

EFFECT OF FOOD NOSTALGIA ON MEMORY ACCURACY AND MEMORY
CONFIDENCE

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By

Sihan Zhou

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ABSTRACT

Previous studies indicated a complex non-linear relationship between memory confidence and memory accuracy (Wixted & Wells, 2017). Across multiple factors that influence memory accuracy, emotion is a significant one. The Fuzzy-trace theory (FTT) proposed our memory-encoding approaches as depending on verbatim traces, the very precise representations, or gist traces, the themes and meaning representations which are less accurate (Brainerd & Reyna, 2005). Evidence also suggests people's increasing tendency to rely on gist traces when events are high-arousal and self-relevant (Reyna & Brainerd, 2012).

As a distinct feature of autobiographical memory and bittersweet emotion, nostalgic memories show high content of personally meaningful moments and relationships with significant others (Jiang, et al., 2021). Food nostalgia memories highlight the tight correlation between memory and food which are found to be more familiar, more autobiographically related, and more arousing (Green et al., 2023). With limited studies on the effects of food nostalgia on the shaping of new memories as well as its accuracy and people's confidence level towards it, our research aims to continually examine the role of food nostalgia on autobiographical memory while investigating how it shaped new memories and its role in the relationship between memory confidence and accuracy.

We assessed participants' autobiographical memories, memory confidence, and memory accuracy through memory recall tasks and Recognition Memory Tests. The

results indicated a significant effect of memory confidence on memory accuracy that the accuracy increases with higher confidence levels. Food nostalgia, on the other hand, exhibits a strong predictability on memory confidence as people tend to report a higher confidence level in those foods they rated as high nostalgic value but shows no effects on memory accuracy. This study connects autobiographical memory with food nostalgia and provides a new perspective on the impacts of food nostalgia on the confidence and accuracy of newly shaped memories.

Keywords: autobiographical memory, food nostalgia, memory accuracy, memory confidence

BIOGRAPHICAL SKETCH

Sihan Zhou was born on January 9th, 2002 in China and came to the United States as an international student in 2019. She received her bachelor's degree in Psychology and Communication from University of California, Davis in March, 2023. After graduation, she began her Master's degree at Cornell University, with Dr. Adam Anderson as her thesis advisor in August 2023.

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INTRODUCTION

Autobiographical Memory

“Autobiographical event memory”, the episodic memory of the personal moment, is a unique neurocognitive system that enables us to remember specific events from our personal past (Grilli & Sheldon, 2022). Unlike a particular kind of memory task, autobiographical memory is a hypothetical memory system that is oriented to the past and is the only memory system that allows us to consciously re-experience our past, and is probably unique to humans (Tulving, 2002). Past studies indicated the biological relationship with autobiographical memory as its impairment is associated with hippocampal damage and leads to medial temporal lobe amnesic (Aggleton & Brown, 1999). K. C., an episodic amnesia patient of a motorcycle accident, was fully close to a healthy person’s intellectual functions except for his totally dysfunctional episodic memory system without any autonoetic consciousness. He lost his ability to pick up new information from his daily life or remember ongoing experiences. Besides that, K.C. was unable to remember any events or circumstances from his whole life, from birth to current (Tulving, 2002). K. C.’s case revealed the functions of autobiographical memory as it serves a multitude of identity, social, and decision-making, provides the subjective sense of remembering past experiences, enables people to “travel into the past”, and maintain a sense of self-identity and continuity (Piolino, et al., 2006).

As an essential component of us, past experiences play a significant role in influencing our thinking of the present and the future. Besides constructing the central

core of human personality, autobiographical memory also shows a direct connection to mental health and well-being as it serves as a source of individuals' self-worth, a resilient buffer against pressure, and a shield of healthy mental status (Wang & Suo, 2023). Many aspects of autobiographical memory such as accessibility (Jing et al., 2016), content focus (Witheridge, 2010), accuracy (Loftus, 1993), vividness (Brainerd & Reyna, 2012), and confidence (Wells, et al, 1998) have been shown to have a strong relationship with personal factors such as age or mental status and demographic characteristics like ethnicity, race, and cultural identity.

When we recall our experience, we may find out that the retrieval ease, vividness, and the amounts of details of all the events are not equal. Previous studies showed that the autobiographical memory we remember most vividly and durably is often composed of high emotional content moments that highlight the role of emotions in autobiographical memory (Berntsen & Rubin, 2002). Compared with neutral events, memories with high emotional content are found to be more vivid, more long-lasting, more likely to be recalled, and contain more details (Holland & Kensinger, 2010). Brown and Kulik (1997) proposed the idea of 'flashbulb memories' and showed the personal specialty about events that contain powerful emotional significance. A famous case is the assassination of John F. Kennedy which most people are able to recall their personal circumstances when they had heard the news even after a decade (Brown & Kulik, 1997). Moreover, these vivid memories are not limited to large public events; individuals can have vivid memories of personal significant events as well such as first year in college and eyewitness testimony (Pillemer, et al., 1988; Yuille & Cutshall, 1986). In addition, the specific emotion tones and valence impact

individuals' autobiographical recall differently (e.g. Holland & Kensinger, 2010).

Berntsen and Rubin (2002) conducted an experiment to assess people's memory recall of their age in events that contain different emotions (e.g. happy, sad, traumatic) in participants from 20 to 93 years old and found a clear bump in the 20s for the most important and happiest memories while happy involuntary memories were over twice as the unhappy ones.

Nostalgia

Taking its rise from Homer's *Odyssey*, Johannes Hofer, a medical student combined two Greek words *nostos* (homecoming) and *algos* (suffering), and created the word 'nostalgia' in 1688. Hofer used this word to refer to the suffering evoked by the desire to return to people's place of origin and believed it to be a 'cerebral disease' (Wildschut, et al., 2008). Till the end of the 20th century, nostalgia was still documented as a psychological illness. Massive findings from the past 20 years reversed the trend that nostalgia is not a mental disease and won't cause any physical or psychological symptoms (Batcho, 2013). Moreover, nostalgia is able to increase social connectedness and self-continuity, create a meaningful life, and maintain mental well-being (Sedikides & Wildschut, 2018).

