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Original communication

## Specific marker of feigned memory impairment: The activation of left superior frontal gyrus

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## ABSTRACT

Faking memory impairment means normal people complain lots of memory problems without organic damage in forensic assessments. Using alternative forced-choice paradigm, containing digital or autobiographical information, previous neuroimaging studies have indicated that faking memory impairment could cause the activation in the prefrontal and parietal regions, and might involve a fronto-parietal-subcortical circuit. However, it is still unclear whether different memory types have influence on faking or not. Since different memory types, such as long-term memory (LTM) and short-term memory (STM), were found supported by different brain areas, we hypothesized that feigned STM or LTM impairment had distinct neural activation mapping. Besides that, some common neural correlates may act as the general characteristic of feigned memory impairment. To verify this hypothesis, the functional magnetic resonance imaging (fMRI) combined with an alternative word forced-choice paradigm were used in this study. A total of 10 right-handed participants, in this study, had to perform both STW and LTM tasks respectively under answering correctly, answering randomly and feigned memory impairment conditions. Our results indicated that the activation of the left superior frontal gyrus and the left medial frontal gyrus was associated with feigned LTM impairment, whereas the left superior frontal gyrus, the left precuneus and the right anterior cingulate cortex (ACC) were highly activated while feigning STM impairment. Furthermore, an overlapping was found in the left superior frontal gyrus, and it suggested that the activity of the left superior frontal gyrus might be acting as a specific marker of feigned memory impairment.

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## 1. Introduction

In recent years, numerous studies have used fMRI to explore the specific neural correlates of deception.<sup>1–13</sup> Despite numerous paradigms are used, a general consensus is that responding deceptively requires more complex cognitive processing or greater

mental control than responding honestly including generating lies and withholding the truth.<sup>14,15</sup> Among all deceptive acts, feigned memory impairment which means normal people attempts to feign amnesia or memory loss is a very specific behavior, and it is an especially common phenomenon in forensic psychiatry evaluations, since demonstration of memory impairment could preclude punishment or bring attractive rewards, such as large financial compensations.

Memory is usually classified as immediate memory, STM and LTM according to its duration and it is one's ability to store, retain and recall information and experiences. To date, studies indicate that different memory types have different neural circuits. For example, STM is supported by transient patterns of neuronal communication, and relies on regions of frontal and parietal lobes. Meanwhile, LTM is maintained by more stable and permanent changes in neural

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connections widely spread throughout the brain. In additions, both STM and LTM share some overlapping regions including the ventrolateral prefrontal cortex, dorsolateral prefrontal cortex and frontopolar prefrontal cortex.<sup>16–19</sup> On the other hand, autobiographical memory, as one of the special types of LTM, is primarily involved in prefrontal cortex, medial, and lateral temporal cortex, as well as posterior cingulate and retrosplenial cortex.<sup>20</sup>

Studies about feigned memory impairment in the past decades were drawn by utilizing the combination of fMRI and forced choice tasks. Among the contents of the task, the digital and word forced-choice paradigms were related to STM and autobiographical memory.<sup>1,3,7</sup> It was reported that a fronto-parietal-subcortical circuit, including bilateral prefrontal regions, fronto-polar prefrontal areas, angular and supramarginal gyri of the parietal lobe, and the cingulate and caudate locations of subcortical regions, was involved in STM task with faking memory impairment.<sup>3,7</sup> On the other hand, faking autobiographical memory impairment was associated with the activation of the ventrolateral prefrontal cortex, dorsolateral prefrontal cortex, ACC and left parietal regions.<sup>1,7</sup> Thus there were huge differences between those two different feigning, and whether the differences resulted from stimuli materials or not is still unknown. Previous studies found that different types of lies were associated with different neural correlates. A study of spontaneous vs. memorized lies showed more activation in right anterior frontal cortices when performed memorized lies than spontaneous lies, whereas the opposite pattern occurred in the ACC and posterior visual cortex, which indicated that different types of deception were supported by distinct neural networks.<sup>4</sup> Another study of autobiographical vs. non-autobiographical lies revealed that dealing with self-relevant information could trigger more conflict and more cognitive control. Increased activation in the ACC, the dorsolateral prefrontal cortex, caudate and thalamic nuclei were found in participants faking autobiographical information than non-autobiographical information.<sup>8</sup> Consistent with that, two recent studies revealed the effect of valence on the neural activity associated with deception.<sup>21,22</sup> Meanwhile, autobiographical memory had unavoidable emotional effects on individuals, and activated brain regions related to emotion. Thus, the comparison of feigned STM and autobiographical memory impairment may not enough to describe the general correlates of feigned memory impairment. Whether neural networks of feigning STM impairment differ from that of feigning LTM impairment or not needs further clarification.

