Routledge
Taylor & Francis Group

Experimental Aging Research

An International Journal Devoted to the Scientific Study of the Aging Process

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uear20

Age-Related Differences in Framing Selective Memory in Terms of Gains and Losses

Dillon H. Murphy, Alan D. Castel & Barbara J. Knowlton

To cite this article: Dillon H. Murphy, Alan D. Castel & Barbara J. Knowlton (2023): Age-Related Differences in Framing Selective Memory in Terms of Gains and Losses, Experimental Aging Research, DOI: 10.1080/0361073X.2023.2233366

To link to this article: https://doi.org/10.1080/0361073X.2023.2233366

Published online: 06 Jul 2023.

EXPERIMENTAL AGING RESEARCH
https://doi.org/10.1080/0361073X.2023.2233366

Age-Related Differences in Framing Selective Memory in Terms of Gains and Losses

Dillon H. Murphy, Alan D. Castel, and Barbara J. Knowlton

Department of Psychology, University of California Los Angeles, Los Angeles, California, USA

ABSTRACT

We examined whether framing younger and older adults learning goals in terms of maximizing gains or minimizing losses impacts their ability to selectively remember high-value information. Specifically, we presented younger and older adults with lists of words paired with point values and participants were either told that they would receive the value associated with each word if they recalled it on a test or that they would lose the points associated with each word if they failed to recall it on the test. We also asked participants to predict the likelihood of recalling each word to determine if younger and older adults were metacognitively aware of any potential framing effects. Results revealed that older adults expected to be more selective when their goals were framed in terms of losses, but younger adults expected to be more selective when their goals were framed in terms of gains. However, this was not the case as both younger and older adults were more selective for high-value information when their goals were framed in terms of maximizing gains compared with minimizing losses. Thus, the framing of learning goals can impact metacognitive decisions and subsequent memory in both younger and older adults.

ARTICLE HISTORY
Received 13 January 2023
Accepted 3 July 2023

When presented with too much information to remember, one should selectively focus on the most valuable information to maximize the rewards of remembering and minimize the losses incurred by forgetting. To measure this form of selective memory, value-directed remembering tasks present learners with words paired with point values that are added to a participant's score if remembered on a test. Generally, learners better remember high-value words relative to low-value words (see Knowlton & Castel, 2022; Madan, Zwaan, & Madan, 2017; for a review; see also Elliott, McClure, & Brewer, 2020), and this ability is preserved in older adults (Castel, 2008; Castel, Benjamin, Craik, & Watkins, 2002; Castel, McGillivray, & Friedman, 2012; McGillivray & Castel, 2011; Murphy & Castel, 2022a, 2022d; Schwartz, Siegel, Eich, & Castel, 2023; Whatley, Murphy, Silaj, & Castel, 2021) despite cognitive deficits that accompany aging (see Hess, 2005; Park & Festini, 2017; Salthouse, 2010).

People are generally metacognitively aware of their selective memory (see Murphy & Castel, 2021a; Murphy, Agadzhanyan, Whatley, & Castel, 2021; Murphy, Huckins, Rhodes, & Castel, 2021) and metacognition may be a crucial aspect of strategically remembering valuable information. Metacognition is the awareness of one's own memory abilities and can

CONTACT Dillon H. Murphy dmurphy8@ucla.edu Department of Psychology, University of California, Los Angeles, CA 90095, USA

be considered in terms of monitoring and control (see Nelson, 1996; Nelson & Narens, 1990). Metacognitive monitoring is typically assessed via predictions of future memory performance made by the learner while metacognitive control is evaluated via study decisions like how long a learner studies some information. Since metacognitive monitoring often occurs during encoding, these assessments inform metacognitive control decisions (see Rhodes, 2016 for a review). Thus, learners should monitor their learning and employ metacognitive strategies like spending more time studying yet-to-be-learned, valuable information to maximize memory utility (see Ariel, Dunlosky, & Bailey, 2009). Since metacognitive monitoring accuracy is generally preserved in older adults (Hertzog & Dunlosky, 2011), metacognition may be a critical component of older adults' preserved memory selectivity.

When making decisions, such as what to study or how long to study something, the framing of task goals can influence decision-making. Specifically, when people make different decisions in equivalent situations based on how something is framed (i.e., which aspects are highlighted), this is known as the *framing effect* (see Kuhberger, 1997; Steiger & Kühberger, 2018 for a review of how framing impacts people's social and economic decisions). For example, a product may be described as 20% fat or 80% fat-free (which are equivalent descriptions regarding their meaning), and the different framing of each description can influence people's preferences (e.g., Levin, 1987; Levin, Schneider, & Gaeth, 1998). Framing effects can differ in younger and older adults, particularly under conditions where older adults may rely more on heuristics, but these effects can be eliminated when older adults are encouraged to use more analytic processing (Kim, Goldstein, Hasher, & Zacks, 2005; Thomas & Millar, 2012).

The framing effect can emerge through various mechanisms, contingent on how the frame is presented to participants. Specifically, framing can be categorized into three forms with each relying on somewhat different mechanisms: risky choice framing (the description of outcomes related to a potential choice that involves options varying in their level of risk can differ based on how they are presented), attribute framing (focusing on a specific characteristic of an object or event which becomes the focal point of the framing effect), and goal framing (framing the goal of an action or behavior; see Levin, Schneider, & Gaeth, 1998). In the context of value-based memory, researchers can manipulate the nature of the goal frame in terms of gains and losses to determine how goal framing impacts memory selectivity, but this could also involve attribute framing as attribute framing involves only a single attribute (points paired with to-be-remembered words) as the subject of the framing manipulation.

Framing may especially impact decision-making when in the context of acquiring gains or avoiding losses. For example, prior work has shown that stressing the positive aspects of achieving a goal or the negative aspects of not achieving a goal can influence decision-making (e.g., Banks et al., 1995). Furthermore, framing outcomes in terms of gains (such as the number of lives saved) compared with losses (the number of lives lost) has also been shown to influence decision-making (e.g., Tversky & Kahneman, 1981). In addition to decision-making, framing effects can also influence metacognition. For example, metacognitive monitoring assessments are often solicited in the form of judgments of learning (JOL) where the learner is asked how likely they are to remember something on a later test. However, prior work has changed the framing of this assessment by asking participants how likely they are to forget something on a later test. When metacognitive judgments were framed in terms of forgetting, confidence in memory performance decreased (Finn, 2008), and people may be aware of how much information will be forgotten when metacognitive assessments are framed in terms of instances of forgetting as opposed to what will be remembered (Halamish, McGillivray, & Castel, 2011).