As a distinct component of autobiographical memory and a bittersweet emotion, nostalgia is defined as 'a sentimental longing or wistful affection for the past' in the dictionary (Pearsall & Hanks, 1998). Nostalgic memories are commonly composed of personally meaningful and significant moments or events and typically evolve interpersonal relationships (Jiang, et al., 2021). Wildschut and colleagues

compared the recalled nostalgic memories between U.S. residents and British undergraduates and found all narratives demonstrate a positive tone and self-relevant emotion which is often associated with close others (Wildschut, et al., 2008).

Although nostalgia will evoke a mixed emotional experience, nostalgic memories include far more positive emotion expressions and often have a positive effect on individuals (Reid, et al., 2015). Moreover, past research on autobiographical memory functions of nostalgia demonstrated its positive psychological profile on both memory functions and psychological benefits such as increasing prosocial behaviors, improving self-esteem, enhancing well-being, strengthening belongingness, and increasing life satisfaction (e.g. Cheung, et al., 2018; Zhang, et al., 2024).

Food Nostalgia and Memory

Similar to our memory, foods are also an unignorable part of our daily lives as they provide daily nutrition needs and evolve in socialization (Marti & Recupero, 2021). In the past few decades, an increasing number of food-related emotion studies provided evidence of food sensory properties like taste and appearance as the most important cues to evoke emotions (e.g., Lagast, et al., 2017). Besides sensory characteristics, food-related emotions can be evoked by past memories and future impacts of foods (Koster & Mojet, 2015). The Proust Effect is defined as the emotionality and vividness of re-experiencing autobiographical memories that are triggered by senses such as reliving the last Thanksgiving when sharing turkey with family (Green, et al., 2023). Similar to nostalgic memories, the Proust Effect also

involves close relations and meaningful moments. Additionally, some studies found the capacity of songs and foods to trigger nostalgia (e.g. Barrett et al., 2010).

Gustatory nostalgia, or food nostalgia, highlights the profound connection between our memory and food (Holtzman, 2006). Not just staying on tasting food, there is also evidence that reading recipes can trigger food nostalgia (Supski, 2013). Considering the complexity of nostalgia in emotional content, Green and colleagues reviewed past sense-evoked nostalgia experiments such as scent-evoked nostalgia (Reid, et al., 2015) or music-evoked nostalgia (Barrett et al., 2010). Specifically, they found food-evoked nostalgia to be more familiar, more autobiographically related, more arousing, and unalloyed positive compared with other nostalgia which contained negative emotions (Green et al., 2023). Extending beyond looking back, nostalgia is also a critical mediation among the past, the present, and the future as it plays a significant role in creating new identities (Anderson, 2016). Besides shaping the emotional tones from past memories, previous experiments also revealed the capability of nostalgia to influence future behaviors such as consumption patterns (Espinoza-Ortega, 2021), purchase intentions (Lasaleta, et al., 2021), and dietary choices (Kersten & Cox, 2023).

Confidence and Accuracy of Memory

‘Don’t trust your memory.’ This oft-repeated statement implies the accuracy of an individual’s memory to be a desirable question to study. For instance, in the forensic field, increasing evidence indicates that false eyewitness identification is the primary cause of the conviction of innocent people (Wells, et al., 1998) which reveals

the underlying concern of the accuracy of autobiographical memory. The suggestibility (Bruck & Ceci, 1999) and malleability (Otgaar & Howe, 2016) are common characteristics of human memories. False memory refers to the situations in which people recollect events that they didn't experience; it's noteworthy that events in false memories are not something we never experienced, are actually something we are quite familiar with, and are usually consistent with the gist of the target context (Bookbinder & Brainerd, 2016). Different from spontaneous false memory which is based on endogenous distortion, implanted false memory is caused by external distortion such as misleading questions, specific or open-ended questions, the emotional tone of interviewers, and either explicit or subtle suggestions from interviewers (Bruck & Ceci, 1999). Moreover, there are individual differences in false memories such as younger children are more suggestible than the elders (Bruck & Ceci, 1999).

Besides the distortion of memories, there is also evidence indicating the capacity to inject a whole event into someone's mind for something that never happened (Loftus, 1993). Piaget discussed his classic childhood memory of an attempted kidnapping. He described that these false memories happened when he was an infant and were with him for decades until his nanny confessed that she had made up this story entirely and felt guilty about it. Piaget said, 'I, therefore, must have heard, as a child. The account of this story, which my parents believed, and projected into the past in the form of a visual memory' (Piaget, 1962). Another case of implanted false memory events is the 'lost-in-the-mall' experiment by Loftus in 1995. In this experiment, all participants were provided with short descriptions of childhood events

and were encouraged to try to remember them. While the participants believed that all the events were real and had been provided by family members, one of them was actually made up and never happened. The result of this experiment shows that 25% of participants were successfully led to believe that they had been lost in a shopping mall at age 5 or 6, were upset, and were eventually reunited with their family (Loftus & Pickrell, 1995). Moreover, participants provided details, showed high confidence, and even expressed emotions about this planted false memory---that's the reason why we sometimes refer to these memories as rich false memories (Loftus & Bernstein, in press).

The accuracy of our memory depends on the memory paradigm we use when encoding experiences or knowledge. In other words, our later memorability is predicted by the neural activity at that time (Mecklinger & Kamp, 2023). Massive previous studies tried to find out the underlying mechanism of memory encoding systems and came up with various theories. The Fuzzy-trace theory (FTT) describes our information-processing approaches as depending on verbatim traces, the very precise representations, or gist traces, the themes or meaning representations which are less accurate (Brainerd & Reyna, 2005). With the evidence that the accuracy of memory increases with the accessibility of verbatim traces, they also found that people tend to rely on the gist traces when events are high-arousal and self-relevant such as flashbulb memories (Reyna & Brainerd, 2012). Different from FTT, the self-reference effect refers to the memory advantage for materials that have been encoded in a self-related way (Kesebir & Oishi, 2010). It highlighted the role of personal involvements and proposed that we are more sensitive to self-related stimuli and show a

performance advantage such as accuracy and response time on certain stimuli (Clarkson, et. al., 2022). This theory was confirmed by later studies that high personal involvement events are more likely to be remembered than events with less personal relevance (e.g. Pezdek, 2003). In addition, there is evidence that people are better at recalling friends' birthdays when it is closer to their own (Kesebir & Oishi, 2010).

