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Younger and Older Adults' Strategic Use of Associative Memory and Metacognitive Control When Learning Foreign Vocabulary Words of Varying Importance

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Older adults often face memory deficits in binding unrelated items. However, in situations such as preparing for foreign travel, a learner may be highly motivated to learn the translations of important words (e.g., "money"). In the present study, younger and older adults studied Swahili–English word pairs and judged the importance of knowing each pair if they were traveling to a foreign country. Generally, we expected older adults to display a memory deficit but for both younger and older adults' memory to be driven by the subjective importance of the to-be-learned information. Both younger and older adults' memory was related to their subjective importance ratings, suggesting that both age groups were able to engage in goal-based value-directed remembering. With increased task experience, older adults appeared to utilize a strategic approach in their study of the translations by spending more time studying the items relative to younger adults. Thus, despite associative memory deficits in older age, both younger and older adults can selectively remember subjectively important information such that older adults can effectively remember new vocabulary that is subjectively important and related to their future goals.

Public Significance Statement
We demonstrated that older adults can employ strategies to overcome some memory deficits and that both younger and older adults selectively recall subjectively important information when learning new vocabulary.

Keywords: cognitive aging, associative memory, learning, importance, responsible remembering

People often need to learn and remember associations such as when finding their car keys, learning a person's name, or studying words in a foreign language. Older adults often struggle to bind associated items in memory (Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Service & Craik, 1993) leading to deficits in remembering things like names and faces (James et al., 2008). Over the course of a lifetime, older adults accumulate an extensive vocabulary that appears to be maintained relative to other forms of memory (Birren & Morrison, 1961; Hartshorne & Germine, 2015; Schaie, 1994). Learning new vocabulary is an essential part of becoming familiar with a new language and knowing basic vocabulary can help when traveling. However, older adults often experience deficits in new language learning which is based on learning and recalling new associations for words as well as phonological processes in working memory (Service & Craik, 1993). Prior work examining binding, associative memory, and language learning has not yet examined how the importance of the vocabulary in question might influence age-related differences in later memory. Thus, we aimed to examine whether older adults, compared with younger adults, can overcome some forms of associative memory deficits by selectively focusing on and later remembering important associations when learning new vocabulary that is relevant to one's potential goals.

Extensive work has documented an associative learning deficit in older adults using paired-associate learning paradigms in which a cue word and a target word are presented together during a study period. On the test, only the cue word is presented, and participants are asked to recall the associated target word (e.g., Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Service & Craik, 1993). Several variables have been shown to influence paired-associate learning such as the concreteness of the cue and target words (Paivio, 1965), the imageability of the cue and target words

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The experiments reported in this article were not formally preregistered. All data and research materials are available on the Open Science Framework at https://osf.io/kxu9b/?view_only=5e1969e635934c719aa944fdced0a21d.

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(Papagno et al., 1991), the degree to which the cue and the target are semantically related (Arenberg & Robertson-Tchabo, 1977), and the number of opportunities to learn the pairs (Kilb & Naveh-Benjamin, 2011; Peterson et al., 1962). In general, while additional study time or restudy opportunities may not reduce an associative deficit in older age (Kausler, 1994), older adults benefit when words pairs are semantically related and can reduce age-related differences in associative memory with the use of associative memory strategies that help link unrelated words (Naveh-Benjamin et al., 2007).

While these factors can impact learning, it can also be advantageous to be goal-directed by focusing on key terms when learning a new language (a form of associative memory). This prioritizing process may help older adults to focus on essential learning, and the importance of the to-be-learned information may affect how learning is guided. This may involve metacognitive processes such that one seeks to prioritize learning and self-regulate study to ensure that the learning of key material has reached a point where it can be utilized in the future (e.g., Dunlosky & Hertzog, 1998b). Thus, while prior work has examined binding and associative memory using recognition or cued recall of different word pairings, we were interested in extending this to situations in which people may differentially focus on remembering certain pairings of new vocabulary due to the necessity or importance of using this information later.

Objective and Subjective Importance

To examine how value drives memory, early work manipulated the importance of individual to-be-learned items by assigning varying point values to words in a list (e.g., Castel et al., 2002, 2007). Participants in such tasks are told that their goal is to maximize their score, which is calculated by adding the points associated with the words they recalled. Substantial work suggests that despite age-related declines in memory (e.g., Craik & Salthouse, 2011; Kausler, 1994; Light, 1991), older adults can remember high-value information as well as younger adults, but their memory for low-value words is impaired (Castel et al., 2002, 2007, 2012; Murphy & Castel, 2022c, 2022d; see also Knowlton & Castel, 2022; Whatley et al., 2021).

Although selective memory for valuable information may be preserved in older age, previous paradigms have illustrated age-related deficits in paired-associate learning, even when that information is important (Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Service & Craik, 1993). For example, in an associative learning paradigm in which word pairs were assigned point values, older adults performed worse than younger adults when learning important cue–target pairs (Ariel et al., 2015), potentially the result of the inability to implement effective encoding strategies (e.g., mental imagery) that are more easily employed when learning lists of words. Other work has manipulated the value of associative information without using point values (e.g., face–name–occupation triads that varied with respect to hypothetical future use, Hargis & Castel, 2017; medication interactions that varied with respect to the danger of the health outcome, Hargis & Castel, 2018). These studies found that younger and older adults performed similarly when learning the most important associative information, though younger adults did outperform older adults when learning lower value information.

While older adults' associative deficit for high-value information is present when point values are assigned objectively (i.e., by the experimenter, often randomly, see Ariel et al., 2015), the more subjective nature of determining value and importance may play a critical role. Thus, it is also of interest, and perhaps of greater external validity, to examine subjective importance in memory tasks—that is, assessing value based on what the *participant* thinks is important to learn. For example, in terms of item memory and free recall, McGillivray and Castel (2017) asked younger and older adults to study lists of words that were relevant to specific activities (e.g., a list of items to take when going on a picnic such as "cookies," "blanket," and "frisbee"). To indicate importance, participants assigned point values (from 0 to 10) to each word while studying these lists. In this case, schematic and contextual support provided by each scenario likely played a crucial role in older adults' performance, and there were no age-related differences in how well participants recalled the lists of words or sensitivity to the assigned point values. Thus, tasks that allow older adults to bring their schemas to bear can enhance memory for subjectively important item information (although McGillivray & Castel, 2017 did not test associative memory which may lead to different effects).

Other work has focused on younger and older learners' curiosity about information to examine subjective importance. For example, McGillivray et al. (2015) assessed initial curiosity in learning the answer to a set of trivia questions as well as their postanswer interest in each question. The predictiveness of the postanswer interest ratings on memory performance increased after a delay for older adults (but not younger adults) suggesting that for older adults, interest in the information—perhaps related to the importance of information—can enhance memory. Additionally, Sakaki et al. (2018) have argued that although curiosity declines in older age, it may serve as a protective factor among older adults, emphasizing the role of subjective importance in learning. Self-regulated study decisions can also be indicative of subjective importance. For example, when self-regulating study time, learners often spend the most time on information that is important to remember (e.g., Ariel et al., 2009; Soderstrom & McCabe, 2011). Thus, subjective importance can be assessed using measures such as study choices, point value assignment, interest, and curiosity.

When presented with more information than we can remember, we need to strategically focus on and remember the most important information with consequences if forgotten, a notion we termed *responsible remembering* (Murphy & Castel, 2020, 2021a, 2021b, 2022a, 2022b; Murphy et al., 2022). Responsible remembering encompasses enhanced metacognitive processes as well as the strategic allocation of attention toward important information to avoid undesirable outcomes and even tragic consequences such as forgetting about a potentially deadly medication interaction or leaving an infant in the backseat of a hot car (see Castel & Rhodes, 2020). Responsible remembering can be implemented when participants make decisions regarding what word pairs are more relevant to their goals but may play a more central role in terms of how to allocate study time to ensure that one remembers what one needs to remember. Specifically, after gaining task experience, both younger and older adults may adaptively learn to be responsible rememberers when there are consequences for forgetting by best remembering the most important information.

Learning Foreign Vocabulary

The relative importance of information can depend on how one intends to use that information (e.g., Hargis et al., 2019; Hess, 2005;

Jenkins, 1979), and in the present study, we aimed to better understand how paired-associate learning occurs when in service of a goal that has a notable social component (see Carstensen et al., 1999, 2003). Specifically, we examined how the learning of important foreign vocabulary words may differ between younger and older adults. For example, it may be important for one to know foreign vocabulary words for basic social interactions (e.g., "hello" and "thank you") or perhaps words that could be needed if difficulty arises (e.g., "doctor" and "embassy"). While the translations for these words may often be featured in guidebooks, introductory foreign language courses, or popular language-learning mobile applications (e.g., Duolingo), it may also be convenient to learn a few important translations before one's trip.

In addition to allowing participants to use their schemas for traveling when deciding what is important, using foreign language nouns paired with English words allows for assessment of subjective importance on paired-associate learning while reducing the likelihood (compared to using pairs of English words) that a participant could employ a sophisticated word-based learning strategy (Zerr et al., 2018). For example, while an image could be easily conjured for the English pair "nurse: spoon," it is likely challenging for a non-Swahili speaker to imagine a picture or story representing the Swahili word for "nurse" ("muuguzi"). If there is no inherent structure or strategy that lends itself to studying the word pairs, a learner's perception of how important each item is to remember may be a strong guide of memory. Further, Swahili is not commonly encountered among most American people, reducing the likelihood of prior knowledge impacting learning (see Nelson & Dunlosky, 1994, for a full discussion of the benefits of using Swahili–English pairs in a paired-associate learning task).

