RECOGNITION OF OBJECTS IN CHANGING CONTEXTS IN YOUNG AND OLDER ADULTS

By

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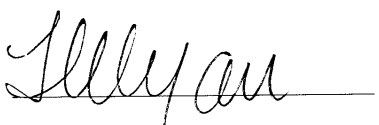

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Abstract

In order to examine the influence of semantic relatedness on object recognition, objects were presented in semantically congruent backgrounds (e.g., toaster in a kitchen) and semantically incongruent backgrounds (e.g., blender in a bathroom) to younger and older adult participants. Regardless of age group, participants performed better on object recognition when making recognition judgments on objects they had seen in the congruent condition compared with the incongruent condition. This suggests that contexts that are semantically related to the object appear to help with learning the object. When older adult participants were separated into high executive functioning and low executive functioning groups, high executive functioning adults performed similarly to the young adults. Additionally, reaction times during recognition revealed that high executive functioning older adults took significantly longer than young adults, suggesting that the high executive function older adults may be utilizing this increased time, as well as their executive function ability, to better discriminate the objects. Thus, the executive functions of the older adults in the high group may exhibit similar patterns of accuracy to that of the young group. This was further supported by the positive correlation shown between overall performance and executive factor scores for both congruent and incongruent conditions.

Introduction

As previous research has shown, the effects of scene context play an important role on episodic object recognition (Hayes, Nadel, & Ryan, 2007). Scene context can be described as the information that is present to constitute the environmental surrounding. For a particular household object such as a vase, scene context may consist of a bedroom or a living room table. Episodic memories are memories for specific past events and are involved in object recognition. When recognizing objects that have been previously viewed in scene contexts, episodic object recognition allows one to refer to the past memory of the object and use that memory to identify the object again. Hayes et al. (2007) demonstrated that object recognition performance in younger adults decreases following a change in context from study to test, specifically when objects studied in a complex scene were then tested on a white background. Thus, the authors suggest that there exists a binding or integration between the object and the scene context in which it is placed during the primary study session.

This binding between an object and its context may have occurred because the object-context scenes were strongly semantically related (Hayes et al., 2007). An example of an object-context scene being strongly semantically related is a toaster presented in a kitchen scene. To investigate the influence of semantic relatedness of a context on objection recognition, we presented objects in semantically congruent backgrounds (a vase on a coffee table) and semantically incongruent backgrounds (a blender in a bathroom). When object recognition was later tested, the objects were all removed from their individual context scenes and placed on white backgrounds. Due to the integrated binding of the object and its context seen in younger adults in the Hayes,

Nadel, & Ryan study (2007), it is hypothesized that young adults will show decreases in performance on object recognition when an object is removed from its originally presented context scene.

Although the effects of binding for younger adult participants may cause an overall decrease in object recognition performance at test, previous research has examined the effects of novelty signaling on recognition in young adults (Tulving & Kroll, 1995). The idea of novelty signaling proposes that young adults possess the ability to discriminate unusual, or novel, information and encode it more efficiently, showing higher episodic recognition for novel than for familiar words (Tulving & Kroll, 1995). This can be referred to as the distinctiveness effect. Younger adults are therefore predicted to perform more successfully at object recognition in the incongruent background condition because of novelty signaling that may occur. This may trigger a distinctiveness effect in which the unusual object-context scene will facilitate recognition of the object.

While Hayes et al. (2007) expressed the effects of context scene changes on object recognition, particularly in younger adults, the effects were not studied extensively in older adults. As such, one of our goals in the present study was to investigate the effects of these context changes on object recognition in older adults. Other theories of memory changes with aging propose that the overall deficit in memory for older individuals is due to associative deficits (Naveh-Benjamin, Guez, Kilb, & Reedy, 2004). In their study, Naveh-Benjamin et al. tested older adults' recognition of names, faces, and name-face pairs. The results demonstrated "that rather than a generalized decrement in memory, older adults showed specific deficits in memory for associative information"

(Naveh-Benjamin et al., 2004, p. 544). This type of memory for associative information deals with the ability to focus on the associations or links between units of memory, rather than on one specific unit itself. Their research claims that this linkage between single units of information is a deficiency in older adults. In another study by Li, Naveh-Benjamin, and Lindenberger (2005), the authors indicated that "relative to young adults, older adults are particularly impaired in episodic memory tasks requiring associative binding of separate components into compound episodes, such as tasks requiring item-context and item-item binding" (p. 445). According to associative theories, the object exists as one unit of memory and the context scene as another, which are then linked together. In line with the study performed by Naveh-Benjamin and colleagues as well as Hayes et al. (2007), it is hypothesized that older adults will show this deficit in linkage, creating a lack of binding between object and context.