As massive studies showed the role of emotion on individuals' autobiographical memories (e.g. Brown & Kulikthere, 1977), there is also evidence of the impacts of emotions on memory accuracy that the emotional content of events can influence how we remember them (Holland & Kensinger, 2010). Although high emotional contents are characterized by high vividness and rich details, subsequent studies found that they are not as accurate as they may seem (Christianson, 1989). Neisser and Harsch (1992) conducted a study on people's memory recall of the explosion of the space shuttle Challenger and found the inconsistency of details at different time intervals. For example, someone recalled learning it from a friend but reported hearing it from a broadcast six months later (Neisser & Harsch, 1992). Other studies that measure the consistency with which people report details found similar results as well (e.g. Talarico & Rubin, 2003). Most interestingly, they found that despite these inconsistencies, participants recalled their experiences as detailed, and vivid, and exhibited a high level of confidence (Kensinger, 2009).

It can be seen from here that confidence and the accuracy of autobiographical memories don't vary uniformly or simply share a directional relation which drives away from our common beliefs that high confidence leads to higher accuracy. Similar

to rich false memories, some studies provide evidence of little correlation between participants' memory confidence and the consistency of their reported details (e.g., Neisser & Harsch, 1992). Later experiments also reported people's memories of emotional experiences as subjectively vivid but hold little accurate detail (Talarico & Rubin, 2003). An experiment on eyewitness confidence and identification accuracy indicates that the predictive power of confidence on memory accuracy only happens under strict conditions such as initial and uncontaminated memory tests (Wixted & Wells, 2017). Similar to accuracy, confidence level towards our memories can be influenced by multiple factors such as the balance of evidence favoring the chosen option over the unchosen one in memory recognition tasks (Hanczakowski, et al., 2021) and the familiarity with the objects from our past experiences (Wynn, et al., 2019). As the relationship between confidence and accuracy of memories remains unclear, there are still consistent findings that compared with people who display little confidence, people who show higher confidence towards their memories are somewhat more likely to be correct (Wells, et al., 1998). In short, a high level of confidence doesn't completely predict the accuracy of memories while low confidence directly relates to the decreasing accuracy of memories.

Current Studies

In light of the above discussion, my work aims to contribute to the study of food nostalgia in autobiographical memory and extend insights into its role in the creation of new memories and people's confidence level in their new memories. I organized my research questions into three main themes: food nostalgia, memory accuracy, and memory confidence.

We chose food images from different countries as the cues to trigger participants' food nostalgia in rating tasks to assess the effects of food nostalgia on an individual's memory. To be specific, we defined this factor as 'Food Relationship' in which foods from participants' country of origin are coded as 'Home' while the rest foods are coded as 'Foreign'. Considering previous evidence of food nostalgia triggered by reading recipes, we believe food images can serve the same function (Supski, 2013). Participants were asked to rate their familiarity, comfort level, likeability, and nostalgic value toward each food image. Intermittently, participants would be asked to recall and describe a food-related memory of certain images. After each recall task, participants rated their sense of time, desirability, accessibility, and vividness of that memory. Their self-reported nostalgic values are applied in data analysis as 'Food Nostalgia'.

To investigate how food nostalgia influences newly formed memories, we conducted a recognition memory task after one week. Recognition memory tasks (RMT) is a frequently used test format in the studies of memory accuracy in which previously presented material is subsequently re-presented along with new material to assess whether the original item is successfully recognized by the participants (Stern

& Hasselmo, 2009). In addition to the accuracy of recognition for food pictures, we were particularly interested in examining the relationship between memory accuracy and memory confidence. After each recognition task, participants were asked to rate their confidence level on the previous answer. In addition, we recorded the participants' response time for recognition task responses as an index of the ease of memory retrieval and recollection for it's widely acknowledged as the reflection of mental process (e.g., Van Zandt, 2002). 'Accuracy', 'Memory Confidence', and 'Reaction Time' are applied in our data analysis as well.

Massive evidence indicated that the accuracy of participants' recognition memory can be influenced by multiple factors. According to the Fuzzy-Trace Theory (FFT), people store dissociated verbatim and gist representations of their experiences. Verbatim traces are events' surface features and details such as shape and color while gist traces refer to events' meanings (Reyna & Brainerd, 1995). While people's false memory increases with their tendency to access gist traces rather than verbatim traces, the accessibility of gist traces in their memory significantly increases when they are emotional, such as flashbulb memories (Reyna & Brainerd, 2012). These memories are characterized by vivid, confidently held, long-lasting, but less accurate (e.g., Talarico. et al., 2019). Previous studies highlighted the features of nostalgia as having memories as more vivid, more arousing, and more self-relevant (Green et al., 2023). Considering the higher vividness and more emotional tones of nostalgic memories, we think participants' tendency to access their gist memory traces may increase and contribute to higher confidence but lower accuracy. Different from the Fuzzy-Trace Theory, the self-reference effect suggests that people remember things better if they

have been encoded in a self-relevant way (Johnson & Symons, 1977). In other words, the self-reference effects would make food nostalgia contribute to a higher accuracy while the gist mechanism from FTT may correlate to fewer correct answers for high nostalgic value foods. As such the memories of events related to food nostalgia should enhance confidence but their associated effect on memory accuracy will reveal more about the underlying mechanisms of nostalgic memory. Furthermore, the results may provide insight into the relationship between memory confidence and accuracy.

