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Recognition Practice Results in a Generalizable Skill in Older Adults: Decreased Intrusion Errors to Novel Objects Belonging to Practiced Categories

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Summary: Accessing memories is often accompanied by both positive and negative consequences. For example, practice recognizing some visual images held in memory can improve memory for the practiced images and hurt memory for related images (i.e., recognition-induced forgetting). However, visual stimuli have been shown to improve memory for older adults by decreasing false memories. This suggests that older adults may be immune to recognition-induced forgetting and that recognition practice may decrease susceptibility to intrusion errors. We first tested the hypothesis that older adults are immune to recognition-induced forgetting. We found older adults exhibit recognition-induced forgetting. Next, we tested the hypothesis that recognition practice decreases older adult's rates of intrusion errors. We found lower intrusion errors for novel objects from practiced categories. This represents a generalizable learning effect; practice recognizing a target object (e.g., your pill bottle) improves the rejection of new lures (e.g., identifying the pill bottle that is not yours).Copyright © 2016 John Wiley & Sons, Ltd.

The potential severity of classifying a novel item as familiar is clear under many real-world circumstances. This is particularly true as people age. For example, it is dangerous if someone mistakes a housemate's pill bottle as one's own or incorrectly thinks a stranger at the door is a familiar face. Incorrectly reporting a novel item as having been encountered before is called an *intrusion error* (Jacobs, Salmon, Troster, & Butters, 1990). The gravity of these errors increases when committed by more vulnerable populations, like older adults. Indeed, older adults commit intrusion errors at higher rates than younger adults (Borella, Carretti, Cornoldi, & De Beni, 2007; Borella, Carretti, & De Beni, 2008; De Beni & Palladino, 2004; Lustig, May, & Hasher, 2001), especially for objects that belong to highly familiar categories, such as a faces (Bartlett & Fulton, 1991; Bartlett, Leslie, Tubbs, & Fulton, 1989; Fulton & Bartlett, 1991; Lamont, Stewart-Williams, & Podd, 2005; Searcy, Bartlett, & Memon, 1999). While relatively few studies on long-term memory and aging have used visual (i.e., picture) stimuli (Park & Gutchess, 2005), recent evidence has demonstrated that visual stimuli reduce older adults' false memories (Gallo, Cotel, Moore, & Schacter, 2007; Schacter, Israel, & Racine, 1999; Smith, Hunt, & Dunlap, 2015), consistent with a large body of work that memory for visual stimuli is superior to memory for verbal stimuli (e.g., Hockley, 2008; Paivio, Rogers, & Smythe, 1968). This begs the question whether experience (or practice) recognizing a visual object can boost older adults' immunity to intrusion errors. Our goal in the present study is to determine whether recognition practice can effectively improve memory for aging individuals by reducing the rates of memory intrusions.

It is particularly plausible that practice recognizing an object may affect rates of intrusion errors given strong evidence that accessing memory representations does not simply involve retrieving a memory and putting it away unaltered. Specifically, research on retrieval-induced forgetting (Anderson, Bjork, & Bjork, 1994) has shown that accessing a memory can change other memory representations. This memory phenomenon illustrates that the act of remembering an item actually alters its representation, typically by strengthening that object's representation. However, these changes do not only affect the memory representation of the remembered item. Memory representations of items that are semantically related to the retrieved memory, but are not themselves retrieved, are also altered. This memory-modifying effect occurs in the opposite direction, by weakening the memory representations of related objects that are not retrieved in the course of practice. Retrieval-induced forgetting has been shown with older adults who are normally aging (Aslan, Bäuml, & Pastotter, 2007; Hogge, Adam, & Collette, 2008) and patients with Alzheimer's disease (Moulin et al., 2002).

