Easily learned, easily remembered: Encoding-fluency predicts hippocampal activation

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Introduction

• Subjective sense of cognitive-task difficulty can have profound effects on how similar tasks will be approached by the perceiver on future occasions.

• One type of cognitive task - forming associative memory - is believed to be important for building relational knowledge systems, which may serve as the foundation of human higher cognition.

• The neural activity that supports the subjective sense of difficulty during associative processing is not known.

• In this fMRI study, we asked participants to associate a face with a house at encoding. Immediately after each face-house encoding trial, participants were asked to indicate whether it was easy (or difficult) to make that association.

• By comparing the brain activation patterns between the encoding trials indicated as “easy” versus as “difficult”, we can investigate the neural activity that supports subjective sense of task difficulty in associative encoding.

Method

Participants:

• 20 participants (8 males, 12 females, all Caucasians).

• Age: 18 – 25 years (Mean = 21.1, SD = 1.5)

fMRI task:

• Stimuli: face-house picture pairs and scrambled picture pairs

  • 60 face-house pairs and 36 scrambled pairs in each run

• Totally of 4 runs: AABB and BBAA , counterbalanced

  • A: famous faces

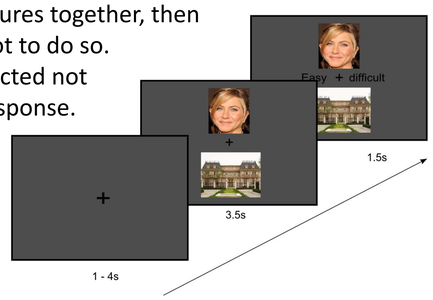
  • B: non-famous faces

• Within each run, face-house pairs and scrambled pairs were pseudo-randomized. Using event-related design, with jitter = 1 – 4s.

• **Associative encoding task using house-face pictures:**

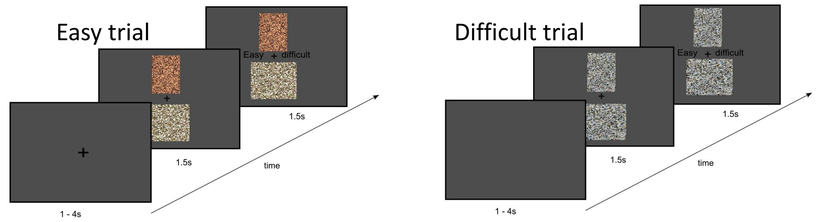
Participants were asked to image and memorize, as vividly as possible, the two pictures together, then indicate whether it was easy or not to do so.

Participants were also instructed not to think hard when making the response. They should make the response just based on their general feeling.



• **Perceptual judgment task using scrambled pairs – control task**

Participants were also asked to differentiate the patterns of the two scrambled pictures. (When the two pictures are similar, it should be difficult to differentiate. Otherwise, it should be easy.)

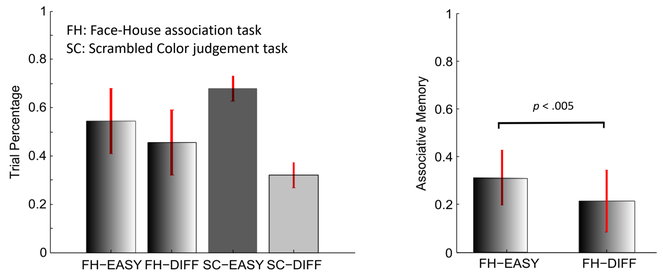


• Associative memory task was given immediately after the fMRI encoding task.

fMRI Analysis: SPM8 parametric modulation analysis was used at first level; One sample t test with subject as random factor was used at group level. Threshold *p* = .005, with 10 voxel extension (Lieberman & Cunningham, 2009).

Results

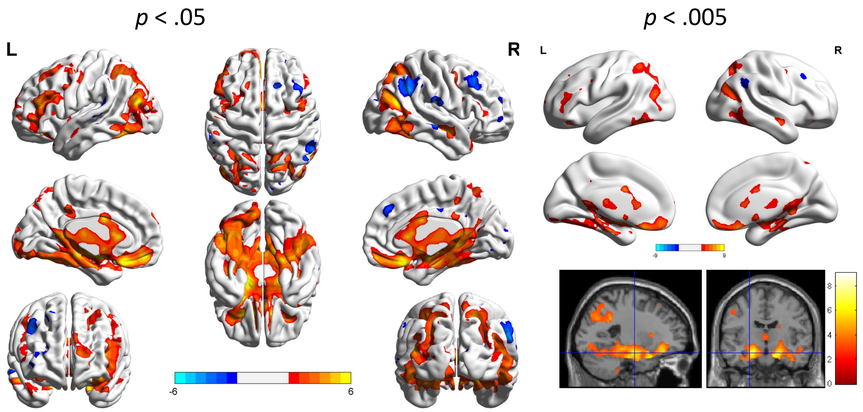
Behavioral data: Easy trials were memorized better than difficult ones.



fMRI data:

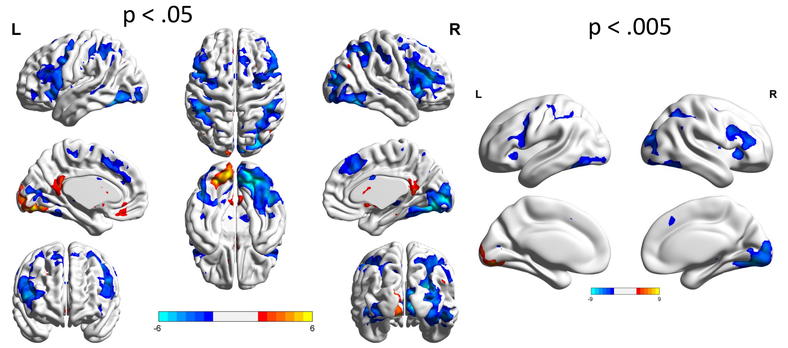
Associative encoding task:

Warm color: Easy > Difficult; Cold color: Difficult > Easy (10-voxel extension)



Perceptual judgment task:

Warm color: Easy > Difficult; Cold color: Difficult > Easy (10-voxel extension)



Conclusion

• During associative encoding, the trials judged as “easy” were also memorized better than the difficult ones.

• During associative encoding, brain regions thought to be important for associative memory, including the medial temporal lobe, were more active on "easy" than "difficult“ trials .

• However, the opposite pattern was found in the perceptual task: there was more activation in the right occipital, bilateral parietal, and prefrontal cortices on "difficult" than "easy“ trials.

• These results suggest that one reason why participants felt some trials to be difficult is that they could not mobilize brain regions that have been found important for associative processing.

• For the brain regions that showed more activation on easy encoding trials, some may be related to memory formation, but others may be related to subjective judgment of task difficulty, effort, or performance (e.g., Modirrousta & Lesley, 2008; Otto, et al., 2012; Qin et al., 2011). Future studies are needed to further delineate these different processes.

References:

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All participants provided informed consent. The study was approved by the Research Ethics Board at Baycrest Hospital.