The Effects of Semantic Similarity and Emotion on False Memory Production

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Abstract: False memory is a long-term memory phenomenon when people report past events differently from the facts. Scientists have been interested in the generation of false memory and numerous studies demonstrated that a region in temporal pole called "semantic hub" of the brain is the origin of false memory induced by semantic similarity among different concepts. According to this neural mechanism, auditorily-presented behavior task and visually-presented retrieval task were conducted and the first hypothesis that semantic similarity promotes false memory generation was confirmed. Additionally, this research aimed to compare the difference between the influence caused by positive words and negative words on false memory. However, the result was not consistent with the second hypothesis that negatively-valenced concepts induce more false memory than positively-valenced ones. Therefore, the effect of emotion to memory distortion requires further investigation while this paper may provide novel insight into the relationship between false memory and emotion.

1 INTRODUCTION

False memory is a long-term memory phenomenon where one recalls something that did not happen or recall it from a different way compared to the truth (Henry, Roediger, Elizabeth 2009). There are numerous factors influencing the generation of false memory and one of the most significant is similarity between new items and past events. In this condition, people may incorrectly consider new items as old things as they are very similar. Among various kinds of similarity, in recent decades, scientists have explored more about the relationship between semantic similarity and false memory production. Chadwick MJ et al. demonstrated that false memories originate from a region known as the "semantic hub" of the brain, which is a similarity-based neural code in the temporal pole. Further, they found that the degree of semantic similarity between different events can be reflected by the extent of overlap among neural representations of relevant concepts in the neural code and this neural overlap predicts the probability of false memory generation (Chadwick, Anjum, Kumaran, Schacter, Spiers, Hassabis, 2016). Another research indicates that in the recognition task showing new words to participants, words of high-similarity with old concepts had remarkably higher likelihood to be improperly recalled as old compared with low-similarity words, even after excluding out the influence of lexical co-occurrence and associative relatedness (Montefinese, Zannino, Ambrosini 2015). A 2016 study showes the neural mechanism of false memory generation is both true and false memories emerge. (Ye, Zhu, Zhuang, Lu, Chen, Xue 2016). In addition to the origin of false memory, the effects of emotion on false memories are gaining increased attention. This is usually reflected by the impact of words' valence on the strength of false memories. For instance, it was reported that the increase of false memories was more pronounced when subjects were instructed to memorize and then recognize negatively-valenced words compared to remembering and recognizing positively-valenced words (Brainerd, Holliday, Reyna, Yang, Toglia 2010). Furthermore, research revealed that words of negative emotional valence tend to induce more false memories due to its automatic neural processing while positive ones often produce less false memories because the related neural processing is more controlled (Knott, Howe, Toffalini, Shah, Humphreys 2018).

In this study, we conducted auditorily-presented behavior task and visually-presented retrieval task online and used words with distinctive emotional valences and semantic similarity to investigate the

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false memory production and its related effects caused by semantic similarity and emotion. We put forwarded two hypotheses. One is that semantic similarity can affect long-term memory and produce false memories and the other is that concepts of negative emotional valence produce more false memory than that of positive ones.

2 METHODS AND MATERIALS

2.1 Collect Personal Information

We collected information of 30 subjects aged from 17 to 24, with the basic education level being high school. Among the 30 subjects, 15 people are females and 15 people are males. The information includes gender, education background and age.

2.2 Behavioral Task: Verbal Memory Task Presented Auditorily

Participants are native Chinese speakers and they were instructed to memorize a set of 80 Chinese two-character words (8 separate lists of 10 words each). The words are broadcast in an audio file in sequence and the time for each word is 2 seconds (includes the time for broadcasting and the interval time). The total time for memorizing is approximately 4 minutes.

These words were selected from the Cornell/Cortland emotional list (Chang, Brainerd, Toglia, Schmidt 2010) consisting of 32 DRM (Deese–Roediger–McDermott) lists which are divided into four groups of lists: 8 positively-valenced/ high arousal lists and 8 positively-valenced/ low arousal lists, 8 negatively-valenced/ high arousal lists and 8 negatively-valenced/ low arousal lists. The mean arousal among all the high-arousal lists is not significantly different and the mean arousal among all the low-arousal lists is also not. In our 8 lists, 4 of them contain words with positive valence and 4 with negative valence. Within each emotion set (positive or negative), there are 2 lists contain words with high arousal and the other 2 lists contain words with low arousal. We provide English translations for presentation purposes and recorded all the words in an audio file.