Since the seminal study of Anderson, Bjork and Bjork (1994), the literature has grown rife with applications of retrieval-induced forgetting (for a great review, see Storm et al., 2015). Studies have examined retrieval-induced forgetting across applications such as education (e.g., Carroll, Campbell-Ratcliffe, Murnane, & Perfect, 2007; Little, Storm, & Bjork, 2011), eyewitness memory (e.g., Camp, Wesstein, & Bruin, 2012; Garcia-Bajos, Migueles, & Anderson, 2009; MacLeod, 2002; Migueles & García-Bajos, 2007; Shaw, Bjork, & Handal, 1995), social cognition (e.g., Coman & Hirst, 2012; Coman, Manier, & Hirst, 2009; Storm, Bjork, & Bjork, 2005), autobiographical memory (e.g., Harris, Sharman, Barnier, & Moulds, 2010; Hauer & Wessel, 2006), and creative cognition (e.g., Storm & Angello, 2010; Storm, Angello, & Bjork, 2011). Interestingly, some studies have also shown better memory for typically forgotten information in these paradigms (e.g., Little, Bjork, Bjork, & Angello, 2012; Little et al., 2011; Storm, Bjork, & Bjork, 2008). Evidence that memory for semantically related items is improved under some conditions suggests that despite being vulnerable to retrieval-induced forgetting, older adults may show some benefit of practice.

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Specifically, older adults may be able to overcome intrusion errors (such as those discussed previously) with practice. The potential importance of such an applied finding would be wide reaching. If recognition practice can improve intrusion error rates, then the present data would serve as empirical evidence that recognition practice provides a generalizable benefit to novel stimuli, improving individuals' ability to reject new items that they have never seen before.

We next review a novel paradigm that allowed us to address whether practice recognizing objects affected rates of intrusion errors in the present paper. Recently, Maxcey and Woodman (2014) found a memory impairment, similar to retrieval-induced forgetting, in visual long-term memory of college-age adults that they called recognition-induced forgetting (see also Maxcey, 2016; Maxcey & Bostic, 2015). Evidence of this impairment is found using a recognition task to assess memory for visual stimuli. In this recognition-induced forgetting paradigm (Figure 2), participants are shown objects from a variety of categories (see Figure S1 for an example of complete categories) in a study phase. Participants are instructed to remember the objects for a later memory test. In the recognition practice phase, participants practice recognizing half of the objects from half of the categories in a two-alternative forced-choice recognition judgment task. This recognition practice phase creates three classes of objects: those that the participant has had practice recognizing (known as *practiced objects*[1]), those that belong to a category that was practiced, but they themselves were not practiced (known as *related objects*), and those drawn from categories that the participant has only been exposed to in the initial study phase but does not have practice recognizing (known as *baseline objects*). At test, participants are sequentially presented with objects, half of which are new (i.e., novel) and half of which are old (i.e., from the study phase in the experiment). Participants are instructed to report whether they have ever seen the exact object previously in the experiment with a button press response. Importantly for the present study, half of the novel objects are from practiced categories, and half are from non-practiced categories. The typical finding that results from recognition practice in this paradigm is significantly worse memory for related objects relative to baseline objects, hence the term *recognition-induced forgetting*.

Using this recognition-induced forgetting paradigm with older adult participants allowed us to answer two questions in the present study. First, does recognition-induced forgetting exist in visual long-term memory of older adults? Given the evidence reviewed previously for the role of pictures in improving memory in older adults, it is possible that older adults will be immune to such forgetting. Second, does practice recognizing a category of objects (e.g., gloves) decrease rates of intrusion errors for novel gloves relative to novel objects from non-practiced categories (e.g., fans)? In other words, does repeated experience (or practice) with a category (e.g., pill bottles) make an older adult less likely to incorrectly identify a novel pill bottle as familiar and subsequently take the wrong medicine?

Two patterns of results for rates of intrusion errors can be motivated by the literature. The first potential outcome stems from research suggesting that the mechanism of induced forgetting effects is inhibition (Anderson, 2003). Consistent with this view, recognition practice decreases susceptibility to intrusion errors in children (Maxcey & Bostic, 2015). Given that older adults are believed to have inhibitory deficits (Hasher & Zacks, 1988) as do children (Bjorklund & Harnishfeger, 1990; Friedman & Leslie, 2004), it may be that recognition practice also decreases susceptibility to intrusion errors in older adults. This possibility would result in higher rates of correct rejections for novel objects from practiced categories versus non-practiced categories.