Since framing effects influence decision-making as well as metacognition, the framing of a learner's goals may also influence memory selectivity. To examine how framing a learner's goals in terms of maximizing gains or minimizing losses impacts memory for valuable information, Murphy and Knowlton (2022) presented younger adults with lists of words to remember for a later test and each word was paired with a point value. Some participants' instructions and feedback were framed in terms of gains (e.g., "your goal is to maximize your score", "you gained xxx points") while other participants' instructions and feedback were framed in terms of losses (e.g., "your goal is to minimize your losses", "you lost xxx points"). Results generally revealed that framing a learner's goals in terms of losses reduced younger adults' ability to selectively remember high-value information, but this effect was reduced when participants were allowed to self-pace their study time.

The reduction in selectivity when a learner's goals are framed in terms of avoiding losses (as shown by younger adults in Murphy & Knowlton, 2022) is consistent with *loss aversion*, a basic principle of decision-making whereby losses are experienced more intensely than gains of the same magnitude (see Hastie, 2001; Kahneman & Tversky, 1979; Thaler, 1999; Tversky, 1994; Tversky & Kahneman, 1991, 1992). Specifically, people tend to avoid risks when faced with possible gains but are risk-seeking when faced with possible losses (which loom larger than gains; Tversky & Kahneman, 1981; see also Whitney, Rinehart, & Hinson, 2008). In Murphy and Knowlton (2022), younger adults may have feared the losses associated with forgetting some of the words, leading them to focus more on maximizing total recall (trying to remember everything) rather than selectively focusing on a smaller number of words (but the highest-valued words).

Strategically working to maximize gains, but particularly aiming to minimize losses, is consistent with the notion of *responsible remembering*: the adaptive memory process of using metacognition and one's memory to avoid negative outcomes that result from forgetting (see Murphy & Castel, 2020, 2021a, 2021b, 2022b; Murphy, Agadzhanyan, Whatley, & Castel, 2021; Murphy, Hoover, & Castel, 2022). Older adults have displayed a particularly good ability to engage in responsible remembering (Murphy & Castel, 2022c; see also Middlebrooks, McGillivray, Murayama, & Castel, 2016) and thus may be differentially impacted by framing effects when selectively remembering. Specifically, younger and older adults may differentially prioritize information when aiming to maximize gains or minimize losses.

Prior work indicates that older adults focus on remembering gain information at the expense of loss information when remembering faces paired with a monetary reward or loss (Castel et al., 2016). However, relative to younger adults, older adults may favor loss prevention in the context of goals and decision-making (see Freund & Ebner, 2005), but it remains unclear if there are age-related differences in loss aversion and framing effects (see Mikels & Reed, 2009; Rönnlund, Karlsson, Laggnäs, Larsson, & Lindström, 2005). Some prior work found less sensitivity to losses in older adults (Samanez-Larkin et al., 2007), but this literature is mixed in that some work has found the opposite, or age-equivalents/null age-related effects (Eppinger, Hämmerer, & Li, 2011; Mata, Josef, Samanez-Larkin, & Hertwig, 2011). Additionally, both younger and older adults may perceive forgotten information as less important (Witherby, Tauber, Rhodes, & Castel, 2019) which could create a bias in memory for gains and losses. In the present study, we investigated whether framing task goals in terms of maximizing gains or minimizing losses differentially impacts selective memory in younger and older adults.

The Current Study

In the current study, we examined whether framing younger and older adults learning goals in terms of maximizing gains or minimizing losses impacts their ability to selectively remember high-value information. Specifically, we presented younger and older adults with lists of words paired with point values and participants were either told that they would receive the value associated with each word if they recalled it on a test or that they would lose the points associated with each word if they failed to recall it on the test. We also asked participants to predict the likelihood of recalling each word to determine if younger and older adults were metacognitively aware of any potential framing effects. We expected participants whose goals were framed in terms of losses to be less selective than participants whose goals were framed in terms of gains (as seen in Murphy & Knowlton, 2022) but for this effect to be more pronounced in older adults.

Experiment 1

In Experiment 1, participants studied six lists of words with each list containing 20 words. Each word was paired with a point value that was either added to participants' scores if recalled on the test or the points for that word would be lost if they forgot it on the test. After studying each word (for a fixed duration), participants predicted the likelihood of recalling it on a later test. We expected decreased selectivity when the learner's goals were framed in terms of losses and for this effect to be more pronounced in older adults.

Method

Participants

After exclusions, younger adults were 99 undergraduate students (*Mage* = 20.33, *SDage* = 2.11) recruited from the University of California Los Angeles (UCLA) Human Subjects Pool. Participants were tested online and received course credit for their participation. Older adults ($n = 88$; *Mage* = 71.01, *SDage* = 4.68) were recruited from Amazon's Cloud Research (Chandler, Rosenzweig, Moss, Robinson, & Litman, 2019), a Web site that allows users to complete small tasks for pay. Participants were excluded from analysis if they admitted to cheating (e.g., writing down answers) in a post-task questionnaire (they were told they would still receive credit if they cheated). This exclusion process resulted in the exclusion of five younger adults and 17 older adults. In each experiment, we aimed to collect around 50 participants per condition. The sample size was selected based on prior exploratory research and the expectation of detecting a medium effect size. With this sample size, we had an 80% chance of detecting a *medium* (Cohen's $d = .41$) effect between younger and older adults.

Materials and Procedure

The materials and procedure were taken from Murphy and Knowlton (2022). Participants were presented with lists of unrelated words with each list containing 20 different words. Each word was presented for 3 seconds and after studying each word, participants were asked to make a judgment as to how likely it is that they would remember it (JOL). Participants answered with a number between 0 and 100, with 0 meaning they definitely would not remember the word and 100 meaning they definitely would remember the word. Participants were given as much time as they needed to make their judgments. After each list was presented, participants were given 1 minute to recall the words from just that list (i.e., not previous lists).