As both theories support the contribution of food nostalgia on memory confidence with previous evidence that individuals' confidence level is enhanced by familiarity (Wynn, et al.2019), personal involvement (Pezdek, 2003), and emotion contents (Talarico & Rubin, 2003), we believed people's food relationship may serve a similar function as nostalgia hypothesized that participants would express a higher level of confidence on food images from their home countries and those they rated them with higher nostalgic value. Thinking that people need less time to recollect strongly encoded memories (Anderson, 1981), we believed the reaction time could be the indicator of accuracy and confidence. Based on this, we hypothesized that participants' reaction time would be shorter on correct responses and the answers they rated as higher confidence levels. Given the significant personal meaning and emotional contents in nostalgic memories (Wildschut, et al., 2008), we think the tendency of participants to access the gist traces should increase consistent with the Fuzzy-Trace Theory. In other words, we hypothesized that participants would show a lower correct proportion of high nostalgic value food images and a higher confidence level links with a lower memory accuracy.

METHOD

Participants

Participants included 66 Americans, Indians, and Indian-Americans. Participants were excluded for eating disorders or different countries of origin. They received either 4 SONA credits or \$20 cash for participating. The protocol was approved by the Cornell University Review Board. After filtering invalid responses, data from 46 participants (21 Indians and 25 Americans) was applied to our analysis.

Stimuli

Food nostalgia stimuli created specifically for Indians and Americans (Doshi et al., in prep) were used. The stimulus set included 102 American foods and 115 Indian foods. All of the images from the set were used. Additionally, a new picture for each food item was selected and standardized using a method identical to the one prescribed in the stimulus paper. These pictures served as “foils”, i.e., decoy images for the memory test to evaluate whether individuals remembered the original stimulus.

Procedure

Session 1

The first session was around 1.5 hours long. There were two tasks: a rating task and a memory task, interspersed with each other. The participant was seated in front of a computer. They were presented with images.

Each image was presented with four questions below: familiarity, comfort, nostalgia, and likeability. They had 12 seconds to rate each image. Participants rated all 217 images. Images were presented in 11 blocks of 20 (last block had 17), with a 15 seconds break in between. For some of the images, after rating them, the participant was prompted to describe a memory for the food item in the image. They had a maximum of 90 seconds to do so. After they finished writing down the memory, they hit the spacebar, which brought up 5 questions the participants had to answer about the memory they just described: how old were they when the event took place (objective time), how far away does the event feel (subjective time), how vivid is the memory (vividness), how often do they consume the food item (accessibility), and how often do they wish they could consume it (desirability). They had 25 seconds to answer these questions. Once they answered the questions, the participants resumed rating images. In each block, participants completed the autobiographical memory recall task for around 2-3 images.

The autobiographical memory task was triggered conditional upon the participants' rating of the images. Every time the participant rated an image, the image was grouped into one of five buckets by home foods:

Food type	Familiarity	Comfort	Nostalgia	Bucket Name
Home	High (> 5)	Low (< 3)	Low (< 3)	F
Home	High (> 5)	High (> 5)	Low (< 3)	FC
Home	High (> 5)	Low (< 3)	High (> 5)	FN
Home	High (> 5)	High (> 5)	High (> 5)	FNC
Foreign	High (> 5)	Any value	High (> 5)	FNf

Table 1. Five buckets that trigger autobiographical memory recall tasks.

An image that fell into one of these buckets would prompt a memory description. Within one block, participants were prompted 2-3 times (Table 1). A maximum of 5 images per bucket were used for the memory task, such that one participant described memories at most for 25 food items. This experimental setup allowed us to mimic the spontaneous recall of nostalgic memories, and autobiographical memories in general, while controlling for recall exhaustion or habituation.

Session 2:

One week after the first session, participants came back to the lab for a 15-minute image recognition task. The participant was seated at the computer. On the screen, the participant saw two pictures of the same food item, one from the original set they viewed one week back and the other a foil image. Participants used the left

and right arrow keys to select which image they had seen the week prior and rated their confidence in their choice on a scale of 1-5. The task was self-paced. The participant completed the task for all 217 images. The order of images was randomized for each person.

Data Analysis Procedure

Overview of analytic approach. During session 1, the autobiographical memory recall tasks were triggered conditional upon the participants' rating of the images. That is, each participant recalled their nostalgic memories of different food images. Since reporting a memory for an image may increase the probability of correctly recognizing that image in our task, images with recall tasks reported were analyzed separately from the rest. The With-Recall dataset had 868 trials (an average of 19 trials per person) and the Without-Recall dataset had 9010 trials (an average of 196 trials per person). The average values of relevant variables (e.g. confidence level) were examined using descriptive statistics. We ran multiple regression analyses using the lme4 package in R (Bates et al., 2015), with p values calculated using lmerTest (Kuznetsova et al., 2017). Both the whole dataset and the two separate datasets were applied in our analysis. Each of the models included random intercepts and slopes.

Data Analysis. Based on our hypothesis, we generated three models to test the effects of each factor on both datasets. Table 2 below shows all hypotheses and corresponding models.

Hypothesis	Models
Participants would express a higher confidence level on foods that from their home countries and those they rated them with higher nostalgic value	Model 1: Confidence Level $\sim$ Nostalgic Value * Food Relationship + (1+Nostalgic value participant)
Participants would show a lower accuracy for higher nostalgic value foods and higher confidence responses	Model 2: Accuracy $\sim$ Confidence Level * Nostalgic Value + (1 + Nostalgic Value + Confidence Level participant)
Participants' reaction time would be shorter on correct responses and the answers they rated with higher confidence level	Model 3: Reaction Time $\sim$ Confidence Level * Accuracy + (1 + Confidence Level participant)

Table 2. Hypothesis and Corresponding Models

To test whether nostalgia was responsible for a possible difference in average confidence for different foods, we ran model 1 and an ANOVA test to analyze the effect of food nostalgia and the food relationship on participants' memory confidence on the whole dataset. It's important to note that we used the whole dataset rather than the two separate datasets in this analysis. Although the autobiographical memory recall tasks were triggered randomly with each participant, their rated nostalgic value is one of the criteria. That is, most of the food images in the With-Recall dataset were rated as having high nostalgic values which may contribute to a ceiling effect on confidence levels. Moreover, because the nostalgic value ranged on a 1-7 Likert scale while the confidence level was on a 1-5 Likert scale, we converted these two factors into z-score which standardized them and made them more comparable. Model 1 is a mixed-effects model with random intercepts and random nostalgia slopes. Similar to the familiarity feature of nostalgia, we think participants' relationship with food should be another sign of familiarity which might contribute to a higher confidence level as well. As a with-in level factor, the F -value and degree of freedom of Food

Relationship differed from food nostalgia which is a participants-level factor. More data points when comparing images than comparing participants contributed to these two incomparable *F*-values.