Alternatively, because it has not been conclusively shown that this task involves inhibition (Maxcey, 2016; Maxcey & Bostic, 2015; Maxcey & Woodman, 2014), older adults may instead show no effect on intrusion errors between practiced and non-practiced categories. This possibility would result in no reliable difference in correct rejections between practiced and non-practiced categories. The goal of the present study is to distinguish between these two alternatives, using a recognition-induced forgetting paradigm with older adult participants.

METHOD

Participants

Our participants were 30 older adults (16 members of the Manchester University community and 14 members of the Montana State University community), with a mean age of 79.5 years (standard deviation = 7.36, age range: 65–91 years). Participants passed the Ishihara color blindness test and reported normal or corrected-to-normal vision. Participants reported no history of cognitive deficit diagnoses. Participants scored above the recommended cutoff on the Mini Mental Status Exam (Folstein, Folstein, & McHugh, 1975) of 24/30, with an average score of 28.2. Informed consent was obtained prior to the beginning of the experiment. All procedures were approved by the appropriate Institutional Review Board.

Stimuli and procedure

Stimuli were presented using E-prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2012). Participants were comfortably seated at a viewing distance of approximately 80 cm. Stimuli were drawn from public domain images downloaded from Google Images (http://images.google.com), viewed on a white background, with each subtending $4.85° \times 4.85°$ degrees of visual angle. An example of a subset of stimuli for one participant is shown in Figure 1 (please see Figure S1 for a complete set of stimuli). The stimuli consisted of 12 categories of real-world objects with 15 exemplars in each category. Two additional categories (tables and goggles) with three exemplars in each served as filler items for the first and final three trials of the study phase.

[1] In order to be more accessible to the reader, Maxcey and Bostic (2015) revised the nomenclature for these objects from the previous terms used by Maxcey and Woodman (2014). Here, we continue to use the revised nomenclature.