As previously stated, participants in this study will be shown numerous objects placed either in a semantically congruent or semantically incongruent context. Their binding of the object to its original background will be investigated when an object recognition test is performed with all objects placed on a white background. On the basis of the research studies described, it is hypothesized that while younger adults will bind the objects to their contexts during encoding, older adults will not. Thus, it can be predicted that older adults will show greater performance when an object has been removed from its context due to a lack of binding between the object-context scenes originally presented.

In order to further consider the differences between young and older adults in object recognition when object-context scenes are changed, we must investigate the

changes that occur in cognitive executive functioning with age. When testing recognition of objects with young and older adults alike, the background in which an object is placed presents contextual information about the object-context scene. Memory for these background scenes, i.e., the contextual information, has been referred to as source memory or source monitoring (Glisky, Rubin, & Davidson, 2001; Johnson, Hashtroudi, & Lindsay, 1993). Source memory depends on executive functioning processes. Importantly, this type of source memory that is dependent on executive functioning processes tends to show declines with aging (Johnson, Hashtroudi, & Lindsay, 1993). In order to examine the effects of executive functioning on the binding of an object with its source, the older adult participants were separated into high and low executive functioning ability groups using a composite measure developed by Glisky and Kong (2008).

Due to reduced binding with the context that may be associated with lower executive function, it is predicted that low executive functioning older adults will show greater performance in object recognition. The reduced binding mechanism may allow for easier separation of object and context, thus resulting in greater accuracy when tested for object recognition when the object is removed from its original context. In contrast with this, the high executive functioning group of older adults is predicted to not perform as well as the low group. Because there has not been as great of a decline in executive functioning, we can predict that binding in the high executive functioning adults will occur similarly to the binding exhibited by the young adults. This may result in a decrease in performance for object recognition when the object is separated from its original context scene.

Methods

Subjects

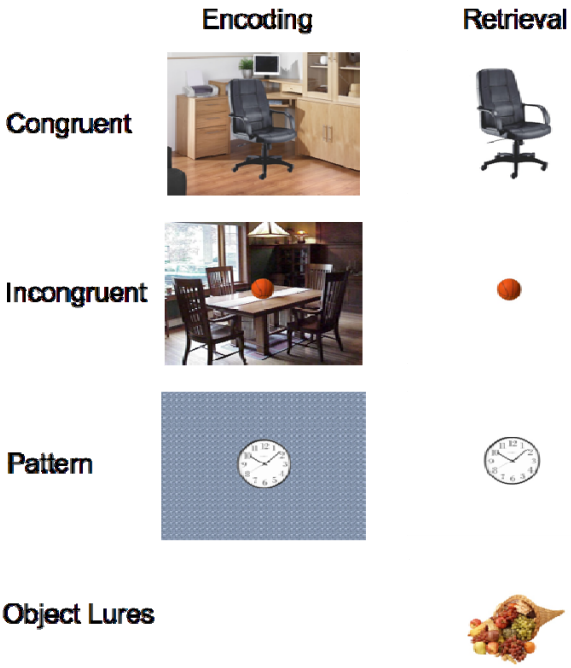
Participants included twelve younger individuals as well as eleven older individuals. The younger subjects consisted of healthy undergraduate students from the University of Arizona obtained from the entry-level psychology course, Structure of Mind and Behavior. The older group of subjects consisted of eleven individuals recruited from the Alzheimer's Disease Risk Study and the Senior Learning Project at the University of Arizona (n = 23; 12 young, 11 older adults). Older participants were divided into high executive functioning and low executive functioning groups based on an executive function *Z* score (n = 11; 6 high executive function, 5 low executive function). These scores are composite measures that indicate an individual's executive function ability, and were developed by Glisky and Kong (2008).

Stimuli and Materials

The stimuli used in this experiment consisted of 120 unique household objects presented during encoding, including objects such as toasters, hair dryers, etc. These objects were shown to subjects in semantically congruent or incongruent rooms of a house or on a pattern background. The backgrounds consisted of six different rooms in a household: a kitchen, living room, dining room, bathroom, home office, and a bedroom. Forty objects were placed in a semantically congruent background, e.g., a toaster in a kitchen. Forty objects were also shown in a semantically incongruent background, or a background that showed no close relation to the specific target object, e.g., a blender in bathroom. The remaining forty objects were presented on a colored, pattern background,

acting as a control variable with a lack of semantic relatedness between the object-context scene while maintaining visual richness and detail. All of the objects were counterbalanced for size and price, ensuring a similar amount of small, medium, and large objects, as well as a similar amount of objects greater than or less than $25 in value.