Next, participants were told that each word in each list would be paired with a unique, randomly assigned value between 1 and 20 indicating how much the word was "worth." However, some participants' instructions about the point values were framed in terms of gains while other participants' instructions about the point values were framed in terms of losses. Specifically, when participants' instructions were framed in terms of gains, they were told that "Each word will be accompanied by an associated number. This number indicates how many points the word is worth. For example, if the word 'apple' appears with a 5 next to it and you remember 'apple' during the test, then you will receive 5 points. The numbers will range from 1 to 20. After each test, you will be told your score for that list. Do your best to maximize your score." In contrast, when participants' instructions were framed in terms of losses, they were told that "Each word will be accompanied by an associated number. This number indicates how many points the word is worth. For example, if the word 'apple' appears with a 5 next to it and you forget 'apple' during the test, then you will lose 5 points. The numbers will range from 1 to 20. After each test, you will be told how many points you lost for that list. Do your best to minimize your losses." Each point value was used only once within each list and the order of the point values within lists was randomized.

Immediately following the recall period, participants were given feedback on their performance for that list but were not given feedback about specific items. However, when participants' instructions were framed in terms of gains, their feedback was phrased in terms of how many points they scored out of how many points they possibly could have scored (i.e., "You got 100 out of 210 points"). In contrast, when participants' instructions were framed in terms of losses, their feedback was phrased in terms of how many points they lost out of how many points they possibly could have lost (i.e., "You lost 110 out of 210 points"). This was repeated for six study-test trials.

Results

In the present study, we computed multilevel models (MLMs) where we treated the data as hierarchical or clustered (i.e., multilevel) with items nested within individual participants. Since recall at the item level was binary (correct or incorrect), we conducted logistic MLMs when examining recall. In these analyses, the regression coefficients are given as logit units (i.e., the log odds of correct 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 a word divided by the odds of not recalling a word). Thus, e^B can be interpreted as the extent to which the odds of recalling a word changed. Specifically, values greater than 1 represent an increased likelihood of recall while values less than 1 represent a decreased likelihood of recall.

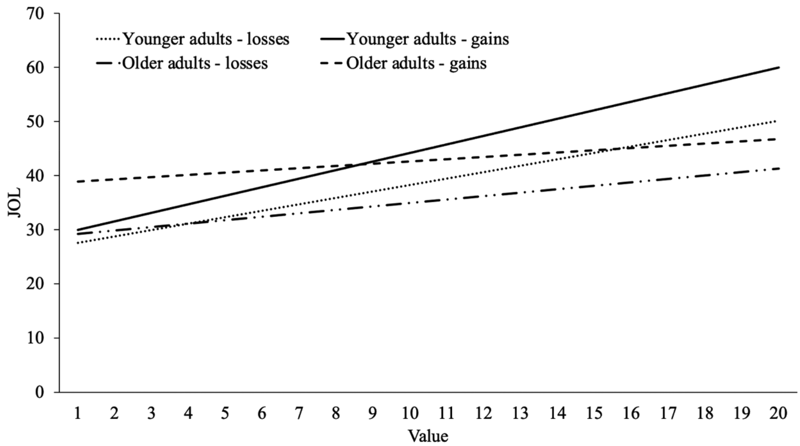

Figure 1. Linear trendlines for JOLs as a function of value, age, and framing in Experiment 1.

To examine participants' JOLs (see Figure 1), we conducted a mixed MLM with item-level JOLs modeled as a function of value with framing (gains, losses) and age (young, old) as between-subjects factors. Results revealed that value significantly predicted JOLs [$t(22248) = 38.54$, $p < .001$] such that high-value words were expected to be better remembered than low-value words. However, age did not predict JOLs [$t(183) = .73$, $p = .464$] and framing also did not predict JOLs [$t(183) = 1.75$, $p = .081$] such that younger and older adults, as well as learners with goals framed in terms of gains versus losses, expected similar levels of recall. Value did not interact with framing [$t(22248) = 1.74$, $p = .082$] and framing did not interact with age [$t(183) = .18$, $p = .857$]. Age interacted with value [$t(22248) = 17.41$, $p < .001$] such that younger adults expected to be more selective than older adults. Finally, there was a three-way interaction between value, age, and scoring [$t(22248) = 6.25$, $p < .001$] such that younger adults expected to be more selective when their goals were framed in terms of gains, but older adults expected to be more selective when their goals were framed in terms of losses.

To examine overall memory selectivity (see Figure 2), we conducted a logistic MLM with item-level recall modeled as a function of value with framing (gains, losses) and age (young, old) as between-subjects factors. Results revealed that value significantly predicted recall [$e^B = 1.07$, $CI_{95\%} = 1.06–1.07$, $z = 24.34$, $p < .001$] such that high-value words were better recalled than low-value words. Additionally, age significantly predicted recall [$e^B = 1.58$, $CI_{95\%} = 1.23–2.03$, $z = 3.54$, $p < .001$] such that younger adults recalled a greater proportion of words ($M = .47$, $SD = .16$) than older adults ($M = .38$, $SD = .20$). Framing did not predict recall [$e^B = .85$, $CI_{95\%} = .66–1.09$, $z = -1.28$, $p = .199$] such that the framing of learners' goals did not significantly impact recall. However, value interacted with framing [$e^B = .98$, $CI_{95\%} = .97–.99$, $z = -4.57$, $p < .001$] such that learners whose goals were framed in terms of gains were more selective than learners whose goals were framed in terms of losses. Age interacted with value [$e^B = 1.04$, $CI_{95\%} = 1.03–1.05$, $z = 6.90$, $p < .001$] such that younger adults were more selective than older adults. Framing did not interact with age [$e^B = 1.05$, $CI_{95\%} = .63–1.74$, $z = .19$, $p = .852$] and there was not a three-way interaction between value, age, and scoring [$e^B = 1.00$, $CI_{95\%} = .98–1.02$, $z = .22$, $p = .822$].