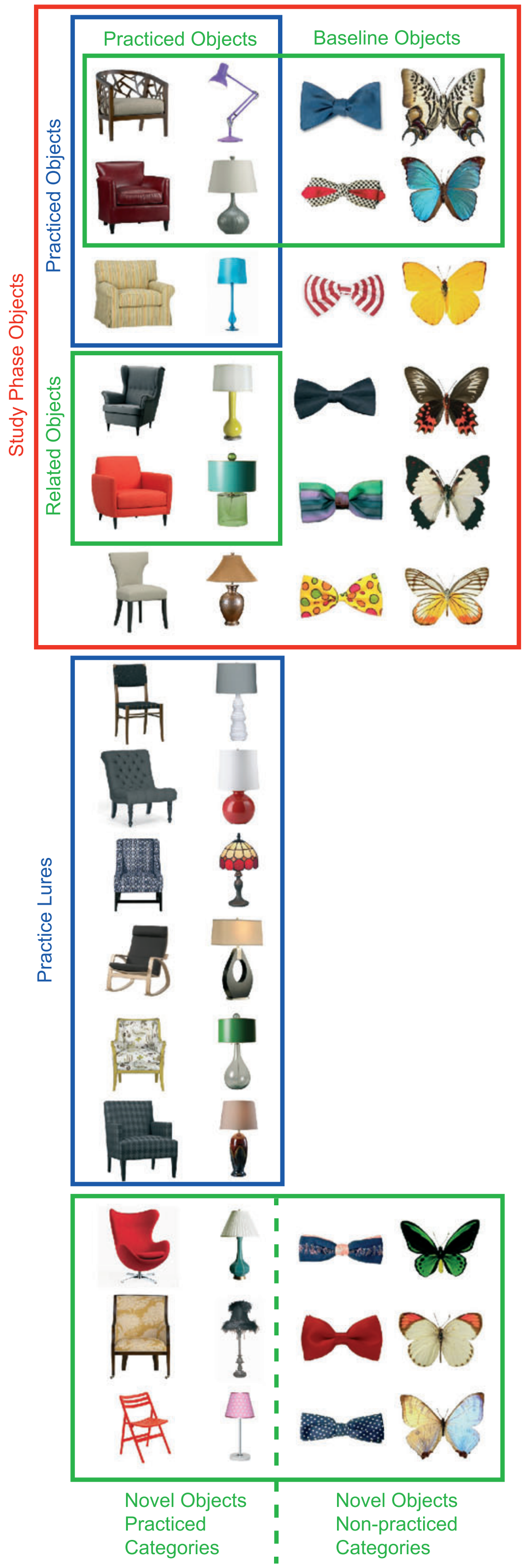

Figure 1. Example of a subset of stimuli. This is an example of the objects from four of the 12 categories for one subject. The red box indicates the objects that were presented in the study phase. The blue boxes show the objects in the practice phase. The green boxes delineate the objects from the test phase. Please see Figure S1 for a complete illustration of the entire stimulus set for one participant

We used the methods of Maxcey and Woodman (2014) as described below. An example of the stimuli and procedure is shown in Figure 2. The experimental session consisted of a study phase, a recognition-practice phase, and a final test phase.

Each session began with a study phase during which participants were shown one object at a time for 5 s, interleaved by a 500-ms center fixation cross, until 78 objects were shown. Participants were instructed to study the visual details of these objects for a later memory test. In order to minimize the influence of primacy and recency effects (Murdock, 1962), three filler objects from two additional categories were included in the beginning and end of the study phase but were not included in the analysis. Therefore, six of the 78 objects were excluded from analysis because of their status as filler objects.

Next, participants completed a recognition-practice phase, during which they practiced recognizing half of the objects (three out of six) from half of the categories (six out of 12) they were shown in the study phase. Recognition practice involved completing a two-alternative forced-choice recognition task for each of these 18 objects. Specifically, participants were shown two objects at a time on the screen, one to the left and one to the right of fixation. One of the objects was an object they were shown during the study phase (i.e., one of the 18 practiced objects). The other object was a novel object from the same category. Participants were instructed to determine which of the objects they had seen in the first block and respond with a two-alternative forced-choice button press. The specific objects practiced were counterbalanced across subjects, such that practiced objects for half of the subjects were not practiced for the other half of subjects. Consistent with previous studies, feedback was not provided during the recognition-practice phase, but performance on recognition practice was analyzed.

Finally, during the test phase, participants were shown one object at a time and asked to report whether they had ever seen the exact image previously in the experiment and respond by button press, from this point forward known as the old-versus-new judgment. These images fell into five categories. In three of the categories, the objects were old, and a correct response would be ‘yes’: (1) *practiced* objects were shown both during the study phase and practiced in the recognition-practice phase; (2) *related* objects were shown during the study phase and then were *not* practiced in the recognition-practice phase, but their category was practiced; and (3) *baseline* objects were shown during the study phase and then were *not* practiced in the recognition-practice phase, and their category was *not* practiced. The hit rates to the aforementioned three classes of objects were analyzed to determine whether recognition-induced forgetting exists for older adults, and whether practice improves memory for practiced objects relative to baseline objects. The final two categories consisted of new objects to which a correct response would be ‘no’: (4) *novel objects from practiced categories* were objects that were never seen before in the experiment but belong to practiced categories; and (5) *novel objects from non-practiced categories* were objects that were never seen before in the experiment and belong to non-practiced categories. The correct rejections to these two types novel objects were analyzed to determine whether recognition practice had a different effect on intrusion errors between practiced and non-practiced categories. Half of the