In the present study, participants were asked to imagine that they were visiting Kenya, where many people speak Swahili. Rather than being told by the experimenter which words were important to remember (as has been the case in many value-directed remembering studies using relatively naturalistic materials, e.g., Hargis & Castel, 2017; Middlebrooks et al., 2016), participants rated how important it would be for them to know the Swahili translation of each English word. After making these ratings, participants studied pairs of words (e.g., "fever: homa") and completed a cued-recall memory test. Since older adults often struggle to bind associated items in memory (Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Service & Craik, 1993), the current task may require the engagement of associative strategies with which older adults struggle, perhaps due to the lack of obvious strategies to use during encoding and the unfamiliarity of the Swahili pairs. Therefore, we expected an overall associative memory deficit in older adults.

We were also interested in the connection between the perceived importance of learning a word and its likelihood of being recalled. If there is no relationship between importance and recall, it may be that all words are considered equally important (meaning that no words are more valuable than others) or that importance does not affect the learning of foreign language vocabulary. However, if there is a relationship between the importance and memory, such that a higher importance rating of an item is related to a greater likelihood of recalling that item, this would provide support for the role of younger and older adults' personal perceptions of importance in guiding memory for difficult-to-learn pairs. In line with prior work that examined item importance and free recall (see Murphy & Castel, 2022a; Schwartz et al., in press), we expected both younger and older adults' memory to be driven by importance, despite the associative memory deficit that may be present for older adults.

Experiment 1a

In Experiment 1a, younger and older adults rated the importance of Swahili–English word pairs, studied the pairs, and were given a cued-recall test for those pairs. The study and test phases were repeated for a total of two study–test cycles (i.e., trials; see Kilb & Naveh-Benjamin, 2011) to (a) increase memory performance and (b) investigate how task experience and instances of forgetting change what younger and older adults remember.

Method

Transparency and Openness

We report an analysis of our sample size and describe all data exclusions, manipulations, and all measures in the present study. This study's design and analyses were not preregistered. All data and research materials are available on Open Science Framework (OSF). Data were analyzed, and all figures were created using Jamovi (The Jamovi Project, 2022), and all information needed to reproduce the analyses is available on OSF. Informed consent was acquired, and the study was completed in accordance with the University of California Los Angeles (UCLA) Institutional Review Board (IRB No. 12-000617; Memory, Attention, Emotion, and Aging).

Participants

Data in each experiment were collected in 2022. Younger adults ($n = 56$; $M_{\text{age}} = 20.66$, $SD_{\text{age}} = 3.04$; 40 female, 16 male; 28 Asian/Pacific Islander, 2 Black, 8 Hispanic, 17 White, 1 other/unknown; in terms of the highest level of education achieved, 13 high school graduate, 25 some college but no degree, 9 associate's degree, 8 bachelor's degree; 1 graduate degree [master's, doctorate, etc.]) were recruited from the UCLAHuman Subjects Pool. Participants were tested online and received course credit for their participation. Older adults ($n = 51$; $M = 72.69$, $SD = 5.57$; 31 female, 19 male, 1 other; 2 Asian/Pacific Islander, 3 Black, 44 White, 2 other/unknown; 7 high school graduate, 14 some college but no degree, 6 associate's degree, 17 bachelor's degree, 7 graduate degree) were recruited from Amazon's Cloud Research (Chandler et al., 2019). Participants were excluded from analysis if they admitted to "cheating" (e.g., writing down answers) in a posttask questionnaire (they were told they would still receive credit if they cheated). This exclusion process resulted in two exclusions from the younger adult group and four exclusions from the older adult group. We did not include any other validity checks.

Given the binary outcome and complex interactions included in our models, conducting power analyses may not be feasible (see Scherbaum & Ferreter, 2009, for a discussion of the difficulties estimating statistical power for cross-level interactions when using multilevel modeling). Thus, we based our sample sizes on some of our prior work using a similar design (e.g., Murphy & Knowlton, 2022) and prior exploratory research (see Hargis, 2019). As such, based on the expectation of detecting a medium effect size, in Experiments 1a and 1b, we aimed to collect around 50 younger adults and 50 older adults in each condition.

Materials and Procedure

Participants were asked to imagine that they would soon take a trip to Kenya, a country in which many people speak Swahili. They were told that before they leave for their trip, it would be helpful to know some Swahili words. Participants were then given the opportunity to rate the words that they would later study on a scale of how important it would be to remember the Swahili translation of the word on their trip, from 1 (*not at all important to know for the trip*) to 7 (*very important to know for the trip*). Participants did not see the Swahili translation at this time; they only rated the importance of knowing the Swahili translation (i.e., the cue) of each English word (i.e., the target). The words were presented in random order. See Table 1, for all Swahili–English translations as well as younger and older adults' average ratings for each translation.

The stimuli were from four different (experimenter-designated) categories, with six words per category. The categories were basic conversational words (e.g., "hello"), words that would be helpful when traveling (e.g., "money"), health-related words (e.g., "fever"), and common objects (e.g., "desk"). These categories were not made explicit to the participants, but participants may have perceived the category structure as the words were chosen to be similar within categories, but not similar between categories. The categories were chosen to include words that are highly common in English and are also words that would likely be learned in an introductory foreign language course. Additionally, the words were chosen because they were words that one would likely see in a guidebook or a basic Swahili–English translation book; words were excluded from the stimuli set if they were cognates between English and Swahili (e.g., "hoteli: hotel"). The English words chosen were, by design, common in the English lexicon; the average log frequency of the English words was 10.20 (SD = 1.62). In terms of concreteness, the words averaged a score of 3.88 (SD = 1.11). The words were an average of 1.91 syllables (SD = 1.24) and were an average of 6.04 letters in length (SD = 2.69). For the Swahili translations, words were an average of 6.25 letters in length (SD = 1.82). Words were classified according to the English Lexicon Project website (Balota et al., 2007).

Once participants rated all the words, they studied each English word paired with its Swahili translation. Participants were told that before they studied the pairs, they would later be presented with the Swahili word and asked to recall the English word. The test was constructed in this way to mirror communicating with someone who speaks a new language in a different country; often the speaker may use a word in a foreign language in conversation and difficulty may arise when one attempts to retrieve the English language translation of that word. This type of retrieval could also be necessary when reading city maps or restaurant menus.

Participants studied each of the 24 pairs (e.g., "homa: fever") for 5 s, presented one at a time, and in a randomized order. Participants were then presented with each Swahili word (in randomized order) and asked to recall the English translation of that word to the best of their ability; the test phase was self-paced. To account for typographical errors in participants' responses, we employed a real-time textual similarity algorithm where responses with at least 75% similarity to the correct answer were counted as accurate (Garcia & Kornell, 2015). There was no explicit feedback during the test phase. After the test, participants were presented with each pair again (in newly randomized order), again for 5 s each, before moving on to another cued-recall test with the same cues as the initial list, again presented in randomized order.

Table 1
Swahili–English Word Pairs Used in the Present Study as Well as Younger and Older Adults' Mean Importance Ratings in Experiment 1

English word	Swahili translation	Category	Younger adults' mean rating	Older adults' mean rating
chair	mwenyekiti	object	2.73	3.84
cup	kikombe	object	3.00	3.94
desk	dawati	object	2.20	2.96
doctor	mganga	health	5.44	6.07
embassy	ubalozi	travel	4.39	5.63
emergency	dharura	health	6.28	6.24
fever	homa	health	4.04	5.14
goodbye	kwaheri	basic	5.96	5.68
hello	hujambo	basic	6.42	6.24
identification	kitambulisho	travel	5.04	5.41
medicine	dawa	health	5.44	5.77
money	fedha	travel	6.32	6.04
no	hapana	basic	6.63	6.22
nurse	muuguzi	health	4.15	5.29
pants	suruali	object	2.86	3.58
pen	kalamu	object	3.23	3.81
plane	ndege	travel	4.86	5.08
please	tafadhali	basic	6.30	6.10
restaurant	mgahawa	travel	5.62	5.74
room	chumba	travel	4.61	5.22
sick	wagonjwa	health	5.02	5.75
thank you	asante	basic	6.59	6.38
window	dririsha	object	2.49	3.48
yes	ndio	basic	6.73	6.25

Results

To examine differences in cued recall (see Figure 1) as a function of participants' own importance ratings (i.e., we used each participant's rating for each word to analyze recall for that translation at the item level),[1] trial (first, second), and age (young, old), we computed a multilevel model (MLM) where we treated the data as hierarchical or clustered (i.e., multilevel) with items nested within individual participants. Since cued recall at the item level was binary (correct or incorrect), we conducted logistic MLMs in our examination of cued recall. In these analyses, the regression coefficients are given as logit units (i.e., the log odds of correct cued recall). We report exponential betas (e^B), and their 95% confidence intervals ($CI_{95\%}$), which give the coefficient as an odds ratio (i.e., the odds of correctly recalling an item divided by the odds of not recalling an item). Thus, e^B can be interpreted as the extent to which the odds of recalling an item differ as a function of the predictor. Specifically, values greater than 1 represent an increased likelihood of cued recall, while values less than 1 represent a decreased likelihood of cued recall. In each of our models, our continuous independent variables (i.e., importance ratings) were centered to their grand means. As such, we note that, in our figures, there are negative values for ratings smaller than the grand mean rating. In each analysis, we first provide the main effects followed by the two-way interactions before the three-way interaction (in the same order each time) as this allows for easy comparisons between experiments and ensures that all effects are reported in a similar, systematic fashion in each experiment.

