Age-Related Differences in Selective Associative Memory: Implications for Responsible Remembering

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Abstract

While often showing associative memory deficits, there may be instances when older adults selectively remember important associative information. We presented younger and older adults with children they would be hypothetically babysitting, and each child had three preferences: a food they like, a food they dislike, and a food they are allergic to and must avoid. In Experiment 1, all foods associated with each child were simultaneously presented while in Experiments 2 and 3, participants self-regulated their study of the different preferences for each child. We were interested in whether people, particularly older adults who often display associative memory impairments, can prioritize the most important information with consequences for forgetting (i.e., allergies), especially with increased task experience. Overall, compared with younger adults, older adults were better at selectively studying and recalling the children's allergies relative to the other preferences, and these patterns increased with task experience. Together, the present results suggest that both younger and older adults can employ strategies that enhance the recall of important information, illustrating *responsible remembering*. Specifically, both younger and older adults can learn to self-assess and prioritize the information that they need to remember, and despite memory deficits, older adults can learn to employ strategies that enhance the recall of important information, using metacognition and goal-directed remembering to engage in *responsible remembering*.

Keywords: memory, responsible remembering, aging, metacognition, importance

Age-Related Differences in Selective Associative Memory:

Implications for Responsible Remembering

Older adults often experience declines in various forms of memory (Craik, 2022), but there are situations in which older adults can overcome memory deficits to selectively remember important information (Castel et al., 2012; Knowlton & Castel, 2022). For example, despite an overall memory deficit, older adults can remember high-value information as well as younger adults (e.g., Castel et al., 2002). Thus, older adults are often aware of memory challenges and may use this awareness to focus on remembering information that is important, sometimes at the expense of less important information (Castel, 2008; Castel et al., 2012).

Metacognition refers to one's beliefs and knowledge about how their memory works and can play a crucial role in what and how much information is accurately remembered (Koriat, 2007; Nelson & Narens, 1990). Specifically, people rely on metacognition to manage their allocation of cognitive resources and the subsequent remembering of valuable information depends on those resources being properly used. In older populations, metacognition is particularly important because of their reduced cognitive resources (Balota et al., 2000) and the need to use them strategically. Thus, determining the value or importance of information (as well as the costs of forgetting) and selectively encoding information accordingly may be crucial in people with declining memory abilities such as older adults.

One aspect of memory that is particularly difficult for older adults is associative memory/binding: the ability to link pieces of information together in memory (e.g., Berry et al., 2013; Castel & Craik, 2003; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003; Old & Naveh-Benjamin, 2008). For example, associative memory deficits can lead to difficulties in remembering names and faces or learning new information about someone. In older adults, an associative deficit has been documented using paired-associate learning paradigms where a cue word and a target word are presented together during a study period and participants are later asked to recall the target word based on the cue. Since older adults may be aware of this deficit (Berry et al., 2013), the metacognitive awareness of associative memory impairments could influence future memory behavior. Thus, considering their associative memory impairments, it may be especially advantageous for older adults to prioritize and focus on only the most pertinent associations when learning new associative information, particularly if it is relevant to their goals, as this prioritizing process may help them compensate for their associative memory deficits by remembering what is most important.

A mechanism that might aid older adults maximize the utility of their memory is engaging in *responsible remembering* in which one prioritizes important information with consequences for forgetting both in terms of study time allocation and memory (Murphy & Castel, 2020, 2021a, 2021b, 2022a, 2022b, 2023; Murphy et al., 2022a; Murphy & Knowlton, 2022; Murphy, 2023). The notion of *responsible remembering* stems from more accurate metacognition and allows for the strategic allocation of attention toward important information to avoid potentially tragic consequences of forgetting. Although cognitive aging often results in a systematic decline in various forms of attention and memory (Balota et al., 2000; Craik & Salthouse, 2011), having experienced more instances of forgetting, older adults may have adapted to engage in responsible remembering to combat memory deficits (e.g., Murphy & Castel, 2022a, 2023). For example, May and colleagues (2005) demonstrated that although older adults are worse at remembering non-emotional information linked to presented food items (e.g., location and serving temperature), older adults can remember associative safety information (e.g., whether a food is safe to eat) as well as younger adults. Thus, older adults may focus on information that is important and relevant to their interests and goals to maximize memory utility (see also Castel, 2008).