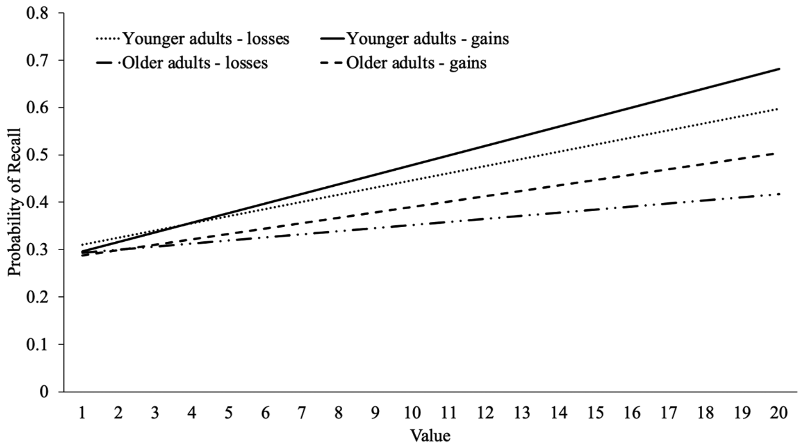

Figure 2. Linear trendlines for recall as a function of value, age, and framing in Experiment 1.

Discussion

In Experiment 1, framing learners' goals in terms of gains and losses impacted metacognitive predictions of performance such that younger adults expected to be more selective when their goals were framed in terms of gains while older adults expected to be more selective when their goals were framed in terms of losses. However, this was not born out in participants' recall such that both younger and older adults were more selective for high-value information when their goals were framed in terms of maximizing gains compared with minimizing losses. This dissociation between metacognition and memory suggests that older adults may have attempted to avoid losses by focusing on the highest-valued words (as these words would have the biggest loss if forgotten) but were unable to effectively employ the strategy. We further explored this issue in Experiment 2 as we allowed participants to self-pace their study time.

Experiment 2

In Experiment 1, we observed similarities in recall and differences in JOLs between younger and older adults. In Experiment 2, we were interested in whether metacognitive control decisions reflect the patterns displayed in participants' monitoring assessments. We used a similar procedure as Experiment 1 but allowed participants to control their study time for each item. When their goals are framed in terms of losses, we expected older adults to be more motivated to avoid losses (and thus spend more total time studying relative to younger adults).

Method

Participants

After exclusions, younger adults were 110 undergraduate students (*Mage* = 20.03, *SDage* = 1.95) recruited from the UCLA Human Subjects Pool. Participants were tested online and received course credit for their participation. Older adults (n = 82; *Mage* = 72.98, *SDage* =

5.62) were recruited from Amazon's Cloud Research. Participants were excluded from analysis if they admitted to cheating (e.g., writing down answers) in a post-task questionnaire (they were told they would still receive credit if they cheated). This exclusion process resulted in the exclusion of five younger adults and 24 older adults. With this sample size, we had an 80% chance of detecting a *medium* (Cohen's $d = .41$) effect between younger and older adults.

Materials and Procedure

The materials and procedures in Experiment 2 were similar to those used in Experiment 1. However, participants were allowed to study each word for as long as they liked but with a maximum of 10 seconds per word.

Results

To examine participants' study time (see Figure 3), we conducted a mixed MLM with item-level study time modeled as a function of value with framing (gains, losses) and age (young, old) as between-subjects factors. Results revealed that value significantly predicted study time [$t(22844) = 15.27$, $p < .001$] such that high-value words were studied longer than low-value words. Additionally, age predicted study time [$t(188) = 3.54$, $p < .001$] such that older adults spent more time studying the words than younger adults. Framing did not predict study time [$t(188) = 1.35$, $p = .178$] such that participants spent the same amount of time studying regardless of how their goals were framed. Framing did not interact with age [$t(188) = .73$, $p = .465$] but value interacted with framing [$t(22844) = 2.89$, $p = .004$] such that participants whose goal was framed in terms of losses were more selective with their study time than participants whose goals were framed in terms of gains. Age interacted with value [$t(22844) = 4.35$, $p < .001$] such that younger adults were more selective with their study time than older adults. Finally, there was not a three-way interaction between value, age, and scoring [$t(22844) = .85$, $p = .393$].

To examine participants' JOLs (see Figure 4), we conducted a mixed MLM with item-level JOLs modeled as a function of value with framing (gains, losses) and age (young, old)

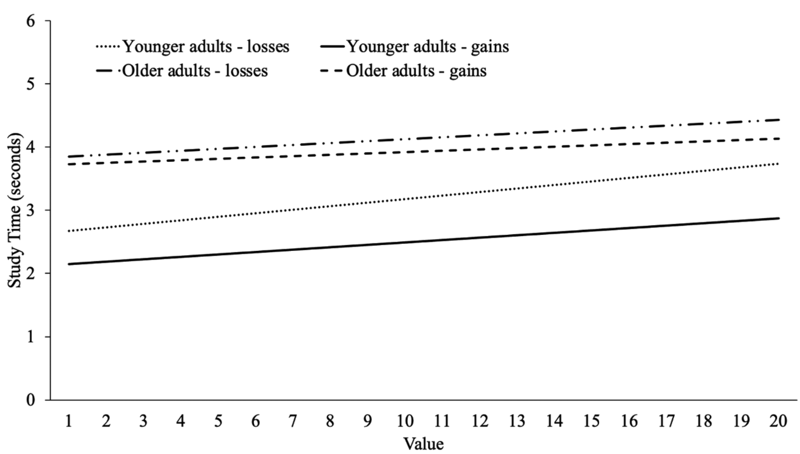

Figure 3. Linear trendlines for study time as a function of value, age, and framing in Experiment 2.