Results revealed that importance ratings significantly predicted cued recall ($e^B = 1.22$, $CI_{95\%}$ [1.17, 1.28], $z = 8.49$, $p < .001$) such that the English words participants rated as important to remember were better recalled than items rated as less important. Age also significantly predicted cued recall ($e^B = 3.99$, $CI_{95\%}$ [2.26, 7.07], $z = 4.75$, $p < .001$) such that younger adults ($M = .40$, $SD = .22$) recalled a greater proportion of translations than older adults ($M = .24$, $SD = .21$). Trial significantly predicted cued recall ($e^B = 3.10$, $CI_{95\%}$ [2.67, 3.60], $z = 14.88$, $p < .001$) such that cued recall was greater on the second trial ($M = .42$, $SD = .27$) than the first trial ($M = .23$, $SD = .20$). Age interacted with trial ($e^B = 1.36$, $CI_{95\%}$ [1.01, 1.84], $z = 2.05$, $p = .041$), and an analysis of the simple effects indicates that younger adults' cued recall improved more on the second trial ($e^B = 3.62$, $CI_{95\%}$ [3.01, 4.36], $z = 13.60$, $p < .001$) compared with older adults ($e^B = 2.65$, $CI_{95\%}$ [2.10, 3.35], $z = 8.22$, $p < .001$). Age did not interact with importance ratings ($e^B = .91$, $CI_{95\%}$ [.83, 1.00], $z = -1.95$, $p = .051$), importance ratings did not interact with trial ($e^B = 1.00$, $CI_{95\%}$ [.93, 1.09], $z = .09$, $p = .926$), and there was not a three-way interaction between importance ratings, age, and trial ($e^B = 1.00$, $CI_{95\%}$ [.84, 1.17], $z = -.07$, $p = .948$).

Discussion

As expected, younger adults were more accurate than older adults in learning the English translations of Swahili words (Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Rast & Zimprich, 2009; Service & Craik, 1993). Additionally, both groups were able to learn with task experience and performed better on the second trial after they had been given a restudy opportunity. Younger adults' performance increased more between Trials 1 and 2 compared with older adults suggesting that younger adults benefited more from the repeated study–test trials than older adults. Critically, both younger and older adults' memory was driven by importance such that the English words rated as important were better recalled than words rated as less important. Overall, Experiment 1a suggests that both younger and older adults engaged in responsible remembering by best remembering the words that they rated as important to remember. However, study time was fixed in Experiment 1a but if allowed to control the study phase, younger and (especially) older adults' tendency to engage in responsible remembering may be enhanced.

Experiment 1b

In Experiment 1a, participants studied a set of Swahili–English translations for a fixed duration. To better allow participants to execute an importance-based strategy (see Ariel, 2013; Ariel & Dunlosky, 2013; Ariel et al., 2009), in Experiment 1b, we allowed younger and older adults to self-pace the study phases to examine how metacognitive control measures impact responsible remembering (see Murphy et al., 2022). Some research suggests that older adults can use metacognitive awareness and strategies to overcome associative memory deficits (Dunlosky & Hertzog, 1998a; Naveh-Benjamin et al., 2007). Thus, although we still expected older adults' memory performance to be less accurate than younger adults, we expected older adults to execute an importance-based study strategy (e.g., Hargis & Castel, 2017). Older adults may also be able to utilize task experience to improve their memory for high-value associative information with an additional study–test trial (Hargis & Castel, 2018; Kilb & Naveh-Benjamin, 2011) as value-directed remembering strategies often develop with task experience (Castel et al., 2002, 2007). Thus, older adults may use self-paced study time to their advantage with increased task experience.

Method

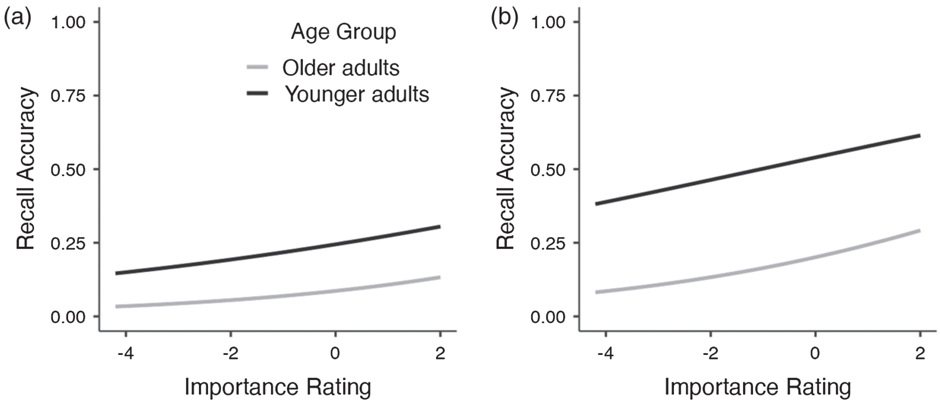
Participants

Younger adults ($n = 57$; $M_{age} = 20.53$, $SD_{age} = 2.03$; 42 female, 14 male, 1 other; 32 Asian/Pacific Islander, 5 Black, 7 Hispanic, 9 White, 4 other/unknown; 1 some high school, 10 high school graduate, 33 some college but no degree, 6 associate's degree, 7 bachelor's degree) were recruited from the UCLA Human Subjects Pool. Participants were tested online and received course credit for their participation. Older adults ($n = 45$; $M = 72.78$, $SD = 4.66$; 34 female, 11 male; 2 American Indian/Alaskan Native, 2 Black, 41 White; 2 some high school, 8 high school graduate, 9 some college but no degree, 7 associate's degree, 10 bachelor's degree, 9 graduate degree) were recruited from Amazon's Cloud Research. Participants were excluded from analysis if they admitted to "cheating" (e.g., writing down answers) in a posttask questionnaire (they were told they would still receive credit if they cheated). This exclusion process resulted in one exclusion from the younger adult group and eight exclusions from the older adult group.

[1] We also conducted similar analyses using the grand mean importance rating for each item (mean ratings across age groups in Experiment 1). Results generally corroborated the effects observed using each participant's own importance ratings, so these analyses are not reported in the article but can be viewed on OSF.

Figure 1

Model-Predicted Values for Cued-Recall Accuracy for Younger and Older Adults on the First Trial (a) and on the Second Trial (b) in Experiment 1a



Materials and Procedure

The materials were the same as in Experiment 1a. The procedure was similar to Experiment 1a except that during each study phase, participants were allowed to regulate their study time. Specifically, participants studied each pair as long as they liked with a maximum of 10 s per pair.

Results

To examine participants' study time (see Figure 2), we conducted a mixed MLM with item-level study time modeled as a function of participants' importance ratings and trial (first, second) with age (young, old) as a between-subjects factor. Results revealed that importance ratings significantly predicted study time, $t(4{,}814.5) = 2.32$, $p = .020$, such that the English words participants rated as important to remember were studied longer than words rated as less important to remember. Age also significantly predicted study time, $t(100) = -2.27$, $p = .026$, such that older adults ($M = 5.72$, $SD = 3.24$) allocated more study time (seconds) per word pair compared with younger adults ($M = 4.31$, $SD = 2.97$). Trial significantly predicted study time, $t(4{,}788) = 4.48$, $p < .001$, such that participants spent more time studying each word on the second trial ($M = 5.05$, $SD = 3.56$) than on the first trial ($M = 4.81$, $SD = 3.45$). Age interacted with trial, $t(4{,}788) = -8.13$, $p < .001$, and an analysis of the simple effects indicates that older adults increased their study time on the second trial, $t(4{,}788) = 8.43$, $p < .001$, whereas younger adults decreased their study time on the second trial, $t(4{,}788) = -2.75$, $p = .006$. Age did not interact with importance ratings, $t(4{,}814.5) = 1.42$, $p = .157$, and ratings did not interact with trial, $t(4{,}788) = .09$, $p = .929$. However, there was a three-way interaction between importance ratings, age, and trial, $t(4{,}788) = -3.22$, $p = .001$, and an analysis of the simple effects revealed that importance ratings only predicted study time for younger adults (not older adults) on the first trial, $t(4{,}795) = 3.91$, $p < .001$; all other $ps > .066$.

Cued recall (see Figure 3) was analyzed as in Experiment 1a. Results revealed that importance ratings significantly predicted cued recall ($e^B = 1.20$, $CI_{95\%}$ [1.14, 1.25], $z = 7.69$, $p < .001$) such that the English words participants rated as important to remember were better recalled. Age did not significantly predict cued recall ($e^B = 1.52$, $CI_{95\%}$ [.73, 3.18], $z = 1.12$, $p = .265$) such that younger adults ($M = .40$, $SD = .23$) recalled a similar proportion of translations as older adults ($M = .35$, $SD = .32$). Trial significantly predicted cued recall ($e^B = 3.75$,

Figure 2

Model-Predicted Values for Study Time for Younger and Older Adults on the First Trial (a) and on the Second Trial (b) in Experiment 1b