Despite an associative memory deficit, task experience and interventions can update learning by helping older adults learn to prioritize important information by selectively remembering given associations if they are likely to be important later (e.g., Friedman et al., 2015; McGillivray & Castel, 2011; Middlebrooks et al., 2016a). This could take the form of remembering medication warnings (e.g., Hargis & Castel, 2018a, 2018b), the names and faces of people that one cares about (e.g., Hargis & Castel, 2017), important things to pack for a camping trip (Murphy & Castel, 2022a), or valuable translations when traveling to a foreign country (Murphy et al., 2023). Thus, while older adults' associative memory impairments could prevent the initial learning of information and lead to deficits in recalling it when it is most needed, older adults may engage in the efficient and responsible use of selective memory to remember important health information, exemplifying the use of *responsible remembering* in an associative memory context.

Again, despite many cognitive abilities generally declining with age (cf. Craik, 2022; Hess, 2005; Park & Festini, 2017; Salthouse, 2010), older adults can often remember important information as well as younger adults by selectively prioritizing and encoding valuable information at the expense of less important information (e.g., Castel et al., 2002, 2007, 2013; Knowlton & Castel, 2022; but see Murphy & Castel, 2022c, 2023). By determining what information is most important, or what information would have the biggest consequence if forgotten, older adults can enhance their metacognitive judgments and memory for what they believe they will remember. For example, McGillivray and Castel (2011) used a value-directed remembering task with a metacognitive "betting" component (i.e., participants bet on whether they would remember words and inaccurate bets hurt their scores) to demonstrate that, with increased task experience, both younger and older adults learn to become more accurate in their metacognitive judgments. Specifically, despite remembering fewer words, older adults scored similarly to younger adults, suggesting that when there are consequences for failing to recall information, older adults can implement strategies that lead to more accurate metacognition and better memory of important information. Thus, having experienced more memory failures, older adults may become aware of their memory capacity limitations and recruit these metacognitive insights to selectively remember valuable information.

One theoretical framework fitting with older adults' ability to recall valuable information is selective optimization with compensation (Baltes, 1997; Baltes & Baltes, 1990; Freund & Baltes, 2000). According to this framework, older adults experience various memory issues and compensate for memory deficiencies by adjusting their goals and expectations. Specifically, older adults may learn to strategically focus on valuable or goal-related information at the expense of less valuable or relevant information as a means of compensating for age-related memory impairments (e.g., Castel, 2008; Castel et al., 2013; Siegel & Castel, 2018; see also Bäckman & Dixon, 1992; Baltes & Baltes, 1990). For example, Murphy and Castel (2022a) demonstrated that older adults use importance to guide the encoding and retrieval of important information and reduce consequences for forgetting by strategically forgetting less important information. This aligns with younger adults generally reporting more growth-oriented goals while older adults report more maintenance or loss prevention goals (Ebner et al., 2006; Freund, 2008). Thus, the availability of cognitive resources may impact whether one's goals are more focused on maximizing gains or minimizing losses, which may impact their ability to engage in responsible remembering.

The Current Study

Prior work has examined responsible remembering by presenting younger adults with lists of children and their food preferences (foods they like, dislike, or are allergic to) to remember for a later test (participants were told that they would be taking care of the children in the future and babysitting; see Murphy & Castel, 2021a; Murphy et al., 2022a). Results demonstrated that younger adults failed to prioritize (both in terms of study time and recall) the most important information with consequences if forgotten (i.e., the children's allergies) unless asked to evaluate the importance of each food preference category. Although younger adults may require a metacognitive intervention in the form of a judgment of importance (JOI) to selectively focus on important information, older adults may have adapted to engage more in responsible remembering, resulting in better memory of children's allergies to avoid the negative outcomes of forgetting. Alternatively, relative to younger adults, older adults better remember positive compared to negative information (Charles & Carstensen, 2010; Rahhal et al., 2002) and in this paradigm, a child's likes are more positive while dislikes are more negative which may differentially impact how these categories of information influence younger and older adults' allocation of attention and subsequent memory.

In the present study, we investigated whether older adults can selectively remember associations with consequences if forgotten (i.e., the child and their specific allergies). We also examined how task experience may update learning based on observations of forgetting (see Halamish et al., 2011) and whether older adults adaptively engage in *responsible remembering* to compensate for declines in memory by systematically shifting their attention and showing a focus on items of importance resulting in the greater recall of these items. To test this metacognitive mechanism and instill consequences for misguided metacognition, we presented younger and older adults with hypothetical children, their food preferences, and foods they are allergic to and later tested them to determine if people (particularly older adults) learn to selectively focus on remembering the children's allergies (adapted from Murphy & Castel, 2021a; Murphy et al., 2022a).