At retrieval, the same 120 objects were presented. However, they had been removed from the object-context scenes and placed on a white background. An additional 90 object lures were also presented on a white background, and were comprised of objects that the subjects had not seen in the previous encoding task. Examples of the stimuli are shown below:



There were three independent variables in this experiment. The first indicated whether the object was placed in a semantically congruent or incongruent background during the encoding session. The second was age group (young vs. old). The third

independent variable existed between the two groups of older subjects, those with high executive functioning and those with low executive functioning.

The dependent variables consisted of three measures. The first was the amount of time subjects spent encoding the object, which refers to the amount of reaction time (RT) specific to each individual when he or she was making price judgments on the object-context scene. The second variable to consider was the amount of time the subjects spent at retrieval (or test) deciding whether they had previously seen the object that was now presented on a white background. This can be referred to as retrieval reaction time for each individual participant. The third dependent variable exists as the recognition accuracy of the object during a yes-no recognition memory task, which occurs after participants have seen all of the objects placed in the semantically congruent or incongruent backgrounds.

Procedure

Encoding (Study)

During encoding, all subjects were instructed that they were going to be viewing various household objects in rooms of houses or in colored, patterned backgrounds on a computer screen. Participants were informed that the objects would always be placed in the middle or forefront of the screen. During this study session, the participants performed an incidental learning task in which they were asked to rate the price of the object shown on the screen as less than or greater than $25 in value. The price estimation task was not of significant value to the results, but simply asked of subjects in order to ensure participants were paying close attention to the target object. The participants

viewed forty objects in a semantically congruent background, forty objects in a semantically incongruent background, and forty objects in a colored, pattern background. Before beginning the actual encoding session, a short practice session was administered to all participants in order to familiarize them with the object-context scenes and timing. All images were randomly displayed for three seconds each with an inter-stimulus interval (ISI) of 1.5 seconds using DMDX stimulus presentation software (version 4.0.1.2, Forster & Forster, 2003).

Distracter Task

In order to account for ceiling effects, a distracter task was administered to all participants between the encoding and retrieval sessions. The Horne and Ostberg (1976) Morningness-Eveningness Questionnaire was administered to participants. The task provided a 5-minute interval between encoding and retrieval sessions.

Retrieval (Test)

After the completion of the encoding session and the Morningness-Eveningness Questionnaire, the test phase was begun. For this session, the participants were instructed that they would again be viewing household objects. However, the objects would now be shown on a white background. The objects were randomized, as to not appear in the same order as which they were encoded. Ninety objects were added as lures, consisting of household objects that the participants had not previously seen in a context during the study session. All participants were instructed that instead of rating the price of the object, the task was to indicate whether or not they recognized seeing the object from the

previous price rating session. This was a yes-no memory recognition test, where subjects responded by pressing the left and right mouse button for ‘yes’ and ‘no’ choices, respectively. Before actual retrieval had begun, participants were once again administered a short practice test in order to familiarize them with the retrieval conditions and timing. Again, the images were displayed for three seconds each with an ISI of 1.5 seconds using DMDX stimulus presentation software. Following the retrieval session, participants were debriefed. This concluded their lab visit.

Young adult participants underwent health screening by completing a Demographic and Health Questionnaire. Older adult participants were previously approved for behavioral studies in the laboratory, and also completed a Demographic and Health Questionnaire Update form. All participants were free from past or current neurological disorders, head injuries, psychological disorders, or a history of alcohol or drug abuse. No participant was taking medications that may have interfered with cognitive functioning ability. Informed consent was obtained from each participant approved by the Human Subjects Committee at the University of Arizona.

Data Analysis

Once the encoding and retrieval tasks were complete for all participants, data analysis could begin. Using DMDX stimulus presentation software (version 4.0.1.2, Forster & Forster, 2003), all responses to the yes-no object recognition task were coded into correct or incorrect responses in a Microsoft Excel spreadsheet. The numbers of correct and incorrect responses were recorded for each participant and for every condition

(amount of correct responses for objects seen in congruent backgrounds, incongruent backgrounds, and colored, pattern backgrounds). These were recorded as correct recognition hits.