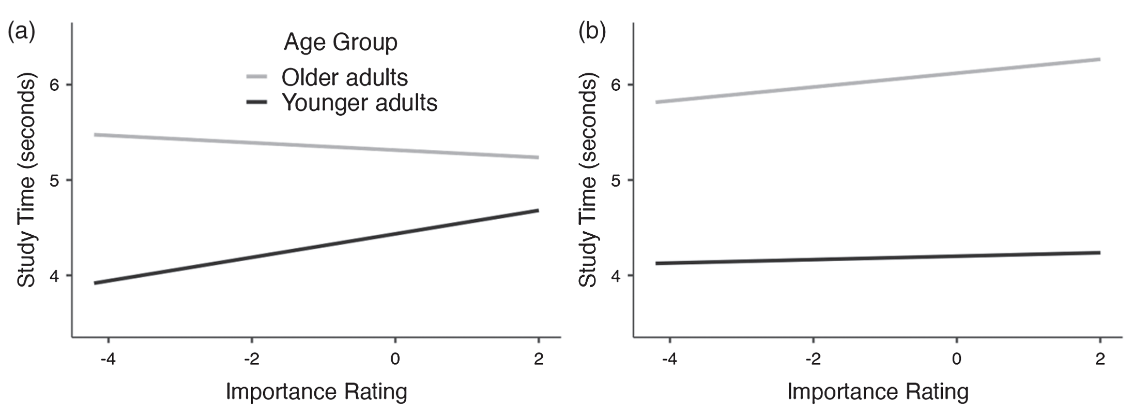
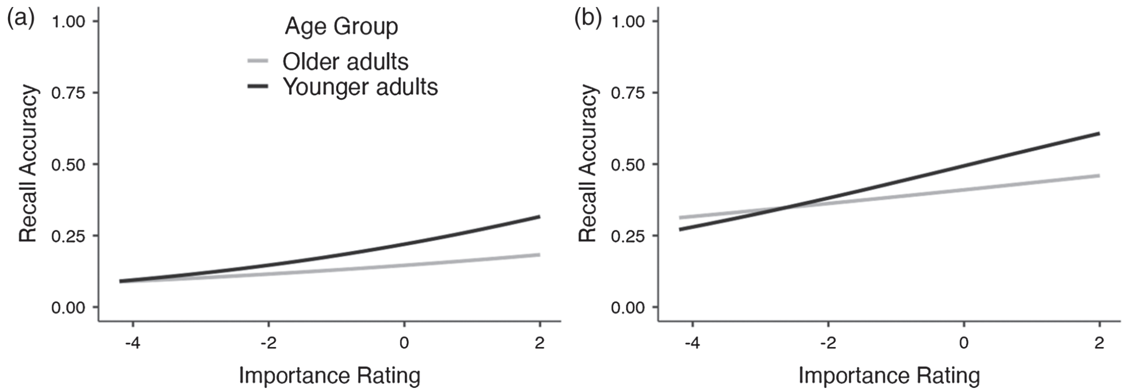


Figure 3

Model-Predicted Values for Cued-Recall Accuracy for Younger and Older Adults on the First Trial (a) and on the Second Trial (b) in Experiment 1b



$CI_{95\%}$ [3.20, 4.41], $z = 16.14$, $p < .001$) such that cued recall was greater on the second trial ($M = .48$, $SD = .32$) than the first trial ($M = .28$, $SD = .27$). Age did not interact with trial ($e^B = .85$, $CI_{95\%}$ [.62, 1.17], $z = -.98$, $p = .326$) but age interacted with importance ratings ($e^B = 1.13$, $CI_{95\%}$ [1.03, 1.24], $z = 2.61$, $p = .009$), and an analysis of the simple effects indicates that younger adults' importance ratings were more predictive of cued recall ($e^B = 1.27$, $CI_{95\%}$ [1.21, 1.34], $z = 9.11$, $p < .001$) compared with older adults ($e^B = 1.13$, $CI_{95\%}$ [1.04, 1.21], $z = 3.08$, $p = .002$). Importance ratings did not interact with trial ($e^B = .97$, $CI_{95\%}$ [.90, 1.06], $z = -.60$, $p = .549$), and there was not a three-way interaction between importance ratings, age, and trial ($e^B = 1.02$, $CI_{95\%}$ [.86, 1.21], $z = .18$, $p = .854$).

The present results may have revealed a dissociation between the sensitivity and subjective importance in the allocation of study time and recall. To more directly examine how the relationship between subjective importance, study time allocation, and retrieval success changes with age, we conducted a logistic MLM with item-level cued recall modeled as a function of participants' importance ratings, study time, and trial (first, second) with age (young, old) as a between-subjects factor. The results are presented in Table 2. Of note, results indicated that, overall, more study time increased the probability of recall. Additionally, age interacted with study time, and an analysis of the simple effects indicates that for younger adults, more study time for a given item did not yield a corresponding memory benefit ($e^B = .99$, $CI_{95\%}$ [.95, 1.04], $z = -.30$, $p = .762$), but for older adults, more study time yielded better recall ($e^B = 1.25$, $CI_{95\%}$ [1.18, 1.32], $z = 8.20$, $p < .001$). Furthermore, age, trial, and study time interacted, and an analysis of the simple effects indicates that more study time helped recall on both trials for older adults (first trial: $e^B = 1.30$, $CI_{95\%}$ [1.21, 1.40], $z = 7.09$, $p < .001$; second trial: $e^B = 1.20$, $CI_{95\%}$ [1.13, 1.28], $z = 5.63$, $p < .001$), but for younger adults, more study time hurt memory on the first trial but helped memory on the second trial, although neither simple effect reached significance (first trial: $e^B = .95$, $CI_{95\%}$ [.90, 1.00], $z = -1.86$, $p = .062$; second trial: $e^B = 1.04$, $CI_{95\%}$ [.99, 1.09], $z = 1.46$, $p = .145$).

Finally, to further examine participants' metacognitive control, along the lines of the discrepancy reduction hypothesis (e.g., Dunlosky & Hertzog, 1998b), we examined whether unlearned items from the first trial were studied for more time in the second study phase than items correctly recalled on the first trial. A paired-samples t test revealed that, in the second study phase, items that were not correctly recalled on the first trial received more study time per pair ($M = 5.17$, $SD = 3.58$) than items that were correctly recalled on the first trial ($M = 4.79$, $SD = 3.54$), $t(85) = 4.35$, $p < .001$. Next, for items not correctly recalled on the first trial, we examined whether study time in the second study phase differed as a function of age or importance ratings. When only examining study time in the second study phase for items that were not correctly recalled on the first trial, importance ratings predicted study time, $t(1{,}680.1) = 2.47$, $p = .014$, such that items rated as important that were not initially recalled received more study time. Additionally, age predicted study time, $t(98.8) = -2.22$, $p = .029$, such that in the second study phase, older adults spent more time studying items

Table 2

Cued Recall Accuracy Predicted by Importance Ratings, Study Time, Trial, and Age

Effect	e^B	$CI_{95\%}$ Lower	$CI_{95\%}$ Upper	z	p
Age	1.98	1.03	3.83	2.04	.041
Trial	3.59	2.98	4.33	13.47	<.001
Rating	1.21	1.15	1.27	7.01	<.001
Study time	1.11	1.08	1.15	6.23	<.001
Age × Trial	1.01	0.70	1.46	0.04	.966
Age × Rating	1.10	0.99	1.23	1.81	.070
Trial × Rating	0.94	0.85	1.04	−1.27	.206
Age × Study Time	0.80	0.74	0.85	−6.64	<.001
Trial × Study Time	1.00	0.95	1.06	0.13	.899
Rating × Study Time	0.99	0.98	1.01	−1.28	.199
Age × Trial × Rating	1.09	0.89	1.33	0.81	.419
Age × Trial × Study Time	1.18	1.07	1.31	3.16	.002
Age × Rating × Study Time	1.00	0.97	1.03	0.00	.996
Trial × Rating × Study Time	1.01	0.98	1.04	0.75	.452
Age × Trial × Rating × Study Time	0.98	0.93	1.03	−0.91	.363

Note. CI = confidence interval; MLM = multilevel model. Results of a logistic MLM with item-level cued recall modeled as a function of participants' importance ratings, study time, and trial (first, second) with age (young, old) as a between-subjects factor in Experiment 1b.

they initially got wrong than younger adults. However, age did not interact with importance ratings, $t(1,680.1) = .95$, $p = .344$.

Discussion

In Experiment 1b, both younger and older adults' study decisions and memory outcomes were driven by the perceived importance of remembering each Swahili–English pair. However, older adults may have been aware of their associative memory deficit and attempted to compensate by spending more time studying each pair than younger adults, particularly on the second trial. Additionally, after failing to recall a Swahili–English pair on the first trial, older adults spent more time studying these forgotten items on the second trial compared with younger adults. Thus, older adults successfully implemented effective metacognitive control mechanisms to enhance overall memory performance and overcome their associative memory deficit (Arenberg & Robertson-Tchabo, 1977; Castel, 2007; Naveh-Benjamin, 2000; Old & Naveh-Benjamin, 2008; Service & Craik, 1993), but younger adults better remembered items they rated as important to remember compared with older adults. Finally, results revealed that participants, particularly older adults, spent more time studying unlearned items than learned items in the second study phase, and participants' allocation of study time for unlearned items was driven by importance in the second study phase.