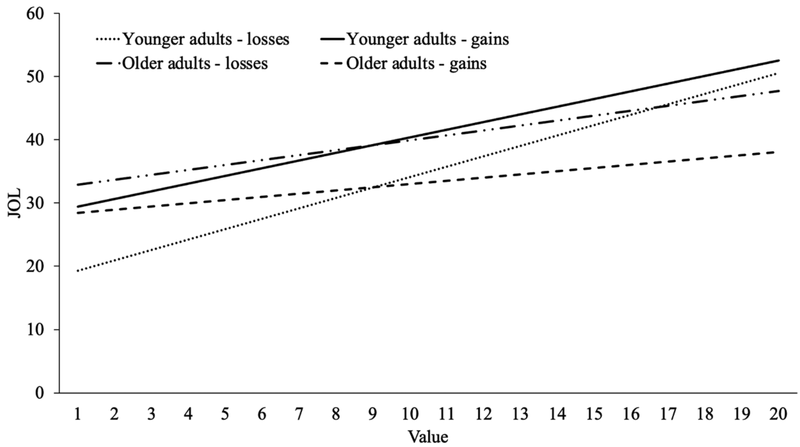

Figure 4. Linear trendlines for JOLs as a function of value, age, and framing in Experiment 2.

as between-subjects factors. Results revealed that value significantly predicted JOLs [t (22842) = 40.56, $p < .001$] such that high-value words were expected to be better remembered than low-value words. However, age did not predict JOLs [$t(188) = .33$, $p = .739$] and framing also did not predict JOLs [$t(188) = .14$, $p = .890$] such that younger and older adults, as well as learners with goals framed in terms of gains versus losses, expected similar levels of recall. Value interacted with framing [$t(22842) = 6.83$, $p < .001$] such that participants whose goals were framed in terms of losses expected to be more selective than participants whose goals were framed in terms of gains. Framing did not interact with age [$t(188) = 1.83$, $p = .069$] but age interacted with value [$t(22842) = 15.35$, $p < .001$] such that younger adults expected to be more selective than older adults. Finally, there was not a three-way interaction between value, age, and scoring [$t(22842) = 1.54$, $p = .123$].

To examine overall memory selectivity (see Figure 5), we conducted a logistic MLM with item-level recall modeled as a function of value with framing (gains, losses) and age (young, old) as between-subjects factors. Results revealed that value significantly predicted recall [$e^B = 1.07$, $CI_{95\%} = 1.06–1.07$, $z = 24.91$, $p < .001$] such that high-value words were better recalled than low-value words. Additionally, age significantly predicted recall [$e^B = 1.38$, $CI_{95\%} = 1.04–1.84$, $z = 2.23$, $p = .026$] such that younger adults recalled a greater proportion of words ($M = .43$, $SD = .18$) than older adults ($M = .37$, $SD = .21$). Framing did not predict recall [$e^B = 1.14$, $CI_{95\%} = .86–1.52$, $z = .92$, $p = .357$] such that the framing of learners' goals did not significantly impact recall. However, value interacted with framing [$e^B = 1.01$, $CI_{95\%} = 1.00–1.02$, $z = 2.47$, $p = .013$] such that learners whose goals were framed in terms of losses were more selective than learners whose goals were framed in terms of gains. Age interacted with value [$e^B = 1.02$, $CI_{95\%} = 1.01–1.03$, $z = 4.27$, $p < .001$] such that younger adults are more selective than older adults. Framing did not interact with age [$e^B = 1.04$, $CI_{95\%} = .59–1.84$, $z = .13$, $p = .893$] and there was not a three-way interaction between value, age, and scoring [$e^B = .99$, $CI_{95\%} = .97–1.01$, $z = -.89$, $p = .375$].

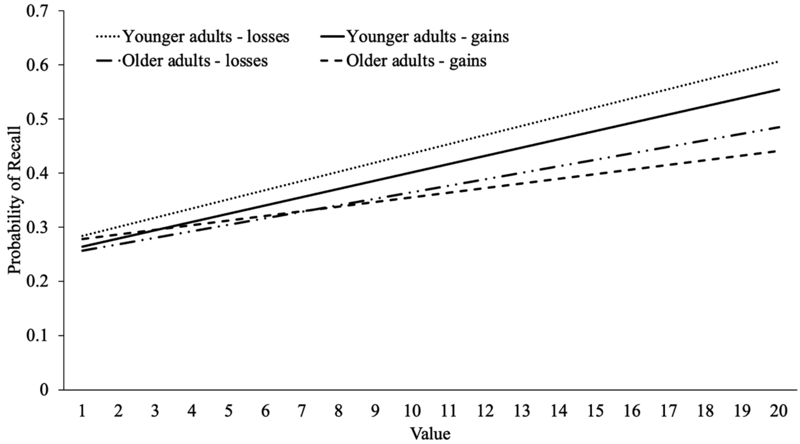

Figure 5. Linear trendlines for recall as a function of value, age, and framing in Experiment 2.

Discussion

In Experiment 2, framing learners' goals in terms of losses led to more selective study time in both younger and older adults, these participants expected to be more selective than participants whose goals were framed in terms of gains, and this was born out in their recall. Moreover, younger adults were more selective with their study time, expected to be more selective than older adults, and subsequently were more selective than older adults. Thus, Experiment 2 indicates that aiming to avoid losses causes learners to better prioritize valuable information both in terms of metacognition and subsequent memory.

General Discussion

Previous work has demonstrated that, under fixed study conditions, framing younger adults' goals in terms of losses reduces memory selectivity and learners may be aware of this trend (Murphy & Knowlton, 2022). In the present study, we were interested in whether older adults would show greater framing effects in value-based memory relative to younger adults. We presented younger and older adults with lists of words paired with point values either counting toward their score if recalled or lost if forgotten. Overall, relative to younger adults, we expected older adults to be less selective when their goals were framed in terms of minimizing losses compared with maximizing gains.

In Experiment 1, participants studied each word for a fixed duration. Results revealed a disassociation between metacognitive monitoring and recall such that older adults expected to be more selective when their goals were framed in terms of losses, but younger adults expected to be more selective when their goals were framed in terms of gains. However, this was not the case as both younger and older adults were more selective for high-value information when their goals were framed in terms of maximizing gains compared with minimizing losses. In Experiment 2, under self-paced study conditions, when aiming to minimize losses, both younger and older adults spent more time studying high- relative to low-value words, expected to better recall valuable words, and were subsequently selective in their recall.

The incongruency between older adults' predictions of memory performance and subsequent recall in Experiment 1 (younger adults expected to be more selective when their goals were framed in terms of gains, and this was the case, so younger adults did not show this dissociation) indicates that they may have attempted to employ different strategies under the two framing conditions but were unable to execute these strategies given the allotted study time. Under self-paced encoding conditions, both younger and older adults appeared to be risk-averse when aiming to avoid losses by not overtaxing their memory system by trying to remember everything. Rather, participants selectively studied and encoded the highest-valued words at the expense of low-value words. In contrast, when aiming to maximize gains, younger and older adults may have been more risk-seeking by trying to remember more information overall rather than selectively encoding the most valuable information (although we note that participants did not spend more total time studying when aiming to maximize gains).