With regard to our hypothesis on the effect of food nostalgia and memory confidence on participants' memory accuracy, we ran model 2 with random intercepts, random confidence slopes, and random nostalgia slopes on the two separate datasets. Before conducting the significant test, we coded 'Correct' answers in 'Accuracy' as '1' and 'Incorrect' answers as '0'. The binary outcomes of the factor 'Accuracy' turned this model into a logistic model.

At the end of our analysis, we ran model 3 and an ANOVA test to see if memory accuracy and memory confidence were related to participants' reaction time on the two separate datasets. Similar to previous models, model 3 is a mixed-effects model with random intercepts and random confidence slopes.

Results

Manipulation Check. Table 3 shows participants' rated nostalgic value by their food relationship on images that triggered memory recall tasks and those that didn't. For images without memory recall tasks, the average nostalgic value for foods from participants' country of origin (Home) was 3.60, and for foreign foods was 1.66. In the dataset of images with memory recall tasks, the average nostalgic value for foods from participants' country of origin was 3.87, and for foreign foods was 4.40. This is a manipulation since mainly images with high nostalgic value were selected for memory recall tasks (see Table 1).

Task	Relationship with Food	Mean Nostalgic Value	SD Nostalgic Value
Without Recall Task	Foreign	1.66	1.45
Without Recall Task	Home	3.60	2.43
With Recall Task	Foreign	4.40	2.12
With Recall Task	Home	3.87	2.24

Table 3. Nostalgic value by participants' relationship with food on food images in the With-Recall dataset and Without-Recall dataset

The effect of nostalgia and food relationship on memory confidence. Table 4 lists the average confidence level by participants' relationship with the food on images in both datasets. For food images in the Without-Recall tasks, the average confidence level in participants' responses was 3.43 for home foods and 3.01 for foreign foods. For images that a memory was recalled for, the average confidence level in participants' responses was 3.64 for home foods and 3.68 for foreign foods.

Task	Food Relationship	Mean Confidence Level	SD Confidence Level
Without Recall Task	Foreign	3.01	1.36
Without Recall Task	Home	3.43	1.29
With Recall Task	Foreign	3.68	1.25
With Recall Task	Home	3.64	1.25

Table 4. Memory confidence by participants' relationship with food on images in both datasets

Model 1 and an ANOVA test were conducted to test our first hypothesis on the effects of nostalgia and food relationship on memory confidence. Despite whether the images triggered the memory recall tasks or not, the results indicated both significant main effects of nostalgia and the relationship with foods on memory confidence. As the nostalgic value increases by 1, the confidence level of participants increases by 0.21 points ($F(1,62.6)=90.54, p<0.001$). And, when participants are looking at home foods, their confidence level in their memory recognition tasks increases by 0.2 points ($F(1,9827)=83.56, p<0.001$) compared to when they are looking at foreign foods. Additionally, the two-way interaction between nostalgic value and the relationship with food on memory confidence is also significant ($b= -0.09, F(1, 8701.1) =14.26, p<0.001$). That is, every 1 unit increase in nostalgic value will result in a decrease of 0.09 units in the food relationship variable. Figure 1 visualizes this interaction: the effect of the food relationship on memory confidence is more pronounced at a low nostalgic value.

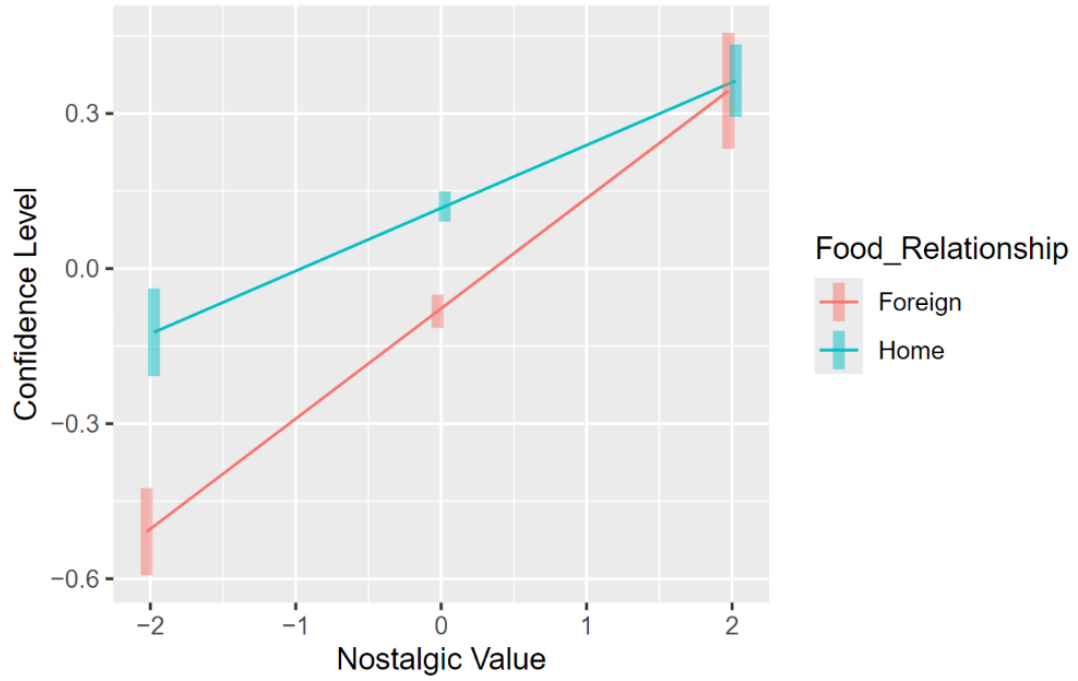


Figure 1. Effect of food nostalgia and food relationship on memory confidence

The effect of food nostalgia and memory confidence on memory accuracy. Table 5 lists the participants' results of memory accuracy in the Recognition Memory Test (RMT). For images in the Without-recall dataset, their overall accuracy was 73.97%, and, for images that triggered recall tasks, participants' overall accuracy was 79.36%.