Cross-Experiment Comparison

We also modeled potential differences in cued recall between experiments (fixed study time in Experiment 1a and self-paced study time in Experiment 1b) as a function of importance ratings and age. Results revealed that importance ratings significantly predicted cued recall ($e^B = 1.19$, $CI_{95\%}$ [1.16, 1.23], $z = 11.21$, $p < .001$) such that the English words participants rated as important to remember were better recalled than words rated as less important. Age predicted cued recall ($e^B = 2.42$, $CI_{95\%}$ [1.57, 3.72], $z = 3.99$, $p < .001$) such that younger adults recalled a greater proportion of translations than older adults. Cued-recall performance was similar across experiments ($e^B = 1.46$, $CI_{95\%}$ [.94, 2.24], $z = 1.70$, $p = .089$), and ratings did not differ between experiments ($e^B = .98$, $CI_{95\%}$ [.92, 1.04], $z = -.81$, $p = .420$). Age interacted with experiment ($e^B = .36$, $CI_{95\%}$ [.15, .86], $z = -2.31$, $p = .021$), and an analysis of the simple effects indicates that older adults' cued recall was better in Experiment 1b than in Experiment 1a ($e^B = 2.43$, $CI_{95\%}$ [1.27, 4.62], $z = -2.69$, $p = .007$), while younger adults' cued-recall performance was similar across experiments ($e^B = .87$, $CI_{95\%}$ [.49, 1.55], $z = -.46$, $p = .643$), indicating that older adults benefited more from the ability to self-pace their study time. Importance ratings did not interact with age ($e^B = 1.01$, $CI_{95\%}$ [.95, 1.07], $z = .32$, $p = .751$), but there was a three-way interaction between importance ratings, age, and experiment ($e^B = 1.23$, $CI_{95\%}$ [1.09, 1.39], $z = 3.26$, $p = .001$), and an analysis of the simple effects indicates that allowing participants to self-pace their study time enhanced sensitivity to importance in younger adults (Experiment 1a: $e^B = 1.15$, $CI_{95\%}$ [1.10, 1.21], $z = 5.93$, $p < .001$; Experiment 1b: $e^B = 1.25$, $CI_{95\%}$ [1.19, 1.31], $z = 8.81$, $p < .001$), self-pacing study time reduced sensitivity to importance in older adults (Experiment 1a: $e^B = 1.26$, $CI_{95\%}$ [1.17, 1.36], $z = 6.17$, $p < .001$; Experiment 1b: $e^B = 1.11$, $CI_{95\%}$ [1.04, 1.19], $z = 2.98$, $p = .003$), although we are cautious to interpret this cross-experiment comparison and follow up on this issue more directly in Experiment 2.

Experiment 2

Given that the examination of different study conditions in Experiments 1a and 1b involved the use of cross-experiment comparison, we conducted another experiment to more closely examine the potential effects observed in Experiment 1. In Experiment 2, using a larger sample size, we manipulated study pacing (fixed or self-paced) in a between-subjects design that also allowed us to more directly contrast the different study conditions in Experiments 1a (fixed) and 1b (self-paced) with younger and older adults.

Method

Transparency and Openness

We report an analysis of our sample size and describe all data exclusions, manipulations, and all measures in the present study. This study's design and analyses were not preregistered. All data and research materials are available on OSF. Data were analyzed and all figures were created using Jamovi (The Jamovi Project, 2022), and all information needed to reproduce the analyses is available on OSF. Informed consent was acquired, and the study was completed in accordance with the UCLA IRB (No. 12-000617; Memory, Attention, Emotion, and Aging).

Participants

In Experiment 2, we aimed to collect around 100 younger adults and 100 older adults in each condition (doubling the sample size of Experiment 1). As previously noted in Experiment 1, given the binary outcome and complex interactions included in our models, conducting power analyses is not always feasible (see Scherbaum & Ferreter, 2009). Thus, our sample size was determined based on our findings from Experiment 1 and prior relevant research (e.g., Hargis, 2019; Knowlton & Castel, 2022; Murphy & Knowlton, 2022). Younger adults ($n = 206$; $M_{age} = 20.59$, $SD_{age} = 3.23$; 172 female, 32 male, 2 other; 97 Asian/Pacific Islander, 8 Black, 32 Hispanic, 57 White, 12 other/unknown; 51 high school graduate, 97 some college but no degree, 37 associate's degree, 21 bachelor's degree) were recruited from the UCLA Human Subjects Pool. Participants were tested online and received course credit for their participation. Older adults ($n = 179$; $M = 72.68$, $SD = 6.07$; 103 female, 74 male, 2 other; 1 American Indian/Alaskan Native, 4 Asian/Pacific Islander, 7 Black, 3 Hispanic, 163 White, 1 other/unknown; 4 some high school, 29 high school graduate, 40 some college but no degree, 27 associate's degree, 47 bachelor's degree, 32 graduate degree) were recruited from Amazon's Cloud Research. Participants were excluded from analysis if they admitted to "cheating" (e.g., writing down answers) in a posttask questionnaire (they were told they would still receive credit if they cheated). This exclusion process resulted in five exclusions from the younger adult group and 25 exclusions from the older adult group.

To control for potential age differences in education and second-language proficiency (which may facilitate the learning of novel language vocabulary, see Kaushanskaya & Marian, 2009), we collected additional demographic information in Experiment 2. This revealed that more younger adults 59% ($SD = 49\%$) reported being fluent in a language other than English than older adults ($M = 11\%$, $SD = 31\%$), $t(383) = 11.27$, $p < .001$, $d = 1.15$. Additionally, participants reported their education levels (in years) by selecting among the following options: less than 9 (did not attend high school), 10 (some high school), 11 (some high school), 12 (high school graduate), 13 (some college), 14 (some college), 15 (some college), 16 (college graduate), 17 (some graduate education), 18 (master's degree), 19, 20, 21+ (PhD or another advanced degree). An independent-samples t test indicated that older adults (M = 15.10, SD = 2.48) reported having more years of education than younger adults (M = 14.30, SD = 1.11), $t(382) = 4.18$, $p < .001$, d = .43. Since our younger and older adult samples differed on these potentially important characteristics, we controlled for second-language proficiency and education statically by including it in each model. In each model, the effects of second-language proficiency and years of education were not significant. More information is available on OSF.

Materials and Procedure

The materials were the same as in Experiment 1. During each study phase, study time was either fixed (5 s per pair; $n = 201$) or participants were allowed to regulate their study time ($n = 184$) with a maximum of 10 s per pair (between-subjects). Again, words were rated, studied (both study cycles), and tested in random order.

Results

To examine participants' study time (see Figure 4), we conducted a mixed MLM with item-level study time modeled as a function of participants' importance ratings and trial (first, second) with age (young, old) as a between-subjects factor. Results revealed that importance ratings significantly predicted study time, $t(18{,}172.31) = 2.34$, $p = .019$, such that the English words participants rated as important to remember were studied longer than words rated as less important to remember. Age did not significantly predict study time, $t(380) = -.32$, $p = .747$, such that younger adults (M = 4.25, SD = 2.69) used a similar amount of study time (seconds) per word pair as older adults (M = 4.43, SD = 2.80). Trial significantly predicted study time, $t(18{,}042) = -3.40$, $p < .001$, such that participants spent more time studying each pair on the first trial (M = 4.45, SD = 3.01) than on the second trial (M = 4.22, SD = 3.21). Age interacted with trial, $t(18{,}042) = -11.42$, $p < .001$, and an analysis of the simple effects indicates that younger adults decreased their study time on the second trial, $t(18{,}042) = -10.90$, $p < .001$, whereas older adults increased their study time on the second trial, $t(18{,}042) = 5.47$, $p < .001$. Age did not interact with importance ratings, $t(18{,}172.53) = -.41$, $p = .682$, and ratings did not interact with trial, $t(18{,}042) = -.25$, $p = .806$. However, there was a three-way interaction between importance ratings, age, and trial, $t(18{,}042) = -2.20$, $p = .028$, and an analysis of the simple effects indicates that younger adults' study time was more sensitive to importance ratings than older adults' study time on the first trial, younger adults: $t(18{,}075.32) = 2.46$, $p = .014$; older adults: $t(18{,}144.23) = .49$, $p = .626$, but on the second trial, older adults' study time was more sensitive to importance ratings compared with younger adults, younger adults: $t(18{,}075.32) = -.14$, $p = .886$; older adults: $t(18{,}144.23) = 2.14$, $p = .032$.

To analyze cued-recall performance (see Figure 5; note that Panels a and b in Figure 5 can be compared to Panels a and b in Figure 1 and Panels c and d in Figure 5 can be compared to Panels a and b in Figure 3), we conducted a logistic MLM with item-level cued recall modeled as a function of participants' importance ratings and trial (first, second) with age (young, old) and study pacing (fixed, self-paced) as between-subjects factors. The results are displayed in Table 3. Of note, results revealed that younger adults recalled more items than older adults, more items were recalled on the second trial, important items were recalled better than items rated as less important, and study pacing did not predict recall success. Additionally, there were no significant interactions between age, trial, importance ratings, and study pacing.

Discussion

In Experiment 2, we directly contrasted younger and older adults' memory when study time was fixed and when the study phase was self-paced. Importance ratings positively predicted study time, but there were no age-related differences in total study time, although younger adults decreased their study time on the second trial, while older adults increased their study time on the second trial. Moreover, younger adults' study time was more sensitive to importance ratings on the first trial, but on the second trial, older adults' study time was more sensitive to importance ratings. Thus, it may be that after experiencing instances of forgetting on the first trial, older adults

Figure 4

Model-Predicted Values for Study Time for Younger and Older Adults on the First Trial (a) and on the Second Trial (b) in Experiment 2