Next, the accuracy of response was found for all of the lure objects for each participant's data. The amount of lure objects a participant responded 'yes' to were added together to produce his or her false alarm rate. By subtracting false alarms from recognition hits, a corrected recognition (% correct recognition hits – false alarm rate) score could be calculated for each participant in each condition.

After determining corrected recognition for each participant, retrieval reaction times were analyzed. The means of median reaction times at retrieval were calculated for all three groups (young adults, high executive functioning older adults, and low executive functioning older adults) across all conditions (congruent, incongruent, pattern, and object lures).

All data was analyzed using the Statistical Package for the Social Sciences (SPSS; PASW 18.0).

Results

Once all of the corrected recognition scores and mean of median reaction times were obtained, differences between groups and conditions could be examined. Overall, object recognition performance was better when participants were identifying objects from the congruent condition, regardless of age or executive function ability. Repeated measures ANOVA with executive function as the between-subjects factor and recognition condition as the within-subjects factor revealed a main effect of recognition

condition between congruent (M = 0.75, SEM = 0.02) and incongruent (M = 0.71, SEM = 0.02) conditions, $F(1, 20) = 6.37$, $p < .05$.

Within the congruent condition, an independent sample t-test revealed that high executive functioning older adults performed significantly better than low executive functioning older adults (high old: mean percent corrected recognition, 80.1%; low old: mean percent corrected recognition, 67.1%), t (9) = 3.01, $p < .05$ (*Figure* 1).

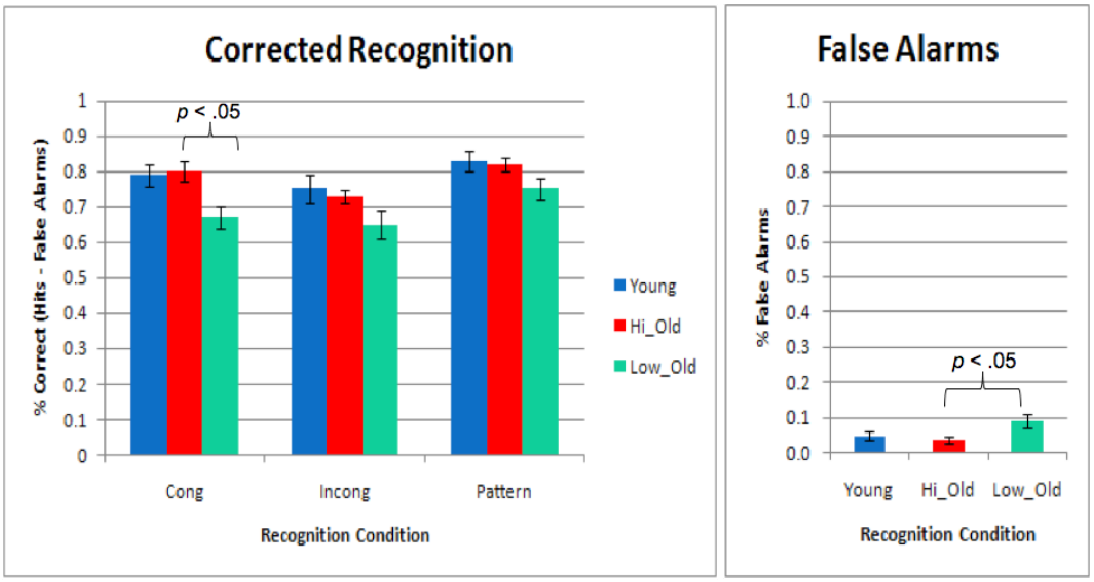


Figure 1. Mean corrected recognition (hits – false alarms) across conditions. Objects presented in congruent or incongruent contexts at study and white background at test. In the congruent condition, high executive functioning older adults performed significantly better than the low, and similarly to the young. It should also be noted that low executive functioning older adults had significantly more false alarms than high executive functioning older adults.

Interestingly, high executive functioning older adults performed similarly to the young adults, showing no significant differences with each other in either the congruent (high old: mean percent corrected recognition, 80.1%; young: mean percent corrected recognition, 78.5%) or incongruent conditions (high old: mean percent corrected recognition, 73.0%; young: mean percent corrected recognition, 74.8%). Independent

sample *t*-tests showed this lack in significance, suggesting that performance between the two groups was similar, *t's* (16) < 1, n.s.