2.3 Distraction Task (Non-Mneumonic)

After encoding, participants were instructed to complete a non-mneumonic task that involves mathematical computations. The questions are 58-25=? and 23+19=? Participants were given 30 seconds to write down the answers in the chat box. Performance was measured using accuracy. Following the distraction task, a retrieval period was conducted.

2.4 Retrieval Task

During retrieval, participants were visually presented with 120 words (40 old, 40 lures, 40 foils), each presented one at a time for 2 second. The lures are selected from Cornell/Cortland emotional list. For each category of words (old, lure, foil), half were positive and the other half were negative. Participants were asked to respond in a table format **(Table 1)** to determine whether they had seen the word during encoding. If the answer is yes, they were supposed to type Chinese character “是” in the table and Chinese character “否” is corresponding to “No”.

Table 1: Table for subjects to write down answers.

The number	Use the drop-down button to fill in "yes" or "no".
1	
…	
120	

2.5 Data Analysis

We calculated the percent correct of studied words (the number of “yes” for old/ the number of all the old words tested (i.e. 40)) and that of critical lures (the number of “no” for lures/ the number of all the lures tested (i.e. 40)). Similarly, the percent correct of negative/ positive studied words and that of negative/ positive lures were calculated. In addition, corrected false memory is also computed by subtracting foils judged as old from lures judged as old and corrected true memory is computed by subtracting foils judged as old from studied words judged as old. Further, we calculated corrected false and true memory rates in positive and negative sets.

(eg: positive corrected false memory rate = percent correct of foils in positive set minus percent correct of positive lures)

(eg: positive corrected true memory rate = percent correct of positive studied words plus percent correct of positive lures minus one.)

3 RESULTS

3.1 The Effect of Semantic Similarity on False Memory Generation

Compared with that of critical lures, the percent correct of studied words is significantly higher ($p<0.05$) **(Figure 1A).** Further, we compared the percent correct of positive studied words and that of positive lures and the result is consistent ($p<0.05$) **(Figure 1B)**. We also compared the percent correct of negative studied words and that of negative lures. **Figure 1C** shows that the percent correct of negative studied words is significantly higher than that of negative lures ($p<0.05$). The results above demonstrate that semantic similarity promotes false memory production.

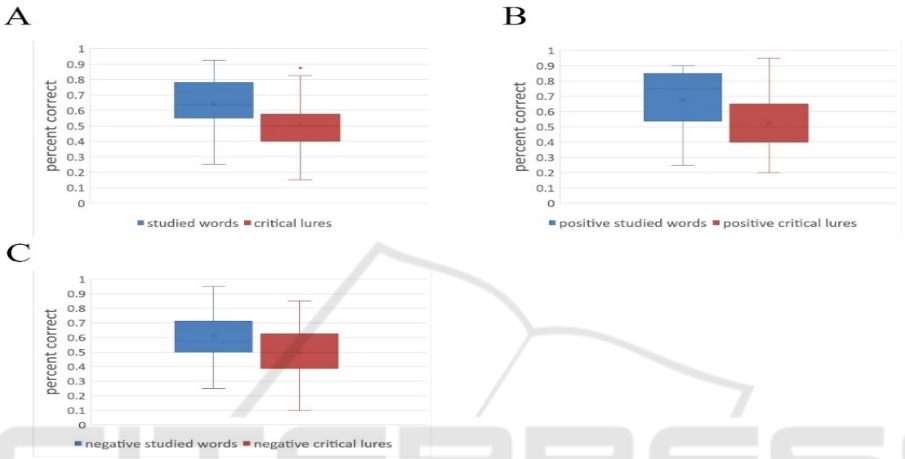

Figure 1: Semantic similarity.

3.2 The Effect of Emotional Valence on False Memory Production

We compared the corrected true memory rate and false memory rate between positive words and negative words. T test indicates that there is no significant difference between the corrected false memory rate of positive words and that of negative words ($p>0.05$). Likewise, no significant distinction is shown between corrected true memory rate of positive words and negative words ($p>0.05$) but this value ($p=0.057$) is close to the significance threshold **(Figure 2)**.