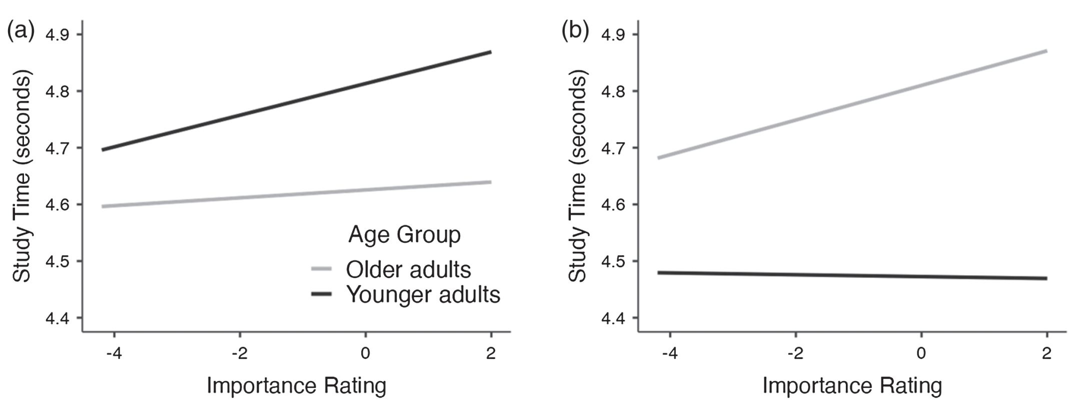
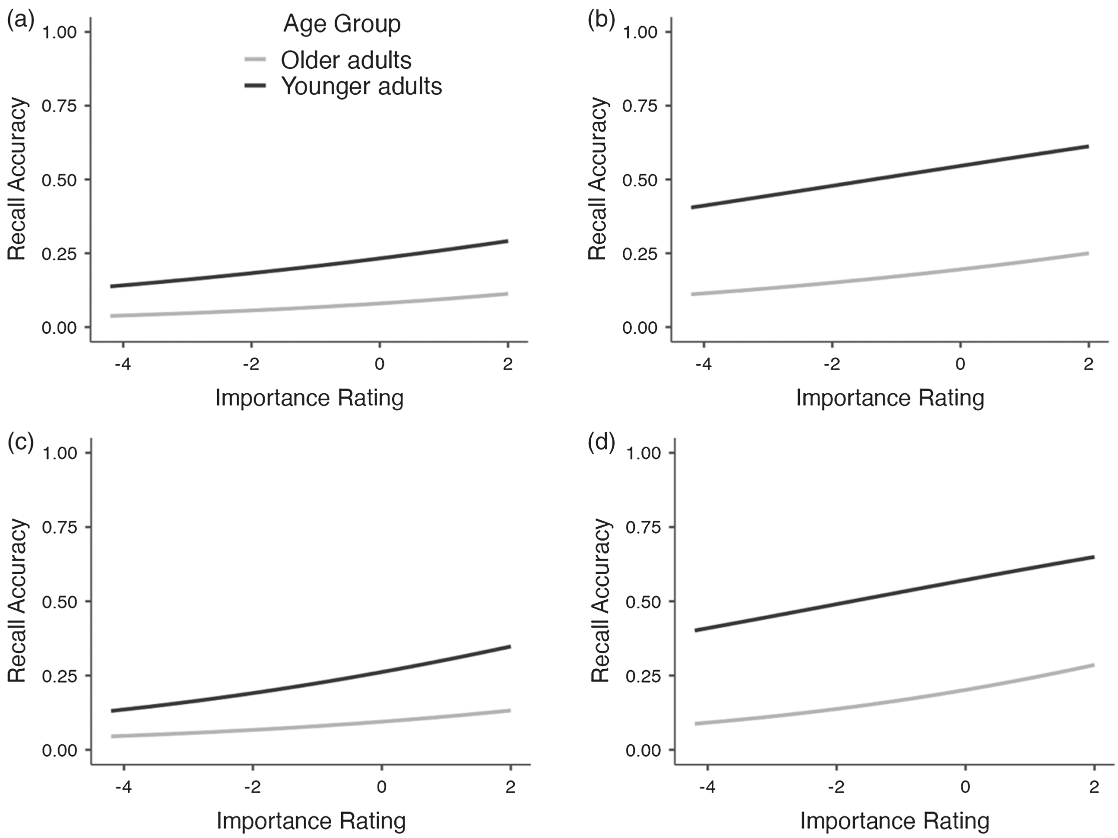


Figure 5
Cued Recall Accuracy in Experiment 2



Note. Model-predicted values for cued-recall accuracy for younger and older adults when study time was fixed on the first trial (a) and on the second trial (b) as well as when study time was self-paced on the first trial (c) and on the second trial (d) in Experiment 2.

may have employed a more strategic approach in their study of the translations by spending more time on the items they considered important to remember.

On the cued-recall tests, younger adults recalled more translations than older adults (likely since older adults in Experiment 2 did not spend more time studying than younger adults to compensate for memory deficits), performance was better on the second trial, and items rated as important to remember were better recalled. These results present some similarities and differences when compared to what was found in Experiment 1. Specifically, while younger adults were more sensitive to subjective importance than older adults when self-pacing study time in Experiment 1b, in Experiment 2, younger and older adults recalled important items better than less important items to the same extent. However, after the first trial, older adults may have employed a more strategic approach in their study of the translations by spending more time on the items they considered important to remember, suggesting a potentially compensatory method to better remember important items.

General Discussion

In the present study, younger and older adults studied Swahili–English translations related to traveling to a foreign country. Before studying and being tested on the word pairs (with two study–test trials), participants were asked to rate the importance of remembering each translation. Thus, this design incorporates subjective importance by assessing the potential relationship between a given participant's importance judgments and memory performance. Results generally revealed that younger and older adults' memory was driven by item importance, exemplifying responsible remembering. Specifically, participants focused on important English translations such as "yes," "no," and "thank you" as forgetting these basic communication words may have negative consequences such as the inability to ask simple questions at a hotel or restaurant. In contrast, forgetting the translations of less important, everyday objects like "desk," "window," or "pants" may be less consequential or useful when traveling to a foreign country (see Table 1, for mean importance ratings).

Age-related differences in associative memory are found in many domains, including memory for word–nonword pairs (Castel, 2007; Naveh-Benjamin, 2000; Old & Naveh-Benjamin, 2008). In the present study, younger and older adults studied Swahili–English translations with the Swahili words likely being unfamiliar to the participants, essentially acting as nonwords. Results from the present studies suggest that younger adults generally outperform older adults in this word-learning task (which is not surprising, given age-related deficits in associative memory; Arenberg & Robertson-Tchabo,

Table 3
Cued Recall Accuracy Predicted by Importance Ratings, Trial, Age, and Study Pacing

Effect	e^B	$CI_{95\%}$ Lower	$CI_{95\%}$ Upper	*z*	*p*
Age	4.30	2.94	6.29	7.50	<.001
Trial	3.74	3.44	4.07	30.66	<.001
Rating	1.19	1.16	1.22	13.78	<.001
Study pacing	1.07	.77	1.48	.41	.684
Age × Trial	1.07	.90	1.26	.77	.442
Age × Rating	.97	.93	1.02	−1.05	.294
Trial × Rating	.97	.92	1.01	−1.52	.129
Age × Study Pacing	1.03	.54	1.96	.08	.940
Trial × Study Pacing	1.08	.91	1.27	.86	.388
Rating × Study Pacing	1.04	.99	1.09	1.63	.103
Age × Trial × Rating	.97	.89	1.07	−.56	.574
Age × Trial × Study Pacing	.90	.64	1.26	−.62	.535
Age × Rating × Study Pacing	1.00	.90	1.10	−.05	.960
Trial × Rating × Study Pacing	1.00	.91	1.09	−.08	.938
Age × Trial × Rating × Study Pacing	.98	.82	1.18	−.18	.858

Note. CI = confidence interval; MLM = multilevel model. Results of a logistic MLM with item-level cued recall modeled as a function of participants' importance ratings and trial (first, second) with age (young, old) and study pacing (fixed, self-paced) as between-subjects factors in Experiment 2.

1977; Naveh-Benjamin, 2000; Service & Craik, 1993). In terms of how participants self-paced their study time, results indicated that importance guided younger and older adults' study time to some extent, although there was not a clear pattern across experiments, and thus future research should examine this issue in more detail.

When participants are faced with the task of learning 24 words in a foreign language, it can be difficult to learn every pair, so learners need to prioritize certain items. While we found some different results across experiments, in general, it appears that both younger and older adults can selectively remember subjectively important information. Additional research may shed more light on this issue by asking about the need for restudy opportunities, rather than self-paced study time, and/or presenting the list of vocabulary pairings simultaneously (as opposed to sequentially) as this may engage a more strategic use of study time (see also Castel et al., 2013). It may also be interesting to determine how having a limited amount of time to study (e.g., when rushed or short on time) may influence selective learning as this constraint may encourage older adults to focus on remembering vocabulary that is most relevant to their future goals.

Taken together, the present studies suggest that both younger and older adults engage in responsible remembering (Murphy & Castel, 2020, 2021a, 2021b, 2022a, 2022b; Murphy et al., 2022) but may do so in different ways. Specifically, under some circumstances, older adults may use study strategies such as spending more time studying on later trials to overcome potential associative memory deficits and remember important information. In contrast, younger adults may be able to remember important information without needing to be as strategic in their allocation of study time. Future work is needed to determine how younger and older adults achieve selective memory for information deemed important to remember as some theoretical frameworks suggest that younger adults have more intact automatic processes that contribute to the binding of important information (cf. Knowlton & Castel, 2022). Also, the present work used two study–test trials, and it may be the case that with additional task experience (such as more trials and greater awareness of associative memory impairments), older adults may become more selective on later trials (see Whatley et al., 2021).

Previous work has found age-related associative deficits for high point value word pairs (Ariel et al., 2015) while work using different value constructs has not found age-related differences for the highest valued associative information (e.g., Hargis & Castel, 2017, 2018). The present paradigm invited participants to bring their schematic knowledge of "traveling abroad" to determine what was important to know (e.g., McGillivray & Castel, 2017). Specifically, participants learned associative information that varied with respect to its subjective importance—that is, participants' importance ratings reflected differences in how important they believed it would be to learn different words (although there may be differences in travel experience between younger and older adults). Using participants' own evaluations of the importance of remembering each pair, we demonstrated that both younger and older adults can prioritize the remembering of important information.