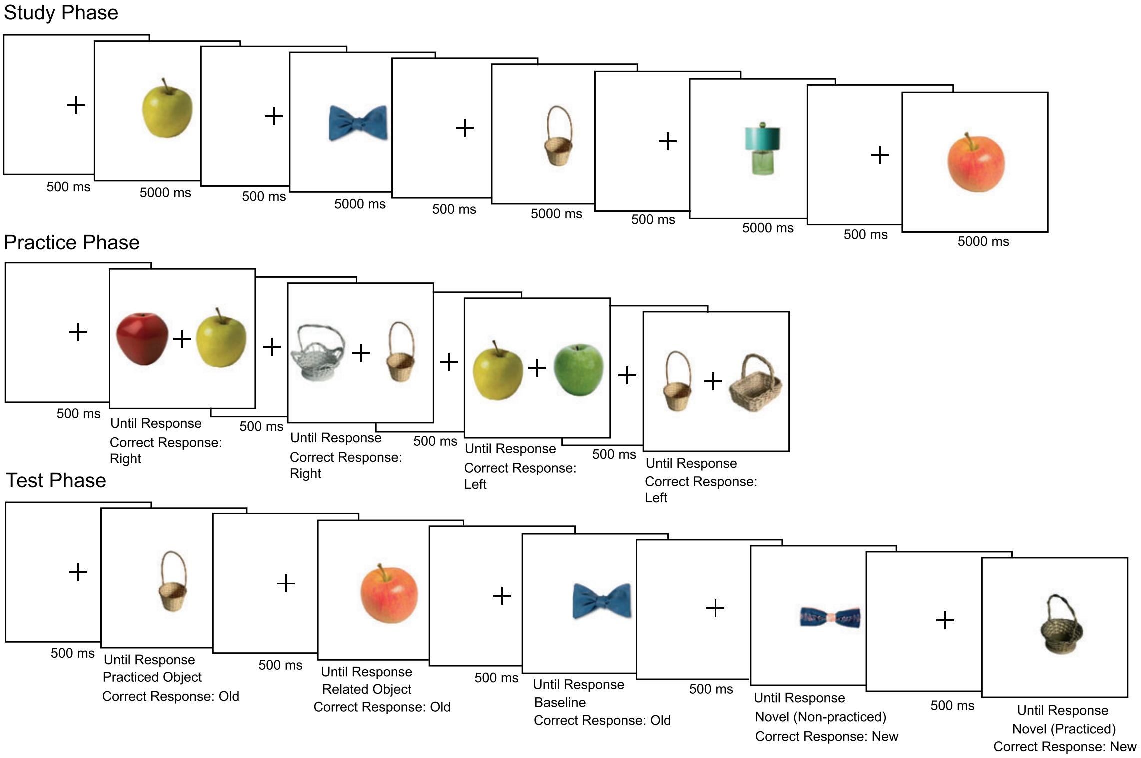

Figure 2. Example of the stimuli and procedure. The study phase consisted of 78 objects presented sequentially for 5 s interleaved by a 500 ms fixation cross. In the practice phase, participants were a subset of the objects from the study phase paired with a novel exemplar from the same category. Participants performed a two-alternative forced-choice recognition task, responding by button press to indicate which object (the object on the left or on the right) was the object they had seen in the study phase. Finally, in the test phase, participants made an old/new recognition judgment. Novel objects (i.e., new objects they had never seen before) were either drawn from practiced categories or non-practiced categories

objects in the memory test were old (36 total practiced, related and baseline objects), and half of the objects were new (36 total novel objects). Novel objects were equally divided into novel objects drawn from practiced categories and non-practiced categories. In between the three blocks, participants completed a 5-min filler task adopted from Maxcey and Woodman (2014).

Data analysis

The primary dependent variable for our recognition data was hit rate (i.e., hits for practiced, related and baseline objects, and correct rejections for test lures). We found the same pattern of results when we computed A′ (Snodgrass, Levy-Berger, & Haydon, 1985) and B''_D (Donaldson, 1992).[2] A complete list of analyses can be found in Table 1. We used a within-subjects analysis of variance and an alpha level of $p = 0.05$ for the omnibus test. Preplanned, two-tailed repeated measures *t*-tests were used to determine whether there was a benefit of recognition practice for practiced objects (hit rate for practiced objects greater than hit rate for baseline objects) and any cost related to related objects (hit rate for related objects less than hit rate for baseline objects). The same follow-up *t*-tests examined any difference between correct rejection rates for novel objects from practiced versus non-practiced categories (% correct rejections for novel objects from practiced categories ≠ % correct rejections for novel objects from non-practiced categories). All *t*-tests are accompanied by measures of Cohen's *d* effect size. To provide a way of quantifying the support for the null hypothesis, we calculated the scaled JZS Bayes factor (as specified in