With regard to retrieval reaction times, repeated measures ANOVA with executive function as the between-subjects factor and retrieval condition reaction time as the within-subjects factor revealed a significant main effect of executive function, $F(2,20) = 3.64$, $p < .05$. There was also a main effect of recognition condition between congruent (M = 1095.38 ms, SEM = 34.65) and incongruent (M = 1149.40 ms, SEM = 41.60) conditions, $F(1,20) = 5.70$, $p < .05$. Independent sample *t*-test showed that high executive functioning older adults took significantly longer than young adults in both the congruent (high old: mean of median RT, 1206.93 ms; young: mean of median RT, 1013.04 ms) and incongruent (high old: mean of median RT, 1241.02 ms; young: mean of median RT, 1005.99 ms) conditions, $t(16) = -2.55$, $p < .05$ and $t(16) = -2.86$, $p < .05$, respectively (*Figure* 2).

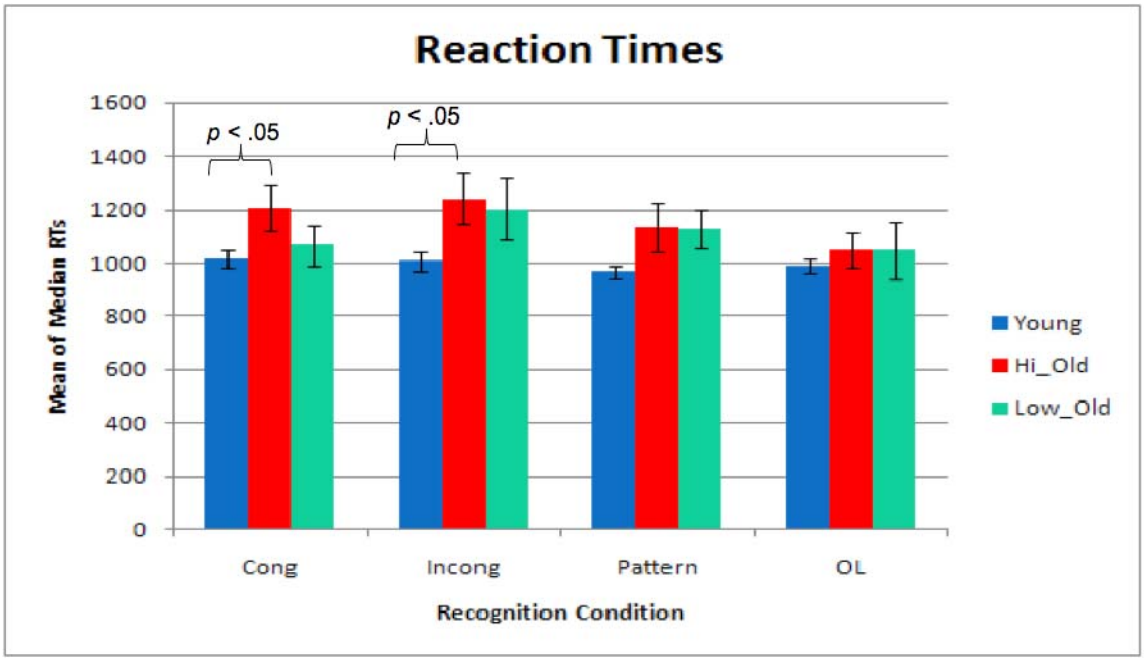


Figure 2. Mean of median reaction times for retrieval across conditions. High executive older adults took significantly longer than young adults in both congruent and incongruent conditions.

For the older adult participants, higher executive function ability was positively correlated with greater accuracy in object recognition for both congruent (r = .61, p < .05) and incongruent (r = .64, p < .05) conditions (*Figure* 3).