Task	Term	Accuracy
Without Recall Task	Overall	73.97%
Without Recall Task	Foreign	74.46%
Without Recall Task	Home	74.67%
With Recall Task	Overall	79.36%
With Recall Task	Foreign	74.20%
With Recall Task	Home	74.84%

Table 5. Average memory accuracy by tasks and participants' relationship with foods.

For our second hypothesis on the relationship between memory confidence and accuracy, we fitted a logistic model (Model 2) separately for the two datasets. For the Without-Recall dataset, a significant main effect of memory confidence on accuracy was detected ($t=0.50$, odds ratio =1.66, $p<0.001$). On average, as the confidence level increases by 1, the odds of giving a correct answer increase by 66% when holding the effect of food nostalgia consistent. Interestingly, the main effect of nostalgia ($t=-0.003$, $p=0.92$) or the interaction ($t=0.006$, $p=0.55$) are non-significant. Figure 2a shows the relationship between memory confidence and memory accuracy on images in the Without-Recall dataset on a logistic scale.

We conducted the same analysis on the second dataset, the With-Recall dataset. Results showed a significant main effect on memory confidence as well ($t=0.69$, odds ratio=2.00, $p<0.001$). That is, with every 1 unit increase in participants' confidence level, the odds of giving a correct answer increase by approximately 100% when

holding the effect of food nostalgia consistent. Similar to the previous analysis, the main effect of food nostalgia ($t=0.10, p=0.37$) and the interaction ($t=-0.03, p=0.35$) are non-significant. Figure 2b shows the effect of memory confidence on memory accuracy on a logistic scale for food images in the With-Recall dataset.

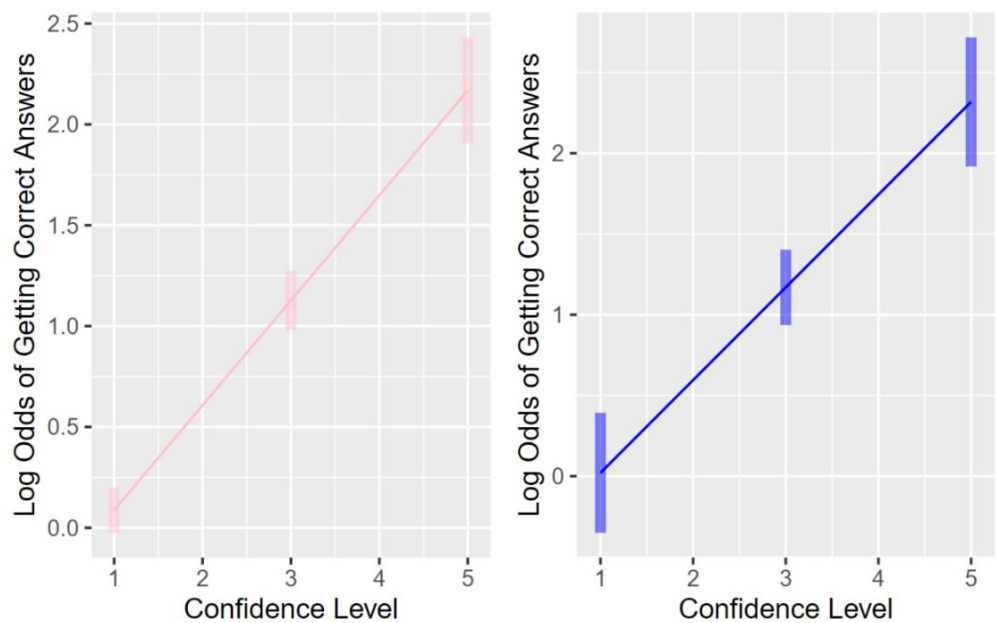


Figure 2a. The relationship between memory confidence and memory accuracy at the average of nostalgic value for food images in the Without-Recall dataset[⌘]

Figure 2b. The relationship between memory confidence and memory accuracy at the average of nostalgic value for food images in the With-Recall dataset[⌘]

The effect of memory confidence and memory accuracy on reaction time. Table 6

shows the participants' median reaction time, first quartile, and third quartile by their

accuracy and relationship with foods for both datasets.

Task	Accuracy	Food Relationship	Median	Q1	Q3
Without Recall Task	correct	Foreign	2.33	1.67	3.36
Without Recall Task	correct	Home	2.29	1.65	3.34
Without Recall Task	incorrect	Foreign	2.38	1.62	3.69
Without Recall Task	incorrect	Home	2.56	1.72	3.91
With Recall Task	correct	Foreign	2.15	1.62	2.92
With Recall Task	correct	Home	2.24	1.66	3.26
With Recall Task	incorrect	Foreign	2.75	1.93	3.82
With Recall Task	incorrect	Home	2.80	2.05	4.10

Table 6. Median reaction time, first quartile, and third quartile by memory accuracy and relationship with foods on both datasets

A regression and an ANOVA test were performed to test if higher memory accuracy and memory confidence were related to participants' shorter reaction time on the two separate datasets. Using Model 3 on the Without-Recall dataset, we find the main effect of memory confidence to be significant: participants' reaction time decreases by 0.30 seconds ($F(1,43.6)=31.38, p<0.001$) with every 1 unit increase in confidence level. However, without finding a significant main effect of accuracy on reaction time ($p=0.27$), the interaction between accuracy and confidence level is significant ($b=0.09, F(1, 8930.3)=6.31, p=0.012$). That is, every 1 unit increase in participants' confidence level will result in an increase of 0.09 units in the accuracy variable. Figure 3a illustrates this interaction: a stronger shortening effect of accuracy on participants' reaction time when they report with a higher confidence level.