Experiment 1

In Experiment 1, we examined how younger and older adults prioritized memory for important information with consequences if forgotten. Participants were presented with lists of children, each with a food they like, a food they dislike, and a food they are allergic to and must avoid. Following the presentation of each list, participants were cued with the children (one at a time) and asked to recall their associated food preferences and allergies. We expected younger adults to fail to prioritize the allergies (e.g., Murphy & Castel, 2021a; Murphy et al., 2022a) but for older adults to engage in responsible remembering by best remembering the children's allergies. Specifically, we expected that older adults would be strategic rememberers by systematically remembering the most important information (allergies) to avoid negative outcomes for forgetting, particularly as they gain task experience.

Method

Participants. Data in each experiment were collected in the Winter of 2023. After exclusions, younger adults were 58 undergraduate students (age range: 18-31; M_{age} = 20.45, SD_{age} = 1.81; 54 female, 4 male; 25 Asian/Pacific Islander, 2 Black, 8 Hispanic, 20 white, 3 other/unknown) recruited from the University of California Los Angeles (UCLA) Human Subjects Pool. In each experiment, participants were tested online and received course credit for their participation. Older adults (n = 55; age range: 60-93; M_{age} = 73.55, SD_{age} = 6.53; 35 female, 20 male; 1 Asian/Pacific Islander, 1 Black, 1 Hispanic, 52 white) were recruited from Amazon's Cloud Research (Chandler et al., 2019), a website that allows users to complete small tasks for pay. In each experiment, our only exclusion criteria were if participants admitted to cheating (e.g., writing down answers) in a post-task questionnaire (they were told they would still receive credit if they cheated)—no other attention checks were included. This exclusion process resulted in the exclusion of no younger adults and two older adults. 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 et al., 2022a, 2023). As such, based on the expectation of detecting a medium effect size, in each experiment, we aimed to collect around 50 younger adults and 50 older adults in each condition.

Materials. The stimuli consisted of 72 food-related items (e.g., bread, apples, milk). Images of children were taken from Google and randomly given arbitrary names. All children were of similar apparent age (around 5 years old). The full stimuli set is available on OSF.

Procedure. Participants were told to imagine that they would be meeting several children that they would be taking care of and babysitting for a week. Specifically, participants were instructed: "For this task, please imagine that you are meeting several children that you will be taking care of and babysitting for a week. Each child has a food they like, a food they dislike, and a food that they are allergic to and must avoid. You will have 15 seconds to study the information associated with each child and your job is to remember this information for a later test where you will see the children again and need to recall the information associated with each kid. Again, imagine that you are babysitting these children and that you are responsible for their well-being. Your job is to remember the food preferences associated with each child." Following the instructions, participants were shown pictures of children; each child had a name, one food they like, one food they dislike, and one food that they are allergic to and must avoid. An example of the study and test phase can be seen in Figure 1 (see also Murphy et al., 2022a).

The to-be-remembered children on each list were two boys and two girls. Food items were used only once throughout the task and were randomly paired with each child and randomly presented as either a like, dislike, or allergy. Likes were always at the top of the screen, dislikes were always in the middle, and allergies were always at the bottom (see Murphy & Castel, 2021a for tests of order effects). During the study phase, each child's name, a picture of the child, and their food preferences were shown for 15 seconds. After the study phase, participants were cued with the name and picture of each child, one at a time, in random order, and asked to recall the child's information (they could recall items in any order they wished). Participants typed their responses into individual text boxes for each food (see Figure 1b) and were given as much time as they needed to recall the foods associated with each child (but were required to spend at least 10 seconds on each child in the test phase) and also were required to indicate whether each recalled item was a like, dislike, or allergy; participants could not advance to the next screen until all recalled items were paired with a preference. This was repeated for a total of six study-test cycles, with new food preferences paired with new children on each list. The task was scored such that items were only considered correct if they were correctly paired with each child and the correct preference.

At the end of the task, participants completed a brief questionnaire where we asked them which food category they felt was most important to remember, what encoding strategies they used for each category, whether they have children, whether they have grandchildren, how many years of babysitting experience they have, and whether they have any allergies. These data are not reported but are available on OSF; however, younger and older adults' selections (across experiments) for which food category they felt was most important to remember are shown in Figure 2. An independent samples *t*-test indicated that a greater proportion of older adults selected allergies relative to younger adults [$t(336) = 2.52$, $p = .012$, $d = .27$].

Results

To examine recall, we computed multilevel models (MLMs) using Jamovi where we treated the data as hierarchical or clustered (i.e., multilevel) with items nested within individual participants; since food items were fully randomized (i.e., any food item could appear on any list, with any child, and as any preference), we did not treat the slope of each item as a random effect. Since recall at the item level was binary (correct or incorrect), we conducted logistic MLMs. 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 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 changed. Specifically, values greater than 1 represent an increased likelihood of recall while values less than 1 represent a decreased likelihood of recall.