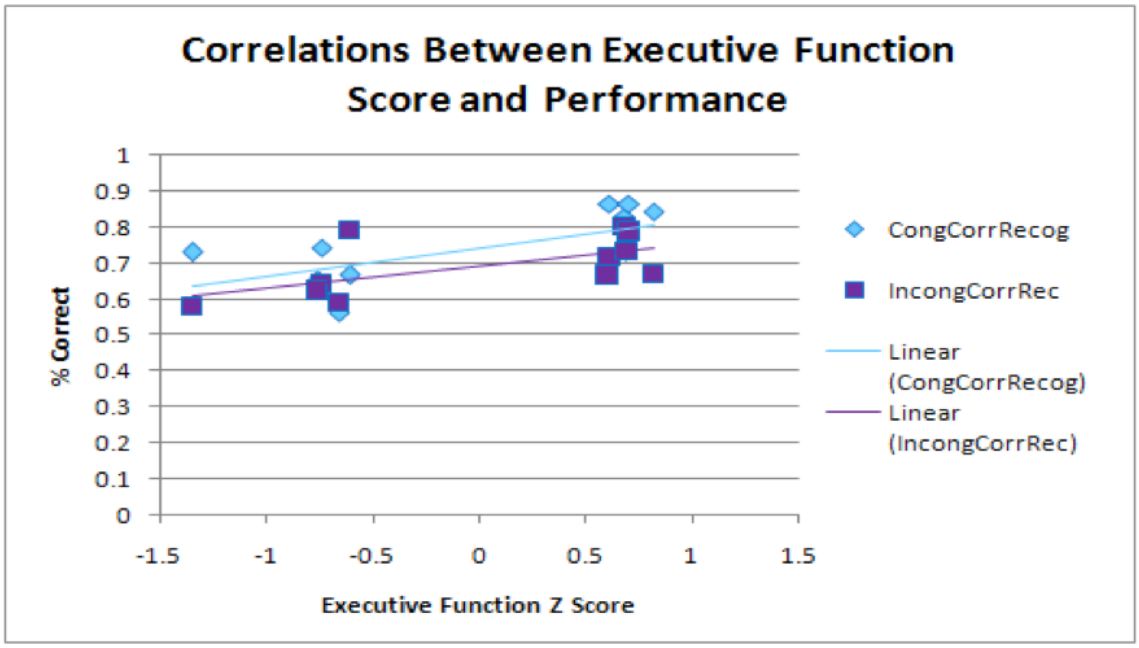


Figure 3. Correlations between performance and executive function scores. Performance was positively correlated with executive function scores for both congruent and incongruent conditions.

Discussion

As performance changes in object recognition occur as a result of changes in context scenes, it is clear that contextual information plays an important role when formulating an episodic memory of an object. As research indicates, object recognition performance in younger adults decreases following a change in context from encoding to retrieval (Hayes, Nadel, & Ryan, 2007), signifying the importance of the contextual information that is presented to us in every day life. Although we predicted that binding between object and context would affect the younger adult's performance on object

recognition compared to the older group's performance, we did not see this decrease in performance for this particular group of younger individuals. What we did see however, was an overall similarity in performance of object recognition between high executive functioning older adults and younger adults. This result suggests that high executive functioning older adults may have executive functioning abilities that more closely resemble that of younger adults. As contextual information about background scenes (source memory) has shown to be partially dependent on executive functioning processes (Johnson, Hashtroudi, & Lindsay, 1993), it can be inferred that those with similar executive functioning ability will show similarities in source memory.

Although object recognition performance showed no significant difference between these two groups, retrieval reaction times showed a significant difference between the two. The high executive functioning older adults took significantly longer than the young adults when recognizing objects from both the congruent and incongruent conditions. This may suggest that the high executive functioning older adults are utilizing this increased retrieval time, as well as their executive function ability, to better discriminate the objects. Perhaps this increased retrieval time further allows for the executive functions of the older adults in the high group to exhibit similar patterns of accuracy to that of the young group.

Supporting this idea further, overall performance of the older adults was positively correlated with executive function scores for both the congruent and incongruent conditions. Regardless of condition, both older adult groups showed an increase in episodic object recognition with increased executive function *Z* scores. This may provide reason to believe that executive functioning plays a vital role in overall

recognition memory ability, especially when performing object recognition tasks where contextual changes have occurred.

All participants had increased performance on object recognition when making recognition judgments on objects they had viewed in the semantically congruent condition compared with the semantically incongruent condition. This increased performance on objects from the congruent condition occurred regardless of age or executive function status. This suggests that contexts that are semantically related to the object may be an important part of remembering that object. Perhaps, these related contexts help us to more effectively learn the object, and perform better on memory recognition tasks when we are asked to identify the object as one we have in our episodic memory. This may be important for practical functions in daily life, suggesting that the contextual information that is related to a specific item may help us to store that item in our memory.

Although the findings of this object-context study provided us with some unexpected results, it was informative. By investigating the effects of age and executive function ability, the present study provided clues as to the similarities between younger adults and older adults with high executive functioning abilities. It also provided insight into the possibility of the role of semantic relatedness in episodic object recognition.

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