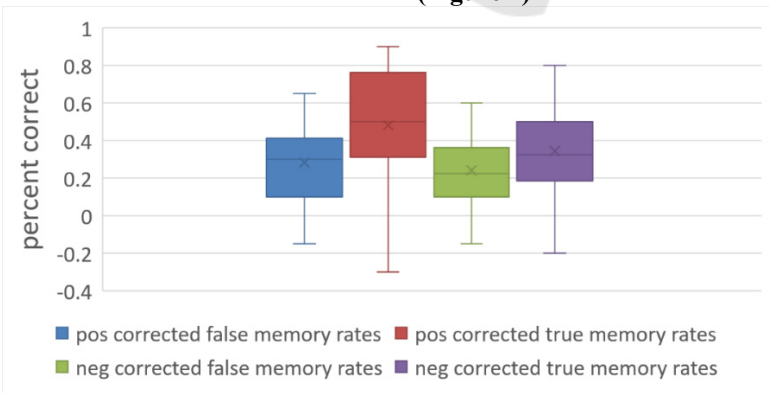

Figure 2: Positive and negative valences.

4 DISCUSSIONS

Memory is the ability of brain to encode, store and retrieve information and is also a result of learning, perception and attention. A true memory is important for solving problems and recognizing items. However, memory is not always reliable. False memory, a recollection that is fake partially or in whole but seems real in someone's mind, often occur in people's life, attracting many psychologists and neuroscientists. There are various studies demonstrating that the generation of false memory is related to neural overlap of neural representations of related concepts. For instance, the similarity between new items and past experiences increases the cortical similarity, eventually leading to false memory (Wing, Geib, Wang, Monge, Davis, Cabeza 2020). Additionally, the same research revealed that the false memory for a given concept's lure tended to reduce when high similarity in cortical region was coexist with differentiated hippocampal patterns, which suggests that hippocampus plays a crucial role in discriminating similar concepts during encoding and retrieval and its interaction with cortex determines whether a similar lure will be incorrectly recognized as old (Wing, Geib, Wang, Monge, Davis, Cabeza 2020). Coane JH et al. found that false identification of critical lures was significantly greater after studying the word lists that have similar characteristics with the critical lures, which indicates that similarity at a taxonomic or categorical level induces false memory (Coane, McBride, Termonen, Cutting 2016). Our results show that semantic similarity between different concepts increases false memory production, which is demonstrated by the higher percent correct of studied words than that of critical lures. Specifically, the percent correct of positive studied words is also higher than that of positive critical lures and the same result is for negative words. Therefore, our results are consistent with previous studies.

However, we did not find a significant difference between the influence of positively-valenced words and that of negatively-valenced words in false memory production. Our results indicate that there is no significant distinction between positive and negative corrected false memory rates. Besides, no significant difference was identified between positive and negative correct true memory rates, though the p value is close to the significance threshold. We think that this result may be attributed to the distinctive effects of emotion on false memory depending on whether the emotion is in the content of items to be memorized or in the participants' moods reflecting the context during encoding. A previous study found that negatively-valenced concepts induce memory distortion and cause false memory while negatively-valenced moods keep memory from being distorted. Moreover, enduring negative moods promotes false memory production (Bookbinder, Brainerd, 2016). Therefore, in our experiment, presenting words with negative emotion may foment negative moods in subjects and this effect may counteract the influence of negative concepts in increasing false memory. As a result, no significant difference can be found between false or true memory rates of positive and negative words.

There are several limitations in our research, among which the most important is latency caused by network and personal affairs as our experiment was conducted online. For instance, after encoding, subjects are supposed to take the distraction test immediately but due to the network he or she may not be able to see the math questions until several minutes, which greatly influences the memory encoding. Also, retrieval task may be interrupted by trifles happening around the subject's environment (eg. someone knocks at the door and the subject needs to stop watching the recognition video to open the door). Another disadvantage is that semantic similarity across lists may disturb our research exploring the effect of semantic similarity of each single list on false memory generation. Additionally, how to properly control variables when investigating the influence of emotion in false memory production remains elusive.

Based on the limitations above, we came up with several ideas to be realized in our future research. First of all, conducting the experiment offline and in this way, subjects tend to be more controlled, which can decrease disturbances and enhance seriousness. Second, we will re-select the words for encoding and retrieval and reduce the semantic similarity across lists to as small as possible. Third, as previous research also suggested the effect of stimulus modalities on false memory, we may alter the encoding and retrieval modalities to explore the difference between the influence of auditory and visual modalities in memory distortion.

5 CONCLUSIONS

In summary, we conducted auditorily-presented encoding task and visually-presented retrieval task using words with different emotions and demonstrated that semantic similarity of similar concepts promotes false memory generation.

However, the enhancement effect of negatively emotional words on false memory production was not verified but this paper offers new ideas about the correlation between emotion and false memory generation and further investigation is required.

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