: Preparation to switch: Activation of the anterior insula and mid frontal area. Deactivation of the precuneus and posterior cingulate cortex.
The anterior insula serves as an integral hub that mediates between the default mode network (DMN) and the central executive network (CEN). When observations in our environment do not match our expectations the anterior insula initiates attentional control by activating the CEN (dorsolateral prefrontal cortex and posterior parietal cortex) and deactivating in the DMN (ventromedial prefrontal cortex and posterior cingulate cortex) (Menon and Uddin, 2010). The anterior insula is usually co-activated with the ACC. This coupling facilitates rapid access to the motor system.
5: Moment of Recognition: Activation in the anterior insula, mid frontal area, caudate, thalamus, inferior frontal & inferior parietal cortex bilaterally. Those activations strongly resemble areas associated with the moment of recognition in a task where pictures were gradually revealed (repetitive priming; Ploran et al, 2007). Findings are also in accordance with the assumption of stronger activation in the CEN (including the areas of the DLPFC, and parietal regions) to mediate executive functions (e.g., attentional, working memory, etc.).
6: Response evaluation and response maintenance: Activation in the left cerebellum, fusiform gyrus, inferior frontal, inferior parietal, medial frontal cortex.
The fusiform gyrus, the right inferior frontal gyrus and the left cerebellum have been demonstrated to be involved object recognition (Gerlach, 2009). Activations may also reflect a still activated CEN due to the need to inhibit the former 'correct response' (i.e., pressing button #1).

References:

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