Recall as a function of age and preference is shown in Figure 3. To examine potential differences, we modeled recall as a function of age group (young, old), preference (likes, dislikes, allergies; allergies were the reference group), and list (as a continuous variable). Results from our model revealed that younger adults recalled a greater proportion of foods ($M = .43$, $SD = .17$) than older adults ($M = .29$, $SD = .24$), [$e^B = 2.19$, $CI_{95\%} = 1.45 – 3.30$, $z = 3.74$, $p < .001$]. Additionally, there was an effect of list [$e^B = .92$, $CI_{95\%} = .89 – .95$, $z = -5.43$, $p < .001$] such that recall declined as participants gained task experience, likely the result of increased interference. The allergies were better recalled ($M = .41$, $SD = .23$) than the dislikes ($M = .30$, $SD = .24$), [$e^B = .51$, $CI_{95\%}$ =

.45 – .58, z = -10.16, p < .001] as well as the likes (M = .38, SD = .25), [e^B = .82, $CI_{95\%}$ = .73 – .93, z = -3.07, p = .002]. The comparison between the dislikes and the allergies interacted with age [e^B = 1.89, $CI_{95\%}$ = 1.46 – 2.44, z = 4.80, p < .001], as did the comparison between the likes and the allergies [e^B = 1.29, $CI_{95\%}$ = 1.01 – 1.65, z = 2.05, p = .041]. Specifically, an analysis of the simple effects revealed that, for older adults, the allergies were better recalled than the dislikes [e^B = .37, $CI_{95\%}$ = .30 – .46, z = -9.54, p < .001] as well as the likes [e^B = .73, $CI_{95\%}$ = .60 – .87, z = -3.36, p < .001]. However, for younger adults, while the allergies were better recalled than the dislikes [e^B = .70, $CI_{95\%}$ = .60 – .82, z = -4.32, p < .001], the allergies were not better recalled than the likes [e^B = .94, $CI_{95\%}$ = .80 – 1.10, z = -.79, p = .428]. Together, this indicates that older adults selectively remembered the allergies relative to the other preferences to a greater extent than younger adults.

In terms of interactions with list, list did not interact with age [e^B = .96, $CI_{95\%}$ = .90 – 1.02, z = -1.27, p = .203] such that recall declined as the task endured for both younger and older adults. The comparison between the dislikes and the allergies interacted with list [e^B = .91, $CI_{95\%}$ = .84 – .98, z = -2.43, p = .015], as did the comparison between the likes and the allergies [e^B = .90, $CI_{95\%}$ = .84 – .96, z = -2.94, p = .003], such that the tendency for participants to selectively recall the allergies over the other preferences increased with task experience. However, there was not a three-way interaction between age, list, and the comparison between the dislikes and the allergies [e^B = 1.08, $CI_{95\%}$ = .93 – 1.25, z = .95, p = .340] or a three-way interaction between age, list, and the comparison between the likes and the allergies [e^B = 1.08, $CI_{95\%}$ = .93 – 1.24, z = .99, p = .320].

Discussion

In Experiment 1, results revealed that younger adults better recalled the allergies compared to the dislikes, but the allergies and likes were similarly recalled. In contrast, older adults selectively remembered the allergies over both other preferences, indicating a greater engagement in responsible remembering to avoid the negative consequences of forgetting. Thus, Experiment 1 provides evidence that older adults may be more strategic in their prioritization of remembering important information compared with younger adults.

Experiment 2

In Experiment 2, we investigated how younger and older adults strategically encoded the food items in the different categories. Specifically, we allowed participants to self-regulate the study phase such that, during the presentation of each child, participants could only view a single preference at a time (see Figure 4 for an example). Thus, we were able to track how younger and older adults distributed their study time between the different food preferences. We expected older adults to spend relatively more time on the allergies than the other categories compared with younger adults, leading to a greater recall of the allergies in older adults' recall as observed in Experiment 1.

Method

Participants. After exclusions, younger adults were 55 undergraduate students (age range: 18-22; M_{age} = 19.89, SD_{age} = 1.15; 44 female, 11 male; 1 American Indian/Alaskan Native, 28 Asian/Pacific Islander, 4 Hispanic, 20 white, 2 other/unknown) recruited from the UCLA Human Subjects Pool. Older adults (n = 58; age range: 61-88; M_{age} = 72.81, SD_{age} = 6.17; 35 female, 23 male; 2 Black, 56 white) were recruited from Amazon's Cloud Research. Zero younger adults and three older adults were excluded for cheating.