Prior work has demonstrated that both younger and older adults used importance to guide the encoding and retrieval of information (Murphy & Castel, 2022a), but this had yet to be tested in an associative memory task (whereby older adults show profound deficits, e.g., Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Service & Craik, 1993). Additionally, prior work has shown little or no benefit of value in some standard associative learning tasks (Ariel et al., 2015). Here, we examined associative memory in a context where there is a need to learn important associations for one's goals, and both younger and older adults were able to selectively remember information that they found would be useful and important to use at a later time. We note that the present paradigm differs from tasks that more closely examine the binding of associative memory via recognition and recombination of word pairings, and future work should examine the persistency of these effects (i.e., age-related differences over long periods of time) using a variety of value-based binding tasks.

We also note that the younger participants in the present studies were university students who are often overwhelmed with information when studying for tests in various classes. As such, these students may have experience reviewing materials for tests and trying to distinguish between more and less important information and, as a result, may have developed a sensitivity to allocate attention and cognitive resources accordingly. In contrast, our older adult sample may have different goals and backgrounds but could be aware of age-related memory changes and the need to be selective when overwhelmed with material to consider for learning. Additionally, our younger adult sample was more diverse than our older adult sample. Thus, these two groups may differ in certain ways, and future research that more closely matches demographic information and learning goals (e.g., when both younger and older adults are actually going on a similar trip) to determine what processes are engaged to prioritize material in light of learning goals and memory limitations would be informative. Future work may also benefit from larger sample sizes and/or include more learning trials as the complexity of our models made analyzing the power of the current experiments difficult. Also, the present findings may be limited to new language learning; future work could examine these trends in younger and older adults with matched cognitive traits like vocabulary or processing speed as well as younger and older adults from different racial and educational backgrounds.

Conclusions

In the present study, we examined how subjective importance may influence age-related differences in new vocabulary learning. While older adults generally remembered less information, both younger and older adults selectively focused on remembering subjectively important information that is necessary for future goals. This idea is somewhat consistent with the notion of selective optimization with compensation (Baltes, 1997; Baltes & Baltes, 1990; Freund & Baltes, 2000), which suggests that older adults can, despite memory deficits, still optimize learning. The present work is in line with previous studies suggesting that older adults perform less accurately than younger adults on some associative memory tasks (Arenberg & Robertson-Tchabo, 1977; Naveh-Benjamin, 2000; Rast & Zimprich, 2009; Service & Craik, 1993; cf. Hargis & Castel, 2017, 2018; Treat & Reese, 1976). However, older adults also demonstrated that in circumstances involving value-based forms of associative memory as well as task experience, older adults can employ useful metacognitive strategies (such as spending more time studying forgotten information) to overcome potential memory deficits.

When learning outside the lab, both younger and older adults engage in language learning, sometimes for travel or interest, and the advent of new language-learning technologies (e.g., Duolingo and Memrise) may allow people to easily prioritize (and perhaps off-load, see Park et al., 2022; Risko & Gilbert, 2016) which words are most important to know when communicating with others in a foreign country. Here, younger and older adults (particularly after gaining task experience) selectively recalled vocabulary they considered important to remember. In sum, older adults may use strategies to overcome some memory deficits, suggesting that one's goals can impact how people learn new vocabulary.

References

Arenberg, D., & Robertson-Tchabo, E. E. (1977). Learning and aging. In I. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 421–449). Van Nostrand Reinhold.

Ariel, R. (2013). Learning what to learn: The effects of task experience on strategy shifts in the allocation of study time. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *39*(6), 1697–1711. https://doi.org/10.1037/a0033091

Ariel, R., & Dunlosky, J. (2013). When do learners shift from habitual to agenda-based processes when selecting items for study? *Memory & Cognition*, *41*(3), 416–428. https://doi.org/10.3758/s13421-012-0267-4

Ariel, R., Dunlosky, J., & Bailey, H. (2009). Agenda-based regulation of study-time allocation: When agendas override item-based monitoring. *Journal of Experimental Psychology: General*, *138*(3), 432–447. https://doi.org/10.1037/a0015928

Ariel, R., Price, J., & Hertzog, C. (2015). Age-related associative memory deficits in value-based remembering: The contribution of agenda-based regulation and strategy use. *Psychology and Aging*, *30*(4), 795–808. https://doi.org/10.1037/a0039818

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. A., Kessler, B., Loftis, B., Neely, J. H., Nelson, D. L., Simpson, G. B., & Treiman, R. (2007). The English lexicon project. *Behavior Research Methods*, *39*(3), 445–459. https://doi.org/10.3758/BF03193014

Baltes, P. B. (1997). On the incomplete architecture of human ontogeny. Selection, optimization, and compensation as foundation of developmental theory. *American Psychologist*, *52*(4), 366–380. https://doi.org/10.1037/0003-066X.52.4.366

Baltes, P. B., & Baltes, M. M. (1990). Psychological perspectives on successful aging: The model of selective optimization with compensation. In P. B. Baltes & M. M. Baltes (Eds.), *Successful aging: Perspectives from the behavioral sciences* (pp. 1–34). Cambridge University Press. https://doi.org/10.1017/CBO9780511665684.003

Birren, J. E., & Morrison, D. F. (1961). Analysis of the WAIS subtests in relation to age and education. *Journal of Gerontology*, *16*(4), 363–369. https://doi.org/10.1093/geronj/16.4.363

Carstensen, L. L., Fung, H. H., & Charles, S. T. (2003). Socioemotional selectivity theory and the regulation of emotion in the second half of life. *Motivation and Emotion*, *27*(2), 103–123. https://doi.org/10.1023/A:1024569803230

Carstensen, L. L., Isaacowitz, D. M., & Charles, S. T. (1999). Taking time seriously. A theory of socioemotional selectivity. *American Psychologist*, *54*(3), 165–181. https://doi.org/10.1037/0003-066X.54.3.165

Castel, A. D. (2007). Aging and memory for numerical information: The role of specificity and expertise in associative memory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *62*(3), 194–196. https://doi.org/10.1093/geronb/62.3.P194

Castel, A. D., Benjamin, A. S., Craik, F. I. M., & Watkins, M. J. (2002). The effects of aging on selectivity and control in short-term recall. *Memory & Cognition*, *30*(7), 1078–1085. https://doi.org/10.3758/BF03194325

Castel, A. D., Farb, N. A., & Craik, F. I. M. (2007). Memory for general and specific value information in younger and older adults: Measuring the limits of strategic control. *Memory & Cognition*, *35*(4), 689–700. https://doi.org/10.3758/BF03193307

Castel, A. D., McGillivray, S., & Friedman, M. C. (2012). Metamemory and memory efficiency in older adults: Learning about the benefits of priority processing and value-directed remembering. In M. Naveh-Benjamin & N. Ohta (Eds.), *Memory and aging: Current issues and future directions* (pp. 245–270). Psychology Press.

Castel, A. D., Murayama, K., Friedman, M. C., McGillivray, S., & Link, I. (2013). Selecting valuable information to remember: Age-related differences and similarities in self-regulated learning. *Psychology and Aging*, *28*(1), 232–242. https://doi.org/10.1037/a0030678

Castel, A. D., & Rhodes, M. G. (2020). When and why we (sometimes) forget really important things. In A. M. Cleary & B. L. Schwartz (Eds.), *Memory quirks: The study of odd phenomena in memory* (pp. 137–149). Routledge. https://doi.org/10.4324/9780429264498-11

Chandler, J., Rosenzweig, C., Moss, A. J., Robinson, J., & Litman, L. (2019). Online panels in social science research: Expanding sampling methods beyond Mechanical Turk. *Behavior Research Methods*, *51*(5), 2022–2038. https://doi.org/10.3758/s13428-019-01273-7

Craik, F. I. M., & Salthouse, T. A. (Eds.). (2011). *The handbook of aging and cognition*. Psychology Press. https://doi.org/10.4324/9780203837665

Dunlosky, J., & Hertzog, C. (1998a). Aging and deficits in associative memory: What is the role of strategy production? *Psychology and Aging*, *13*(4), 597–607. https://doi.org/10.1037/0882-7974.13.4.597

Dunlosky, J., & Hertzog, C. (1998b). Training programs to improve learning in later adulthood: Helping older adults educate themselves. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Metacognition in educational theory and practice* (pp. 249–275). Erlbaum.

Freund, A. M., & Baltes, P. B. (2000). The orchestration of selection, optimization and compensation: An action-theoretical conceptualization of a theory of developmental regulation. In W. J. Perrig & A. Grob (Eds.), *Control of human behavior, mental processes, and consciousness: Essays in honor of the 60th birthday of August Flammer* (pp. 35–58). Lawrence Erlbaum.

Garcia, M., & Kornell, N. (2015). *Collector* [Computer software]. https://github.com/gikeymarcia/Collector

Hargis, M. B. (2019). *Aging, motivation, and memory for important information*. University of California.