Individual differences in loss aversion can be influenced by factors such as income and age (Gächter, Johnson, & Herrmann, 2022; see also Strough, Karns, & Schlosnagle, 2011), and in some cases, older adults have been shown to be more loss averse than younger adults in a risky decision-making task (O'Brien & Hess, 2020). However, other research has shown similar effects of framing for both younger and older adults (Mikels & Reed, 2009; Weller, Levin, Shiv, & Bechara, 2009). In the present study, older adults incorrectly predicted that they would be more selective in focusing on high-value items when the task was framed in terms of losses for forgotten items. As such, older adults may have expected that they would differentially encode items for which losses would be greatest if forgotten (i.e., older adults may be aware of being loss-averse and predict that they will perform most efficiently under framing based on losses for forgetting).

Since participants in the present study were aware that they were performing a memory test, we may have induced stereotype threat for older adults as older adults may feel more anxiety/stress about having an upcoming memory test that could result in losses (Fourquet, Patterson, Li, Castel, & Knowlton, 2020). This may have led to older adults' judgments that they would be more selective in this case. Future research could examine how time pressure, stereotype threat, and anxiety could impact age-related differences in learning information to achieve gains or avoid losses. Despite their motivation to be more selective when faced with losses, older adults did not prioritize learning the items that would lead to the greatest losses when forgotten but rather attempted to avoid even small losses resulting in reduced selectivity.

In Murphy and Knowlton (2022), when study time was fixed, younger participants whose goals were framed in terms of gains were more selective than participants whose goals were framed in terms of losses (and JOLs mapped onto this trend), and this effect was found in the current study (see Experiment 1) for both younger and older adults. However, when participants were allowed to self-regulate their study time, the effect of framing on selectivity was reduced (there was not a statistically significant difference between framing conditions). Murphy and Knowlton (2022) also directly compared sensitivity to value under different framing conditions with fixed and self-paced study time in younger adults. However, the three-way interaction was marginal but seemed to suggest that under fixed study-time conditions, when goals are framed in terms of gains, participants are more selective, but this is not the case under self-paced study conditions. This is supported by the patterns obtained here in Experiment 2 which demonstrated that both younger and older participants are more selective when avoiding losses under self-paced study conditions. Thus, metacognitive control may be a critical aspect of how framing a learner's goals influences selective memory. Specifically, when learners can apply a straightforward means to differentially encode items by allocating more study time, items associated with high potential losses were studied longer. However, participants seemed to engage in similar encoding strategies for items associated with high and low potential losses when they were not able to differentially allocate study time.

In contrast to prior work (e.g., Castel, Benjamin, Craik, & Watkins, 2002), older adults in the present study demonstrated less memory selectivity than younger adults. Specifically, across framing conditions, younger adults were more selective than older adults regardless of whether study time was fixed or self-paced. The need to make metacognitive judgments (see Li et al., 2022 for an examination of how judgments of learning and forgetting impact memory) could reduce selectivity since older adults may be unable to selectively ignore lower-value information and inhibit trying to remember this less-valuable information (see Castel, Farb, & Craik, 2007). Specifically, asking older adults to monitor their learning may increase cognitive load and make it more difficult to selectively encode high-value items. Thus, although certain conditions may indicate that selectivity is preserved in older adults (e.g., Castel, Benjamin, Craik, & Watkins, 2002), future research should further investigate how younger and older adults may differentially encode and retrieve valuable information when presented with goals related to gains and losses.

Given that the framing effect can stem from various mechanisms including risky choice framing, attribute framing, and goal framing, there may be different mechanisms that contributed to the present findings. While our manipulation focused on the nature of the goal in terms of gains and losses, attribute framing could also be involved, particularly when the framing manipulation centers on a single attribute, such as points (Levin, Schneider, & Gaeth, 1998). Consequently, minimal age differences may arise when only one attribute is employed in the framing manipulation (Mata, Josef, Samanez-Larkin, & Hertwig, 2011; Weller, Levin, Shiv, & Bechara, 2009). Age differences might become more pronounced when decision-making under risk is more prominent, such as when people can only gain or lose points when they bet on remembering the information (Fourquet, Patterson, Li, Castel, & Knowlton, 2020) or in more complex decision-making settings (Peters, Dieckmann, & Weller, 2011). It would be worthwhile to explore potential emotional responses associated with focusing on gains and losses, as this could further elucidate age-related differences (Kircanski et al., 2018). Additionally, future research could investigate this matter in the context of divided attention (see Middlebrooks, Kerr, & Castel, 2017; Murphy, Schwartz, & Castel, 2023), assessing how cognitive resources might contribute to age-related effects on framing gains and losses, potentially unveiling individual differences (e.g., Simon, Fagley, & Halleran, 2004) – such investigations could have implications for financial decision-making (Seaman, Leong, Wu, Knutson, & Samanez-Larkin, 2017).

In sum, we demonstrated that both younger and older adults are more selective in their recall of valuable information when aiming to maximize gains under fixed study conditions (Experiment 1) but were more selective when trying to minimize losses under self-paced study conditions (Experiment 2). However, there was a metacognitive disassociation between predictions of performance and recall for the different framing conditions in older adults when study time was fixed; both younger and older adults were generally metacognitively aware of their selectivity when study time with self-paced. Thus, the framing of learning goals critically impacts metacognitive decisions and subsequent memory in both younger and older adults.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the National Institute on Aging [R01 AG044335].