Procedure and Materials. The task in Experiment 2 was similar to the task in Experiment 1 (i.e., six lists of four kids, 15 seconds of study time for each kid, etc.) except that on each trial, participants could only view one of the food preferences at a time and self-regulated their study of the likes, dislikes, and allergies. Participants clicked on an opaque box beneath each category label to reveal the food item in the category and when they clicked on a new category, the previously studied item became hidden again. At the top of their screen, participants were given a clock indicating the total study time remaining (in seconds) for each child. An example of the study phase is shown in Figure 4.

Results

Study time as a function of age and preference is shown in Figure 5. To examine potential differences, we modeled study time as a function of age group (young, old), preference (likes, dislikes, allergies; allergies were the reference group), and list. Results from our model revealed that younger adults spent more time (seconds)[1] studying each child's preferences (M = 13.03, SD = 1.06) than older adults (M = 11.85, SD = 1.16), [Estimate: .39, $CI_{95\%}$ = .26 – .53, $t(111) = 5.64$, $p < .001$], indicating that younger adults were quicker to make their first study selection. However, there was not an effect of list [Estimate: .01, $CI_{95\%}$ = -.02 – .04, $t(8013) = .81$, $p = .418$]. Each child's allergies were studied longer (M = 6.48, SD = 2.03) than their dislikes (M = 2.80, SD = 1.00), [Estimate: -3.67, $CI_{95\%}$ = -3.80 – -3.54, $t(8013) = -55.78$, $p < .001$] as well as their likes (M = 3.15, SD = 1.25), [Estimate: -3.32, $CI_{95\%}$ = -3.45 – -3.20, $t(8013) = -50.54$, $p < .001$]. The comparison between the dislikes and the allergies interacted with age [Estimate: .77, $CI_{95\%}$ = .51 – 1.03, $t(8013) = 5.86$, $p < .001$], as did the comparison between the likes and the allergies [Estimate: .52, $CI_{95\%}$ = .26 – .78, $t(8013) = 3.95$, $p < .001$]. Specifically, an analysis of the simple effects revealed that, relative to younger adults, older adults spent more time studying the allergies than the dislikes [older adults: Estimate: -4.05, $CI_{95\%}$ = -4.23 – -3.87, $t(8013) = -44.18$, $p < .001$;

[1] We note that average study time was less than 15 seconds as all items were covered by an opaque box until participants made their first study decision. Thus, the time preceding participants' first study decision was not counted towards total study time.

younger adults: Estimate: -3.28, $CI_{95\%}$ = -3.47– -3.10, $t(8013) = 34.83$, $p < .001$] as well as the likes [older adults: Estimate: -3.58, $CI_{95\%}$ = -3.76– -3.40, $t(8013) = -39.05$, $p < .001$; younger adults: Estimate: -3.06, $CI_{95\%}$ = -3.25– -2.88, $t(8013) = -32.52$, $p < .001$]. Collectively, this indicates that older adults prioritized allergies relative to the other preferences in their allocation of study time to a greater extent than younger adults (i.e., younger adults spent significantly more time studying the allergies than the likes and dislikes, but there was not as much of a relative difference compared with older adults).

In terms of interactions with list, list interacted with age [Estimate: -.07, $CI_{95\%}$ = -.13 – -.01, $t(8013) = -2.10$, $p = .036$] such that older adults only spent less time studying relative to younger adults on early lists (but older adults spent a similar amount of time studying the preferences as younger adults on later lists). The comparison between dislikes and allergies interacted with list [Estimate: -.36, $CI_{95\%}$ = -.43 – .28, $t(8013) = -9.30$, $p < .001$], as did the comparison between likes and allergies [Estimate: -.32, $CI_{95\%}$ = -.40 – -.25, $t(8013) = -8.40$, $p < .001$], such that the tendency for participants to prioritize the allergies over the other preferences in their distribution of study time increased with task experience. However, there was not a three-way interaction between age, list, and the comparison between dislikes and allergies [Estimate: .13, $CI_{95\%}$ = -.02 – .28, $t(8013) = 1.67$, $p = .095$] or a three-way interaction between age, list, and the comparison between likes and allergies [Estimate: .08, $CI_{95\%}$ = -.07 – .23, $t(8013) = 1.00$, $p = .318$].