Similarly, we found a significant main effect of memory confidence on participants' reaction time for the With-Recall dataset. With every 1 unit increase in confidence level, participants' reaction time decreases by 0.31 seconds ($F(1,56.61)=12.82, p<0.001$). However, both the main effect of memory accuracy

($p=0.60$) and interaction ($p=0.30$) are non-significant. Figure 3b shows the effect of memory confidence on participants' reaction time for food images from the With-Recall dataset.

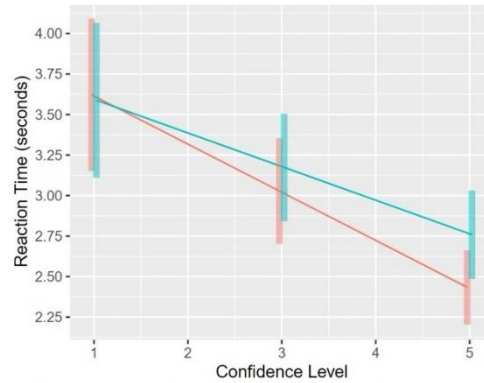


Figure 3a. *Effect of memory confidence and memory accuracy on reaction time in the Without-Recall dataset*

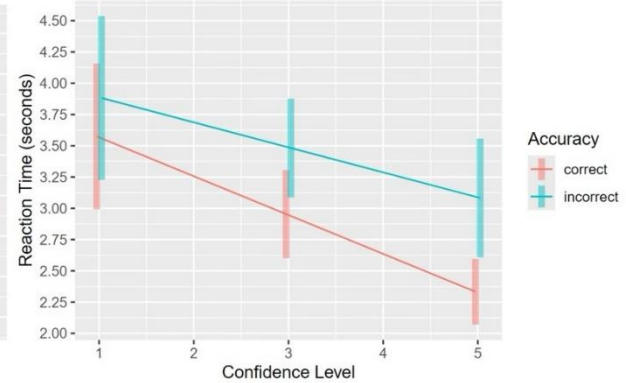


Figure 3b. *Effect of memory confidence and memory accuracy on reaction time in the With-Recall dataset*

Discussion

Our studies aimed to investigate the effects of food nostalgia on memory accuracy and memory confidence while assessing the relationship between people's confidence level and their memory accuracy. Thinking of nostalgia and participants' relationship with foods as the indication of familiarity (Jiang, et al., 2021), higher emotional contents (Green et al, 2023), and personal involvement (Pezdek, 2003), we hypothesized that participants would exhibit a higher level of confidence in higher nostalgic value food images and those foods from their country of origin. And because of taking less time to retrieve strongly encoded memories (Robinson, et al., 1997), we believed that participants' reaction time would be shorter on correct answers and the answers they rated with higher confidence level. And considering the significant personal meaning and emotional contents in nostalgic memories (Jiang, et al., 2021), we think the tendency of participants to access the gist traces should increase consistent with the Fuzzy-Trace Theory and hypothesized that participants would show a lower correct proportion of high nostalgic value food images while a higher confidence level would suggest a lower memory accuracy. Parts of our hypothesis were supported by the evidence while some revealed an opposite situation.

Besides separating the whole results into two datasets, we removed the results of 13 Indian-Americans as well before data analysis. Because our experiment setting involved food nostalgia and food images from different countries (the 'Food Relationship' factor), we think the multi-cultural background of Indian-Americans may contribute to confounds when testing these variables. Moreover, the sample size

of Indian-American participants (13) is lower compared with Indians (21) and Americans (25). We analyzed participants' average nostalgic value by their relationship with foods on both datasets as a manipulation check (Table 3). The results indicated an overall higher nostalgic value for the With-Recall datasets which were consistent with our setting of the autobiographical memory recall tasks (Table 1). Additionally, we analyzed the standard variation of participants' nostalgic value to get insight into the variability and dispersion of the results.

With regard to memory confidence, we used the whole dataset to avoid the potential ceiling effect of food nostalgia on memory confidence in the With-Recall dataset (see Table 1). Our current findings show both nostalgic value and food relationship as strong indicators which is in support of our hypothesis and is consistent with previous studies that nostalgia can enhance psychological well-being (e.g. Zhang et al., 2024) and people's confidence level is enhanced by familiarity and personal involvement (Pezdek, 2003; Wynn, et al.2019). Besides the findings that people demonstrate a higher confidence level towards higher nostalgic value food and food that comes from their home of origin, the food nostalgia X food relationship interaction was also significant. At a lower level of nostalgic value, participants' memory confidence is higher on foods that are from their country of origin (Figure 1). We think that with little effect of food nostalgia, a relatively higher familiarity with home food may contribute to this effect of food relationship on participants' memory confidence which shows a 'home foods advantage' and again, implies the contribution of familiarity on individuals' memory confidence.

Participants' accuracy is higher in the With-Recall dataset compared with the Without-Recall dataset which confirmed our consideration that spending more time to recall nostalgic memories may increase memory accuracy in RMTs (Table 5). As for our hypothesis on the relationship between food nostalgia, memory confidence, and memory accuracy, the current findings indicate a significant effect of memory confidence on memory accuracy but a non-significant effect of food nostalgia for both datasets. To be specific, a higher confidence level can be an indicator of higher memory accuracy for all the food images which is contrary to our hypothesis but is consistent with some previous evidence on a positive relationship between memory confidence and memory accuracy (e.g. Wixted & Wells, 2017). However, there was also evidence of high-confidence false memories (e.g. Piaget, 1962; Loftus & Pickrell, 1995; Schacter & Dodson, 2001). Wells and colleagues proposed that memory confidence and accuracy should be considered as two different variables that both of them are based on various factors, e.g. familiarity (Wells, et al., 2002). Moreover, there is also evidence suggesting multiple factors may influence the confidence-accuracy relationship such as memory-match signals, if the new signals are consistent with their memory (Mickes, et al., 2011). A previous experimental analysis of confidence-accuracy characteristics (CAC) suggested the predictability of confidence level on memory accuracy under experimental conditions (Juslin, et al., 1996). We think our laboratory settings took control of these confounding variables and contributed to this positive correlation between memory confidence and memory accuracy.