ORCID

Dillon H. Murphy http://orcid.org/0000-0002-5604-3494
Alan D. Castel http://orcid.org/0000-0003-1965-8227
Barbara J. Knowlton http://orcid.org/0000-0002-1532-5081

References

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. doi:10.1037/a0015928

Banks, S. M., Salovey, P., Greener, S., Rothman, A. J., Moyer, A., Beauvais, J., & Epel, E. (1995). The effects of message framing on mammography utilization. *Health Psychology*, *14*(2), 178–184. doi:10.1037/0278-6133.14.2.178

Castel, A. D. 2008. The adaptive and strategic use of memory by older adults: Evaluative processing and value-directed remembering. In (Eds.), *The psychology of learning and motivation*, Vol. 48, (pp. 225–270). London, UK: Academic Press. doi:10.1016/S0079-7421(07)48006-9

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. doi:10.3758/BF03194325

Castel, A. D., Farb, N., & 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. doi:10.3758/BF03193307

Castel, A. D., Friedman, M. F., McGillivray, S., Flores, C. C., Murayama, K., Kerr, T., & Drolet, A. (2016). I owe you: Age-related similarities and differences in associative memory for gains and losses. *Aging, Neuropsychology & Cognition*, *23*(5), 549–565. doi:10.1080/13825585.2015.1130214

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). New York: Psychology Press.

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. doi:10.3758/s13428-019-01273-7

Elliott, B. L., McClure, S. M., & Brewer, G. A. (2020). Individual differences in value-directed remembering. *Cognition*, *201*, 104275. doi:10.1016/j.cognition.2020.104275

Eppinger, B., Hämmerer, D., & Li, S.-C. (2011). Neuromodulation of reward-based learning and decision making in human aging. *Annals of the New York Academy of Sciences*, *1235*, 1–17. doi:10.1111/j.1749-6632.2011.06230.x

Finn, B. (2008). Framing effects on metacognitive monitoring and control. *Memory & Cognition*, *36* (4), 813–821. doi:10.3758/MC.36.4.813

Fourquet, N. Y., Patterson, T. K., Li, C., Castel, A. D., & Knowlton, B. J. (2020). Effects of age-related stereotype threat on metacognition. *Frontiers in Psychology*, *11*, 604978. doi:10.3389/fpsyg.2020.604978

Freund, A. M., & Ebner, N. C. (2005). The aging self: Shifting from promoting gains to balancing losses. *The Adaptive Self: Personal Continuity and Intentional Self-Development*, 185–202.

Gächter, S., Johnson, E. J., & Herrmann, A. (2022). Individual-level loss aversion in riskless and risky choices. *Theory and Decision*, *92*(3–4), 599–624. doi:10.1007/s11238-021-09839-8

Halamish, V., McGillivray, S., & Castel, A. D. (2011). Monitoring one's own forgetting in younger and older adults. *Psychology and Aging*, *26*(3), 631–635. doi:10.1037/a0022852

Hastie, R. (2001). Problems for judgment and decision making. *Annual Review of Psychology*, *52*(1), 653–683. doi:10.1146/annurev.psych.52.1.653

Hertzog, C., & Dunlosky, J. (2011). Metacognition in later adulthood: Spared monitoring can benefit older adults' self-regulation. *Current Directions in Psychological Science*, *20*(3), 167–173. doi:10.1177/0963721411409026

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

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*(2), 263–291. doi:10.2307/1914185

Kim, S., Goldstein, D., Hasher, L., & Zacks, R. T. (2005). Framing effects in younger and older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *60*(4), 215–P218. doi:10.1093/geronb/60.4.P215

Kircanski, K., Notthoff, N., DeLiema, M., Samanez-Larkin, G. R., Shadel, D. . . . Gotlib, I. H. (2018). Emotional arousal may increase susceptibility to fraud in older and younger adults. *Psychology and Aging*, *33*(2), 325–337. doi:10.1037/pag0000228

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. doi:10.1146/annurev-psych-032921-050951

Kuhberger, A. (1997). Theoretical conceptions of framing effects in risky decisions. In R. Ranyard, W. R. Crozier, & O. Svenson (Eds.), *Decision making: Cognitive models and explanations* (pp. 128–144). New York: Routledge.

Levin, I. P. (1987). Associative effects of information framing. *Bulletin of the Psychonomic Society*, *25* (2), 85–86. doi:10.3758/BF03330291

Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All frames are not created equal: A typology and critical analysis of framing effects. *Organizational Behavior & Human Decision Processes*, *76*(2), 149–188. doi:10.1006/obhd.1998.2804

Li, B., Zhao, W., Zheng, J., Hu, X., Su, N., Fan, T. . . . Luo, L. (2022). Soliciting judgments of forgetting reactively enhances memory as well as making judgments of learning: Empirical and meta-analytic tests. *Memory & Cognition*, *50*(5), 1061–1077. doi:10.3758/s13421-021-01258-y

Madan, C. R., Zwaan, R., & Madan, C. (2017). Motivated cognition: Effects of reward, emotion, and other motivational factors across a variety of cognitive domains. *Collabra: Psychology*, *3*(1), 24. doi:10.1525/collabra.111

Mata, R., Josef, A. K., Samanez-Larkin, G. R., & Hertwig, R. (2011). Age differences in risky choice: A meta-analysis. *Annals of the New York Academy of Sciences*, *1235*(1), 18–29. doi:10.1111/j.1749-6632.2011.06200.x

McGillivray, S., & Castel, A. D. (2011). Betting on memory leads to metacognitive improvement by younger and older adults. *Psychology and Aging*, *26*(1), 137–142. doi:10.1037/a0022681

Middlebrooks, C. D., Kerr, T. K., & Castel, A. D. (2017). Selectively distracted: Divided attention and memory for important information. *Psychological Science*, *28*, 1103–1115. doi:10.1177/0956797617702502

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. doi:10.1093/geronb/gbv032

Mikels, J. A., & Reed, A. E. (2009). Monetary losses do not loom large in later life: Age differences in the framing effect. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *64*(4), 457–460. doi:10.1093/geronb/gbp043

Murphy, D. H., Agadzhanyan, K., Whatley, M. C., & Castel, A. D. (2021). Metacognition and fluid intelligence in value-directed remembering. *Metacognition and Learning*, *16*(3), 685–709. doi:10.1007/s11409-021-09265-9

Murphy, D. H., & Castel, A. D. (2020). Responsible remembering: How metacognition impacts adaptive selective memory. *Zeitschrift für Psychologie*, *228*(4), 301–303. doi: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. doi: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. doi:10.3758/s13421-021-01139-4

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

Murphy, D. H., & Castel, A. D. (2022b). Responsible attention: The effect of divided attention on metacognition and responsible remembering. *Psychological Research*, *87*(4), 1085–1100. doi:10.1007/s00426-022-01711-w