Recall as a function of age and preference is shown in Figure 6. To examine potential differences, we modeled recall as a function of age group (young, old), preference (likes, dislikes, allergies; allergies were the reference group), and list. Results from our model revealed that younger adults recalled a greater proportion of foods ($M = .48$, $SD = .19$) than older adults ($M =$

.21, *SD* = .18), [$e^B = 4.76$, $CI_{95\%} = 3.15 – 7.20$, $z = 7.40$, $p < .001$]. Additionally, there was an effect of list [$e^B = .94$, $CI_{95\%} = .91 – .97$, $z = -3.84$, $p < .001$] such that recall generally declined as participants gained task experience. Allergies were better recalled (*M* = .36, *SD* = .24) than dislikes (*M* = .29, *SD* = .24), [$e^B = .63$, $CI_{95\%} = .55 – .73$, $z = -6.64$, $p < .001$] but not the likes (*M* = .37, *SD* = .27), [$e^B = 1.04$, $CI_{95\%} = .91 – 1.18$, $z = .54$, $p = .590$]. The comparison between the dislikes and the allergies interacted with age [$e^B = 1.37$, $CI_{95\%} = 1.04 – 1.79$, $z = 2.28$, $p = .023$] and an analysis of the simple effects revealed that older adults demonstrated a greater difference in recall for the allergies relative to the dislikes [$e^B = .54$, $CI_{95\%} = .44 – .67$, $z = -5.67$, $p < .001$] compared with younger adults [$e^B = .74$, $CI_{95\%} = .63 – .88$, $z = -3.53$, $p < .001$]. However, the comparison between the likes and the allergies did not interact with age [$e^B = 1.11$, $CI_{95\%} = .86 – 1.43$, $z = .77$, $p = .440$]. Together, this indicates that older adults selectively recalled the allergies relative to the dislikes to a greater extent than younger adults.

In terms of interactions with list, list did not interact with age [$e^B = .95$, $CI_{95\%} = .89 – 1.01$, $z = -1.62$, $p = .105$] such that recall declined as the task endured for both younger and older adults. The comparison between dislikes and allergies interacted with list [$e^B = .91$, $CI_{95\%} = .84 – .98$, $z = -2.44$, $p = .015$] such that the tendency for participants to recall more allergies than dislikes increased with task experience. However, the comparison between likes and allergies did not interact with list [$e^B = .98$, $CI_{95\%} = .91 – 1.05$, $z = -.64$, $p = .524$]. There was not a three-way interaction between age, list, and the comparison between dislikes and allergies [$e^B = .96$, $CI_{95\%} = .82 – 1.13$, $z = -.45$, $p = .653$] or a three-way interaction between age, list, and the comparison between likes and allergies [$e^B = .97$, $CI_{95\%} = .84 – 1.13$, $z = -.39$, $p = .699$].

Discussion

In Experiment 2, results revealed that both younger and older adults prioritized studying the foods the children were allergic to, but this effect was more prominent in older adults. However, this did not translate to recall performance such that the children's allergies were recalled better than the dislikes but not the likes (although older adults selectively recalled the allergies relative to the dislikes to a greater extent than younger adults). Thus, allowing participants to self-regulate their study time appears to have reduced their ability to engage in responsible remembering despite allocating their study time responsibly, but older adults still demonstrated a greater relative prioritization of the allergies compared with younger adults.

Experiment 3

In Experiments 1 and 2, relative to younger adults, older adults generally seemed to selectively encode and allocate attention toward the most important information (i.e., allergies) at the expense of less important information (i.e., likes, dislikes), illustrating responsible remembering. However, it is possible that older adults' ability to engage in responsible remembering may depend on the conditions of the task or environment (e.g., time pressure). In daily life, people often find themselves overwhelmed with information to remember and may be under time constraints in terms of selecting what is most important to remember. For instance, older adults might need to remember important medical information while consulting with a doctor or pharmacist in a limited time frame such as a rapidly presented list of medication side effects (Hargis & Castel, 2018a, 2018b). As such, in Experiment 3, we investigated older adults' ability to selectively remember important information when rushed and or/under time pressure.

Previous research has demonstrated that both younger and older adults can prioritize the encoding and retrieval of high-value information over low-value information when given sufficient study time (e.g., Castel et al., 2002). Moreover, even when given insufficient study time, prior work has found that younger adults can still selectively encode and remember such information (Middlebrooks et al., 2016b). However, it is unclear whether older adults can still prioritize important information when time is limited and constrained. Unlike younger adults, older adults experience difficulties with selective attention and processing speed which could negatively impact their ability to selectively encode and retrieve important information when rushed (Hess, 2005; Park & Festini, 2017; Salthouse, 2010). Alternatively, when older adults become more aware of the limited time frame, this might encourage selectivity if they realize that they cannot encode and remember all the presented information. Thus, with task experience and awareness of limited time, older adults may selectively focus on the foods that have the most consequences if forgotten via responsible remembering.

In Experiment 3, to induce a feeling of being rushed, younger and older adults were given 30 seconds of study time for each child on the first three lists and 15 seconds of study time for each child on the last three lists. As in Experiment 2, participants were allowed to distribute their study time among the different preferences for each child. We hypothesized that, despite time constraints, older adults would demonstrate a greater prioritization of children's allergies on the rushed lists as there may be an increased awareness of the importance of not forgetting critical information and the need to selectively attend to the most valuable details.