Table 1. Results summary tables from the participants' responses to objects in the test phase

Old objects	Practiced objects	Baseline objects	Related objects
Hit	0.89	0.86	0.74
Miss	0.11	0.14	0.26
A′	0.9	0.89	0.84
B''_D	−0.41	−0.28	0.05

New objects	Practiced category	Non-practiced category
False alarm	0.18	0.25
Correct rejection	0.82	0.75

Old objects are objects that were previously seen in the experiment and warranted a 'yes' response at test. New objects are objects that were novel and warranted a 'no' response at test.

[2] Here, we report the analyses from hit rates for efficiency of presentation. However, the analyses of A′ and B''_D are also useful because they illustrate that recognition-induced forgetting is not simply due to participants becoming more conservative for categories with larger set sizes (as do practiced and related objects relative to baseline objects). This is clear because B''_D for practiced objects is not significantly different than B''_D for baseline objects, $t(29) = 1.265$, $p = .216$, scaled JZS Bayes factor 2.50 (see also Maxcey, 2016).

Rouder, Speckman, Sun, Morey, & Iverson, 2009). Finally, we ran a Pearson's correlation to examine any correlation between age and the difference in correct rejection rates between novel objects from practiced relative to non-practiced categories. The two subgroups of participants (members of the Manchester University community and Montana State University community) performed similarly; thus, data were collapsed across these two subgroups in all of the aforementioned analysis conditions.

RESULTS

Recognition-induced forgetting

The mean hit rates across the types of test objects are shown in Figure 3. These means show that, using pictures, older adults show only the impairment for related objects and not the benefit for practiced objects shown in college-age adults (Maxcey & Woodman, 2014). These findings resulted in a significant main effect of trial type in the analysis of variance, $F(2, 58) = 16.05$, $p < .001$. Specifically, participants were significantly better at identifying practiced objects (.89) than related objects (.74, $t(29) = 5.98$, $p < .001$, $d = 1.26$). However, participants showed no significant benefit for practiced objects (.89) over baseline objects (.86, $t(29) = 1.37$, $p = .182$). To provide another way of quantifying this similarity in performance across the practiced objects and baseline objects, we calculated the scaled JZS Bayes factor, which provided the estimate that the null hypothesis was 2.21 times more likely than the hypothesis that these means do differ (as specified in Rouder et al., 2009). This comparison between baseline and practiced objects is significant among college-age adults (Maxcey, 2016; Maxcey & Woodman, 2014) and is interpreted as the benefit of practice in recognition-induced forgetting paradigms (see also Maxcey & Bostic, 2015). The absence of a significant benefit for practiced objects is not due to poor performance during recognition practice because participants performed very well during recognition practice (.89).

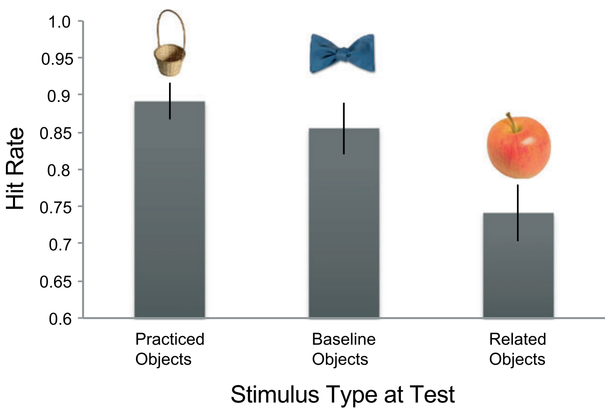

Figure 3. Hit rates of the responses to the old memory test objects in the test phase. Practiced objects were recognized during the practice phase. Related objects are the objects that belong to practiced categories but were not themselves practiced. Baseline objects are categories of objects that were not practiced. The error bars show the 95% within-subjects confidence intervals as described by Cousineau (2005) with Morey's correction applied (Morey, 2008)

Despite this absence of a benefit of recognition practice for practiced objects, participants did show a significant cost for related objects. This emerged as reliably better performance in identifying baseline objects (.86) relative to related objects (.74), $t(29) = 3.67$, $p = .001$, $d = .83$. These results suggest that recognition practice did indeed hurt memory for related objects, even in the absence of a benefit for practiced objects. This finding serves as the first evidence of recognition-induced forgetting in older adults.