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

Murphy, D. H., & Castel, A. D. (2022d). The role of attention and aging in the retrieval dynamics of value-directed remembering. *Quarterly Journal of Experimental Psychology*, *75*(5), 954–968. doi: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*(6), 1350–1361. doi:10.3758/s13421-022-01317-y

Murphy, D. H., Huckins, S. C., Rhodes, M. G., & Castel, A. D. (2021). The effect of perceptual processing fluency and value on metacognition and remembering. *Psychonomic Bulletin & Review*, *29*(3), 910–921. doi:10.3758/s13423-021-02030-8

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

Murphy, D. H., Schwartz, S. T., & Castel, A. D. (2023). Value-directed retrieval: The effects of divided attention at encoding and retrieval on memory selectivity and retrieval dynamics. *Journal of Experimental Psychology Learning, Memory, and Cognition*. doi:10.1037/xlm0001264

Nelson, T. O. (1996). Consciousness and metacognition. *American Psychologist*, *51*(2), 102–116. doi:10.1037/0003-066X.51.2.102

Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. *Psychology of Learning and Motivation*, *26*, 125–141.

O'Brien, E. L., & Hess, T. M. (2020). Differential focus on probability and losses between young and older adults in risky decision-making. *Aging, Neuropsychology & Cognition*, *27*(4), 532–552. doi:10.1080/13825585.2019.1642442

Park, D. C., & Festini, S. B. (2017). Theories of memory and aging: A look at the past and a glimpse of the future. *Journals of Gerontology: Psychological Sciences*, *72*(1), 82–90. doi:10.1093/geronb/gbw066

Peters, E., Dieckmann, N. F., & Weller, J. (2011). Age differences in complex decision making. In *Handbook of the psychology of aging* (pp. 133–151). Academic Press. doi:10.1016/B978-0-12-380882-0.00009-7

Rhodes, M. G. (2016). Judgments of learning. In J. Dunlosky & S. K. Tauber (Eds.), *The Oxford handbook of metamemory* (pp. 65–80). New York: Oxford University Press. doi:10.1093/oxfordhb/9780199336746.013.4

Rönnlund, M., Karlsson, E., Laggnäs, E., Larsson, L., & Lindström, T. (2005). Risky decision making across three arenas of choice: Are younger and older adults differently susceptible to framing effects? *The Journal of General Psychology*, *132*(1), 81–93. doi:10.3200/GENP.132.1.81-93

Salthouse, T. A. (2010). Selective review of cognitive aging. *Journal of the International Neuropsychological Society*, *16*(5), 754–760. doi:10.1017/S1355617710000706

Samanez-Larkin, G. R., Gibbs, S. E., Khanna, K., Nielsen, L., Carstensen, L. L., & Knutson, B. (2007). Anticipation of monetary gain but not loss in healthy older adults. *Nature Neuroscience*, *10*(6), 787–791. doi:10.1038/nn1894

Schwartz, S. T., Siegel, A. L. M., Eich, T. S., & Castel, A. D. (2023). Value-directed memory selectivity relies on goal-directed knowledge of value structure prior to encoding in young and older adults. *Psychology and Aging*, *38*(1), 30–48. doi:10.1037/pag0000720

Seaman, K. L., Leong, J. K., Wu, C. C., Knutson, B., & Samanez-Larkin, G. R. (2017). Individual differences in skewed financial risk-taking across the adult life span. *Cognitive, Affective, & Behavioral Neuroscience*, *17*(6), 1232–1241. doi:10.3758/s13415-017-0545-5

Simon, A. F., Fagley, N. S., & Halleran, J. G. (2004). Decision framing: Moderating effects of individual differences and cognitive processing. *Journal of Behavioral Decision Making*, *17*(2), 77–93. doi:10.1002/bdm.463

Steiger, A., & Kühberger, A. (2018). A meta-analytic re-appraisal of the framing effect. *Zeitschrift für Psychologie*, *226*(1), 45–55. doi:10.1027/2151-2604/a000321

Strough, J., Karns, T. E., & Schlosnagle, L. (2011). Decision-making heuristics and biases across the life span. *Annals of the New York Academy of Sciences*, *1235*(1), 57–74. doi:10.1111/j.1749-6632.2011.06208.x

Thaler, R. (1999). Mental accounting matters. *Journal of Behavioral Decision Making*, *12*(3), 183–206. doi:10.1002/(SICI)1099-0771(199909)12:3<183:AID-BDM318>3.0.CO;2-F

Thomas, A. K., & Millar, P. R. (2012). Reducing the framing effect in older and younger adults by encouraging analytic processing. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *67*(2), 139–149. doi:10.1093/geronb/gbr076

Tversky, A. (1994). Contingent preferences: LA and tradeoff contrast in decision making. *Japanese Psychological Research*, *36*(1), 3–9. doi:10.4992/psycholres1954.36.3

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science: Advanced Materials and Devices*, *211*(4481), 453–458. doi:10.1126/science.7455683

Tversky, A., & Kahneman, D. (1991). LA in Riskless choice: A reference-dependent model. *The Quarterly Journal of Economics*, *107*(4), 1039–1061. doi:10.2307/2937956

Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. *Journal of Risk and Uncertainty*, *5*(4), 297–323. doi:10.1007/BF00122574

Weller, J. A., Levin, I. P., Shiv, B., & Bechara, A. (2009). The effects of insula damage on decision-making for risky gains and losses. *Social Neuroscience*, *4*(4), 347–358. doi:10.1080/17470910902934400

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. M. Hess, & D. R. Touron (Eds.), *Multiple pathways of cognitive aging: Motivational and contextual influences* (pp. 40–65). Oxford University Press.

Whitney, P., Rinehart, C. A., & Hinson, J. M. (2008). Framing effects under cognitive load: The role of working memory in risky decisions. *Psychonomic Bulletin & Review*, *15*(6), 1179–1184. doi:10.3758/PBR.15.6.1179

Witherby, A. E., Tauber, S. K., Rhodes, M. G., & Castel, A. D. (2019). Aging and forgetting: Forgotten information is perceived as less important than is remembered information. *Psychology and Aging*, *34*(2), 228–241. doi:10.1037/pag0000322