Method

Participants. After exclusions, younger adults were 57 undergraduate students (age range: 18-33; M_{age} = 20.53, SD_{age} = 2.35; 43 female, 14 male; 20 Asian/Pacific Islander, 1 Black, 17 Hispanic, 17 white, 2 other/unknown) recruited from the UCLA Human Subjects Pool. Older adults (n = 55; age range: 62-85; M_{age} = 71.22, SD_{age} = 5.75; 33 female, 22 male; 1 Asian/Pacific

Islander, 1 Black, 2 Hispanic, 51 white) were recruited from Amazon's Cloud Research. Zero younger adults and three older adults were excluded for cheating.

Procedure and Materials. The task in Experiment 3 was similar to the task in Experiment 2 except that on the first three lists, participants were given 30 seconds to study time to allocate for each child (rather than 15 seconds as in Experiment 2). However, to induce the feeling of being rushed, on the last three lists participants' study time was reduced to 15 seconds per child. Additionally, after being tested on the four children in each list, we asked participants to rate (on a 7-point Likert scale) how rushed they felt during the study phase.

Results

A 2 (age: young, old) x 2 (list type: not rushed, rushed) mixed-factor ANOVA revealed that participants rated feeling more rushed on lists with less study time ($M = 5.80$, $SD = 1.57$) than on lists with 30 seconds of study time per kid ($M = 4.35$, $SD = 1.80$), [$F(1, 110) = 180.12$, $p < .001$, $\eta_p^2 = .62$]. There was not an effect of age [$F(1, 110) = .04$, $p = .841$, $\eta_p^2 < .01$] such that younger adults ($M = 5.11$, $SD = 1.08$) felt similarly rushed as older adults ($M = 5.05$, $SD = 1.96$). List type interacted with age [$F(1, 110) = 26.97$, $p < .001$, $\eta_p^2 = .20$] but the pairwise comparisons of interest did not reach significance [all *p*s > .107].

Study time as a function of age and preference on each list type (not rushed, rushed) is shown in Figure 7. To examine potential differences, we modeled study time as a function of age group (young, old), preference (likes, dislikes, allergies; allergies were the reference group), and list type (not rushed, rushed). Results from our model revealed that younger adults spent more time (seconds) studying each child's preferences ($M = 20.29$, $SD = .89$) than older adults ($M = 18.83$, $SD = 1.84$), [Estimate: .49, $CI_{95\%} = .31 – .66$, $t(110) = 5.37$, $p < .001$], again indicating that younger adults were quicker to make their first study selection. There was also an effect of list type

[Estimate: -4.72, $CI_{95\%}$ = -4.89 – -4.55, $t(7942) = -54.40$, $p < .001$] such that participants spent more time on Lists 1-3 (as per the procedure). Each child's allergies were studied longer (M = 10.08, SD = 2.51) than their dislikes (M = 4.40, SD = 1.30), [Estimate: -5.68, $CI_{95\%}$ = -5.89 – -5.47, $t(7942) = -53.43$, $p < .001$] as well as their likes (M = 5.09, SD = 1.66), [Estimate: -4.99, $CI_{95\%}$ = -5.20 – -4.79, $t(7942) = -46.97$, $p < .001$]. The comparison between the dislikes and the allergies did not interact with age [Estimate: .24, $CI_{95\%}$ = -.18 – .66, $t(7942) = 1.13$, $p = .259$] nor did the comparison between the likes and the allergies [Estimate: .06, $CI_{95\%}$ = -.36 – .48, $t(7942)$ = .29, $p = .775$]. Together, this indicates that participants prioritized allergies relative to the other preferences in their allocation of study time, but this did not differ between younger and older adults.

In terms of interactions with list type, list type did not interact with age [Estimate: -.23, $CI_{95\%}$ = -.57 – .11, $t(7942) = -1.33$, $p = .183$]. The comparison between the dislikes and the allergies interacted with list type [Estimate: 4.13, $CI_{95\%}$ = 3.71 – 4.54, $t(7942) = 19.41$, $p < .001$], as did the comparison between the likes and the allergies [Estimate: 4.17, $CI_{95\%}$ = 3.75 – 4.58, $t(7942)$ = 19.60, $p < .001$], such that the tendency for participants to prioritize the allergies over the other preferences in their distribution of study time increased on rushed lists. However, there was not a three-way interaction between age, list type, and the comparison between dislikes and allergies [Estimate: -.70, $CI_{95\%}$ = -1.54 – .13, $t(7942) = -1.65$, $p = .099$] but there was a three-way interaction between age, list type, and the comparison between likes and allergies [Estimate: -1.85, $CI_{95\%}$ = -2.68 – -1.02, $t(7942) = -4.35$, $p < .001$] such that the difference between the allergies and the likes was smaller for older adults on rushed lists.