Our previous study, by using fMRI and STM digital forced choice task, have already demonstrated that the behavioral data and neural activations involved in feigned memory impairment are distinguish from that in answering correctly/randomly/incorrectly conditions.<sup>23</sup> Thus, in this study, we only adopted three conditions, including “answer correctly”, “answer randomly” and “feigned memory impairment”, as the response style or strategy for the subjects to make the conscious manipulation of recalled information. Previously identified neural correlates of feigned memory impairment, such as the prefrontal, anterior cingulate and parietal regions, reflects executive processes that may not specific to feigned memory impairment. Here based on above studies, we hypothesized that difference existed between feigning STM and LTM impairment due to different memory task, and might also have common neural correlates, which is specific to feigned memory impairment.

## 2. Material and methods

### 2.1. Subjects

A total of 12 healthy volunteers (6 males and 6 females), aged from 25 to 28 years (mean age 26.1 years, SD = 1.2), were recruited to take part in this study. All participants were right-handed judged

by the Chinese Lateral Dominance Test, had normal or corrected-to-normal vision and normal mental state measured by Symptom Checklist-90 (SCL-90). Subjects with antisocial personality traits were excluded from the study, and none of the participants had a history of neurological or psychiatric illness. This study was approved by the Institutional Ethics Review Board of Zhongshan School of Medicine, Sun Yat-Sen University, and all participants gave written informed consent.

### 2.2. Stimuli

A total of 255 Chinese nouns of two characters were adopted as the experimental stimuli in this study, 120 words for the LTM task (60 targets and 60 non-targets) and the rest for the STM task (60 targets and 75 non-targets). All of the words were chosen from the Frequency Dictionary of Modern Chinese (Beijing Institute of Language Teaching and Research, 1986), with frequency ranging from 20 to 47/million (mean frequency 32.2/million). Words with too many ( $\geq 20$ ) or too few ( $\leq 1$ ) strokes, and words with emotional or pronunciation similarity, were excluded.

### 2.3. Experimental design and procedures

We performed a block-designed fMRI study employing a word task in a two-alternative forced-choice format. The experimental paradigm used in our previous study<sup>23</sup> was modified and then used in this study. There were three experimental conditions for both STM and LTM tasks in this study while scanning: (1) “answering correctly”, required the participants make accurate, honest responses; (2) “answering randomly”, required the participants feel free to make random responses, do not care right or wrong; (3) “feigned memory impairment”, required the participants intentionally and tactfully falsify memory impairment. The condition “answering correctly” is no doubt used as baseline, whereas the condition “answering randomly” was included as a poor lie strategy, aimed to encourage the participants fake with a skill rather than simply provide random choice. To motivate the participants to fake with a strategy and to make more reality, the following instruction was used: “Imaging a scenario, in which your memory problem will lead to sum of attractive money as compensation. Thus, you should fake well and do it skillfully to avoid detection. Everyone who reached that goal would get 200 Yuan (about 32 US dollars) as encouragement”. In fact, all the participants were paid after completion of the experiment.

A word memory task of a forced-choice format was utilized in this study. For the LTM task, one week before scanning, participants were asked to read and remember a word list consisting of 60 Chinese words and were monitored by an examiner twice a day until the day before scanning. For STM part, participants were required to study a list of words for 15 s during scanning instead. And to avoid the influence of new words during STM task, all the participants were asked to finish the LTM task first (Fig. 1a). During scanning, the participants were positioned on their back, and a soft sponge was fixed to their head to reduce movement. Both the LTM and STM task consisted of three runs, with each run for each condition. During scanning, subjects were requested to answer the questions correctly/randomly/faking according to the instruction shown at the beginning of each run. And the sequence of the presentation of the conditions was counterbalanced among subjects.

For LTM task, each run contained five blocks, subjects were presented with four cards in succession during each block, each one containing two words which were presented in the Chinese font, like “狐狸 野鸭”, one word was memorized for a week before test (‘the correct choice-狐狸’) and the other one was not (‘a foil-野鸭’), each participant was requested to choose the correct answer by

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