Hargis, M. B., & Castel, A. D. (2017). Younger and older adults' associative memory for social information: The role of information importance. *Psychology and Aging*, *32*(4), 325–330. https://doi.org/10.1037/pag0000171

Hargis, M. B., & Castel, A. D. (2018). Younger and older adults' associative memory for medication interactions of varying severity. *Memory*, *26*(8), 1151–1158. https://doi.org/10.1080/09658211.2018.1441423

Hargis, M. B., Siegel, A. L. M., & Castel, A. D. (2019). Motivated memory, learning, and decision-making in older age: Shifts in priorities and goals. In G. Samanez-Larkin (Ed.), *The aging brain: Functional adaptation across adulthood* (pp. 135–163). American Psychological Association. https://doi.org/10.1037/0000143-006

Hartshorne, J. K., & Germine, L. T. (2015). When does cognitive functioning peak? The asynchronous rise and fall of different cognitive abilities across the life span. *Psychological Science*, *26*(4), 433–443. https://doi.org/10.1177/0956797614567339

Hess, T. M. (2005). Memory and aging in context. *Psychological Bulletin*, *131*(3), 383–406. https://doi.org/10.1037/0033-2909.131.3.383

James, L. E., Fogler, K. A., & Tauber, S. K. (2008). Recognition memory measures yield disproportionate effects of aging on learning face-name associations. *Psychology and Aging*, *23*(3), 657–664. https://doi.org/10.1037/a0013008

Jenkins, J. J. (1979). Four points to remember: A tetrahedral model of memory experiments. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 429–446). Lawrence Erlbaum.

Kaushanskaya, M., & Marian, V. (2009). The bilingual advantage in novel word learning. *Psychonomic Bulletin & Review*, *16*(4), 705–710. https://doi.org/10.3758/PBR.16.4.705

Kausler, D. H. (1994). *Learning and memory in normal aging*. Academic Press.

Kilb, A., & Naveh-Benjamin, M. (2011). The effects of pure pair repetition on younger and older adults' associative memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(3), 706–719. https://doi.org/10.1037/a0022525

Knowlton, B. J., & Castel, A. D. (2022). Memory and reward-based learning: A value-directed remembering perspective. *Annual Review of Psychology*, *73*(1), 25–52. https://doi.org/10.1146/annurev-psych-032921-050951

Light, L. L. (1991). Memory and aging: Four hypotheses in search of data. *Annual Review of Psychology*, *42*(1), 333–376. https://doi.org/10.1146/annurev.ps.42.020191.002001

McGillivray, S., & Castel, A. D. (2017). Older and younger adults' strategic control of metacognitive monitoring: The role of consequences, task experience and prior knowledge. *Experimental Aging Research*, *43*(3), 233–256. https://doi.org/10.1080/0361073X.2017.1298956

McGillivray, S., Murayama, K., & Castel, A. D. (2015). Thirst for knowledge: The effects of curiosity and interest on memory in younger and older adults. *Psychology and Aging*, *30*(4), 835–841. https://doi.org/10.1037/a0039801

Middlebrooks, C. D., McGillivray, S., Murayama, K., & Castel, A. D. (2016). Memory for allergies and health foods: How younger and older adults strategically remember critical health information. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *71*(3), 389–399. https://doi.org/10.1093/geronb/gbv032

Murphy, D. H. (2023, January 12). *Younger and older adults' strategic use of associative memory and metacognitive control when learning foreign vocabulary words of varying importance*. https://osf.io/kxu9b/?view_only=5e1969e635934c719aa944fdced0a21d

Murphy, D. H., & Castel, A. D. (2020). Responsible remembering: How metacognition impacts adaptive selective memory. *Zeitschrift für Psychologie mit Zeitschrift für Angewandte Psychologie*, *228*(4), 301–303. https://doi.org/10.1027/2151-2604/a000428

Murphy, D. H., & Castel, A. D. (2021a). Metamemory that matters: Judgments of importance can engage responsible remembering. *Memory*, *29*(3), 271–283. https://doi.org/10.1080/09658211.2021.1887895

Murphy, D. H., & Castel, A. D. (2021b). Responsible remembering and forgetting as contributors to memory for important information. *Memory & Cognition*, *49*(5), 895–911. https://doi.org/10.3758/s13421-021-01139-4

Murphy, D. H., & Castel, A. D. (2022a). Responsible remembering and forgetting in younger and older adults. *Experimental Aging Research*, *48*(5), 455–473. https://doi.org/10.1080/0361073X.2022.2033592

Murphy, D. H., & Castel, A. D. (2022b). Responsible attention: The effect of divided attention on metacognition and responsible remembering. *Psychological Research*. Advance online publication. https://doi.org/10.1007/s00426-022-01711-w

Murphy, D. H., & Castel, A. D. (2022c). Differential effects of proactive and retroactive interference in value-directed remembering for younger and older adults. *Psychology and Aging*, *37*(7), 787–799. https://doi.org/10.1037/pag0000707

Murphy, D. H., & Castel, A. D. (2022d). The role of attention and ageing in the retrieval dynamics of value-directed remembering. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *75*(5), 954–968. https://doi.org/10.1177/17470218211046612

Murphy, D. H., Hoover, K. M., & Castel, A. D. (2022). Strategic metacognition: Self-Paced study time and responsible remembering. *Memory & Cognition*, *50*, 1350–1361. https://doi.org/10.3758/s13421-022-01317-y

Murphy, D. H., & Knowlton, B. J. (2022). Framing effects in value-directed remembering. *Memory & Cognition*, *50*(6), 1350–1361. https://doi.org/10.3758/s13421-022-01317-y

Naveh-Benjamin, M. (2000). Adult age differences in memory performance: Tests of an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(5), 1170–1187. https://doi.org/10.1037/0278-7393.26.5.1170

Naveh-Benjamin, M., Brav, T. K., & Levy, O. (2007). The associative memory deficit of older adults: The role of strategy utilization. *Psychology and Aging*, *22*(1), 202–208. https://doi.org/10.1037/0882-7974.22.1.202

Nelson, T. O., & Dunlosky, J. (1994). Norms of paired-associate recall during multitrial learning of Swahili-English translation equivalents. *Memory*, *2*(3), 325–335. https://doi.org/10.1080/09658219408258951

Old, S. R., & Naveh-Benjamin, M. (2008). Differential effects of age on item and associative measures of memory: A meta-analysis. *Psychology and Aging*, *23*(1), 104–118. https://doi.org/10.1037/0882-7974.23.1.104

Paivio, A. (1965). Abstractness, imagery, and meaningfulness in paired-associate learning. *Journal of Verbal Learning and Verbal Behavior*, *4*(1), 32–38. https://doi.org/10.1016/S0022-5371(65)80064-0

Papagno, C., Valentine, T., & Baddeley, A. (1991). Phonological short-term memory and foreign-language vocabulary learning. *Journal of Memory and Language*, *30*(3), 331–347. https://doi.org/10.1016/0749-596X(91)90040-Q

Park, J. S., Kelly, M. O., Hargis, M. B., & Risko, E. F. (2022). The effect of external store reliance on actual and predicted value-directed remembering. *Psychonomic Bulletin & Review*, *29*(4), 1367–1376. https://doi.org/10.3758/s13423-022-02064-6

Peterson, L. R., Saltzman, D., Hillner, K., & Land, V. (1962). Recency and frequency in paired-associate learning. *Journal of Experimental Psychology*, *63*(4), 396–403. https://doi.org/10.1037/h0043571

Rast, P., & Zimprich, D. (2009). Age differences in the underconfidence-with-practice effect. *Experimental Aging Research*, *35*(4), 400–431. https://doi.org/10.1080/03610730903175782

Risko, E. F., & Gilbert, S. J. (2016). Cognitive offloading. *Trends in Cognitive Sciences*, *20*(9), 676–688. https://doi.org/10.1016/j.tics.2016.07.002

Sakaki, M., Yagi, A., & Murayama, K. (2018). Curiosity in old age: A possible key to achieving adaptive aging. *Neuroscience and Biobehavioral Reviews*, *88*, 106–116. https://doi.org/10.1016/j.neubiorev.2018.03.007

Schaie, K. W. (1994). The course of adult intellectual development. *American Psychologist*, *49*(4), 304–313. https://doi.org/10.1037/0003-066X.49.4.304

Scherbaum, C. A., & Ferreter, J. M. (2009). Estimating statistical power and required sample sizes for organizational research using multilevel modeling. *Organizational Research Methods*, *12*(2), 347–367. https://doi.org/10.1177/1094428107308906

Schwartz, S. T., Siegel, A. L. M., Eich, T. S., & Castel, A. D. (in press). Value-directed memory selectivity relies on goal-directed knowledge of value structure prior to encoding in young and older adults. *Psychology and Aging*.

Service, E., & Craik, F. I. M. (1993). Differences between young and older adults in learning a foreign vocabulary. *Journal of Memory and Language*, *32*(5), 608–623. https://doi.org/10.1006/jmla.1993.1031

Soderstrom, N. C., & McCabe, D. P. (2011). The interplay between value and relatedness as bases for metacognitive monitoring and control: Evidence for agenda-based monitoring. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *37*(5), 1236–1242. https://doi.org/10.1037/a0023548

The Jamovi Project. (2022). *jamovi* (Version 2.3) [Computer Software]. https://www.jamovi.org

Treat, N. J., & Reese, H. W. (1976). Age, pacing, and imagery in paired-associate learning. *Developmental Psychology*, *12*(2), 119–124. https://doi.org/10.1037/0012-1649.12.2.119

Whatley, M. C., Murphy, D. H., Silaj, K. M., & Castel, A. D. (2021). Motivated memory for what matters most: How older adults (selectively) focus on important information and events using schematic support, metacognition, and meaningful goals. In G. Sedek, T. Hess, & D. Touron (Eds.), *Multiple pathways of cognitive aging: Motivational and contextual influences* (pp. 40–65). Oxford University Press. https://doi.org/10.1093/oso/9780197528976.003.0003

Zerr, C. L., Berg, J. J., Nelson, S. M., Fishell, A. K., Savalia, N. K., & McDermott, K. B. (2018). Learning efficiency: Identifying individual differences in learning rate and retention in healthy adults. *Psychological Science*, *29*(9), 1436–1450. https://doi.org/10.1177/0956797618772540

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