Intrusion errors for novel objects

We next sought to examine whether there was a cost to correctly rejecting novel objects from non-practiced categories, relative to novel objects from practiced categories. We found that correct rejections of novel objects from non-practiced categories (75%) were significantly lower than correct rejections of novel objects that were members of a practiced category (82%), $t(29) = 2.80$, $p = .009$, $d = .60$. These findings indicate that when older adults are presented with a new object from a semantic category to which they have previous experience with recognition practice, they are more accurate at identifying it as novel, compared with a new object from a semantic category with which they have less such experience. This latent effect of practice is also positively correlated with age, such that older participants showed a greater difference in correct rejection rates between novel objects from practiced relative to non-practiced categories, $r = +.463$, $p = .01$. In sum, older adults showed decreased intrusion errors to novel objects from practiced categories, a difference that increased with age. This demonstrates the surprising result that practice did not improve memory for the practiced objects but did improve the ability of the participants to reject other objects (e.g., as not the pill bottle I am looking for).

GENERAL DISCUSSION

Older adults incorrectly endorse novel stimuli as familiar under many circumstances, such as false seeing (Jacoby, Rogers, Bishara, & Shimizu, 2012), false hearing (Rogers, Jacoby, & Sommers, 2012), and false remembering (Jacoby, Bishara, Hessels, & Toth, 2005). However, the consequence of practicing object recognition in older adults was unknown. In the present study, we first sought to determine whether older adults exhibit recognition-induced forgetting. Indeed, older adults did exhibit a cost of recognition-induced forgetting. This cost emerged as reliably worse memory for related objects relative to baseline objects, as expected in this paradigm. Recognition practice did not significantly improve memory for practiced objects relative baseline. The absence of a benefit of recognition practice for practiced objects is in contrast to college-age adults who do show improved performance after recognition practice (Maxcey, 2016; Maxcey & Woodman, 2014). However, this lack of benefit for practiced objects is consistent with developmental evidence that children ages 6–8 years also do not show a benefit for practiced objects in the recognition-induced forgetting paradigm, while children ages 9–10 years do show better memory for practiced objects (Maxcey & Bostic, 2015).

We then sought to determine whether the memory impairment in recognition-induced forgetting had residual effects on intrusion errors for novel objects. We found significantly more intrusion errors to novel objects from non-practiced categories, relative to novel objects from practiced categories. Therefore, although there was no overt benefit of practice for practiced objects relative to baseline, practice clearly did have an effect on intrusion errors of novel objects. Specifically, practice boosted immunity to intrusion errors of novel objects from practiced categories. Interestingly, children ages 6–8 years who did not show an advantage for practiced objects (similar to the older adults herein) also show reliably more intrusion errors for novel objects from non-practiced categories relative to novel objects from practiced categories (Maxcey & Bostic, 2015).

Recent evidence from our lab has demonstrated that increased practiced in the recognition-induced forgetting paradigm in college-age adults increases memory for practice objects but does not worsen forgetting of related objects (Maxcey, 2016). In that study, intrusion errors did not differ across categories that were practiced two, four, or six times. However, the effect of parametrically manipulating the amount of practice objects receive on intrusion errors in the aging population is unknown. Future research is necessary to determine whether a similar parametric manipulation of recognition practice with older adults would further boost their immunity to intrusion errors, as well as reliably increase memory for practiced objects relative to baseline.

The present study offers a paradigm that empirically demonstrates a generalizable improvement in older adults' correct rejections of novel items. Specifically, older adults were better able to correctly reject objects they had never seen before when they belonged to a practiced category, generalizing the effect of recognition practice to new objects. This study sets the stage for future research to further examine these results in applied settings. For example, the development of apps that mimic the recognition-induced forgetting paradigm may help protect this vulnerable population from potentially dangerous intrusion errors.

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