It is noteworthy that we found no effect of food nostalgia on memory accuracy no matter whether the food images triggered the autobiographical memory recall tasks or not. In other words, the effect of food nostalgia and memory accuracy is non-significant for all images which may suggest there is no relationship between food nostalgia and memory accuracy. Although the interactions between memory confidence and food nostalgia in both datasets were non-significant, they should be interpreted differently because most food images in the With-Recall dataset were reported as having high nostalgic value, this dataset had no variation in food nostalgia (Table 3). However, the results of model 1 showed that people's confidence level increases with their nostalgic value, in this case, a higher nostalgia value should also contribute to higher accuracy. Thinking of the significant effect of food nostalgia on memory confidence in the previous analysis, we think the relationship between food nostalgia on memory accuracy may be indirect, and memory confidence serves as the mediator. However, our experiment setting wasn't sufficient enough for a mediation test. So the role of memory confidence in the food nostalgia-memory accuracy relationship remains unknown.

As for participants' reaction time during RMTs, we test the relationship between memory confidence, memory accuracy, and participants' reaction time at the end of our analysis. We analyzed the median, first quartile, and third quartile of participants' reaction time during RMTs by their memory accuracy and relationship with foods on both datasets. We chose the median because of its robustness to outliers compared with the mean. Aligning with part of our hypothesis, the effect of memory confidence on participants' reaction time was significant for all the food images. A

prominent shortening effect can be found on the reaction time as people's confidence levels increase. However, the effects of accuracy are little for both images that contained memory recall tasks and didn't contain them. The significant effect of memory confidence on participants' reaction time can be attributed to the self-reference effect theory that people are more sensitive to self-related stimuli and show a performance advantage, e.g. faster response, on certain stimuli (Kesebir & Oishi, 2010). However, our findings are only partly consistent with past studies that the reaction time was negatively related to confidence and accuracy (e.g., Anderson, 1981). Previous results can be easily understood that people tend to give correct answers faster because of taking less time to retrieve strongly encoded memory traces (Robinson, et al., 1997). In addition, for food images from the Without-Recall dataset, we found a significant Memory Confidence X Memory Accuracy interaction as the reaction time between correct and incorrect answers departed more for higher confidence level ratings (Figure 3a). Interestingly, this interaction became non-significant for food images that triggered memory recall tasks (Figure 3b). We think this difference is due to the smaller trial size in the With-Recall dataset because this significant interaction in the Without-Recall dataset showed a relatively low effect size ($p = 0.012$). Also, the non-significant memory accuracy effect and the ambiguous interaction may be attributed to a relatively small sample size (66 participants) and task difficulty (recognition of images); the results might be different if the stimuli are more difficult, e.g. numbers. To go a step further, our findings on reaction time revealed the complex correlation between memory accuracy and memory confidence.

There are still several limitations in our studies and the first one is the time interval between the rating tasks and RMTs. Massive evidence suggests the precision and retrieval ease of memory decreases over time while increasing the time for us to recollect (e.g., Scofield & Johnson, 2022). As for the measurement of memory accuracy, our present findings only assess the newly formed memory for a one-week interval which is relatively easy to access. If the interval was pulled longer (maybe half a month), participants would find it more difficult to retrieve their memory which may contribute to different results of accuracy, confidence level, and reaction time.

In addition, the present results were obtained from mostly university students with a relatively small sample size, the demographic profile might be less representative and generalizable; a more demographically diverse sample might exhibit a different pattern of the effect of food nostalgia on people's memory. Besides individual differences, nostalgia can be influenced by multiple factors such as cultural background, age, family circumstance, and religion which were not assessed in our experiments. Although the sample from our studies contains both Indians (collectivism) and Americans (individualism) while the Indian-American participants were removed in data analysis, the effects of cultural role in our studies are still less representative since all the Indian participants are now in the United States. Different from individualistic culture which emphasizes autonomy and independence, collectivistic culture values more on interdependence and relationship with others (e.g., Fatehi, et al., 2020). Nostalgia memory, on the other hand, typically evolves interpersonal relationships with close others (Jiang, et al., 2021). In this case, we may expect more

significant effects of nostalgia on people's memory under a more representative cultural difference group in the future.

We reviewed past nostalgic memory studies and found most of their focus was on past autobiographical memory experiences which are difficult to confirm the accuracy (e.g., Cheung et al., 2018; Yang et al., 2023), the studies on nostalgia and newly formed memory are rare. As for the potential indirect effect of food nostalgia on memory accuracy, our laboratory setting didn't allow us to conduct a mediation test. Our experiments provide a very first step on the effects of food nostalgia on memory accuracy and future studies may consider investigating their relationship further under laboratory conditions and specifically test the mediation effect of memory confidence in the relationship between food nostalgia and memory accuracy. The results of our experiments showed the predictability of memory confidence on memory accuracy. However, it did not indicate a perfect linear relationship between memory confidence and accuracy just as previous evidence that there are still multiple factors that can influence the confidence-accuracy correlation (e.g. Mickes, et al., 2011). As we mentioned before, the relationship between memory confidence and memory accuracy is always a desirable question. Future research should try to analyze this correlation and find out some new factors as well.

Conclusion

Our current research found a significant effect of memory confidence on memory accuracy. To be specific, a higher confidence level can be an indicator of increasing memory accuracy. Food nostalgia, on the other hand, exhibits a strong predictability on memory confidence as people tend to report a higher confidence level in those foods they rated as high nostalgic value. However, the non-significant main effect of food nostalgia on memory accuracy may suggest a mediation role of memory confidence which we were not able to test. While the effect of memory confidence on people's reaction time during the tasks is significant, we found little effect of memory accuracy which again, revealed the complex correlation between memory confidence and accuracy.

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