Recall as a function of age and preference for each list type is shown in Figure 8. To examine potential differences, we modeled recall as a function of age group (young, old), preference (likes, dislikes, allergies; allergies were the reference group), and list type (not rushed, rushed). Results from our model revealed that younger adults recalled a greater proportion of foods (*M* = .53, *SD* = .22) than older adults (*M* = .29, *SD* = .21), [e^B = 3.68, $CI_{95\%}$ = 2.34 – 5.77, *z* = 5.67, *p* < .001]. Additionally, there was an effect of list type [e^B = .45, $CI_{95\%}$ = .40 – .50, *z* = -14.85, *p* < .001] such that recall was better when there was more study time. The allergies were better recalled (*M* = .43, *SD* = .26) than the dislikes (*M* = .36, *SD* = .26), [e^B = .65, $CI_{95\%}$ = .57 – .74, *z* = -6.54, *p* < .001] but not the likes (*M* = .43, *SD* = .27), [e^B = 1.01, $CI_{95\%}$ = .89 – 1.15, *z* = .18, *p* = .854]. The comparison between the dislikes and the allergies interacted with age [e^B = 1.37, $CI_{95\%}$ = 1.06 – 1.78, *z* = 2.37, *p* = .018] and an analysis of the simple effects revealed that older adults demonstrated a greater difference in recall for the allergies relative to the dislikes [e^B = .55, $CI_{95\%}$ = .45 – .67, *z* = -5.85, *p* < .001] compared with younger adults [e^B = .76, $CI_{95\%}$ = .64 – .90, *z* = -3.22, *p* = .001]. However, the comparison between the likes and the allergies did not interact with age [e^B = 1.00, $CI_{95\%}$ = .78 – 1.29, *z* < .01, *p* = .998]. Collectively, this indicates that older adults selectively recalled the allergies relative to the dislikes (but not the likes) to a greater extent than younger adults.

In terms of interactions with list type, list type did not interact with age [e^B = .90, $CI_{95\%}$ = .73 – 1.11, *z* = -1.00, *p* = .318] such that recall was worse with less study time for both younger and older adults. Additionally, the comparison between the dislikes and the allergies did not interact with list type [e^B = .83, $CI_{95\%}$ = .64 – 1.08, *z* = -1.41, *p* = .160] nor did the comparison between the likes and the allergies [e^B = 1.00, $CI_{95\%}$ = .78 – 1.29, *z* = .01, *p* = .988]. Finally, there was not a three-way interaction between age, list, and the comparison between dislikes and allergies [e^B = 1.08, $CI_{95\%}$ = .64 – 1.81, *z* = .28, *p* = .783] or a three-way interaction between age, list, and the comparison between likes and allergies [$e^B = .90$, $CI_{95\%} = .54 - 1.48$, $z = -.43$, $p = .670$].

Discussion

In Experiment 3, participants spent more time studying the allergies relative to the other preferences, but in contrast to Experiment 2, this did not differ between younger and older adults. Additionally, reducing learners' study time on the second half of the task did not have much of an effect on participants' prioritization of the allergies in study time or recall, although older adults selectively studied the allergies relative to the likes to a slightly smaller extent when rushed. However, participants recalled the allergies better than the dislikes (and this pattern was greater for older adults), but the allergies and likes were similarly recalled.

General Discussion

In the present study, we presented younger and older adults with images of children they would be hypothetically babysitting. Each child had a food they like, a food they dislike, and a food they are allergic to and must avoid. In Experiment 1, all the foods associated with each child were simultaneously presented (see Figure 1) while in Experiments 2 and 3, participants self-regulated their studying of the different preferences for each child (see Figure 4; see also Castel et al., 2013) as these different presentation formats can influence the learning of important information (see Middlebrooks & Castel, 2018). We were interested in whether learners, particularly older adults (who show deficits in associative memory, see Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003; Old & Naveh-Benjamin, 2008), prioritize the information with the most severe consequences for forgetting (i.e., allergies) in study time and memory, especially with increased task experience.

In Experiment 1, older adults prioritized the children's allergies relative to the other preferences to a greater extent than younger adults, but both younger and older participants' tendency to selectively recall the allergies relative to the other preferences increased with task experience. In Experiment 2, when participants were allowed to self-regulate how they studied the different food preferences, both younger and older adults strategically spent the most time studying the allergies, though this trend was greater in older adults. Surprisingly, this additional study time for the allergies relative to the other preferences did not yield a corresponding memory benefit in either the younger or older adults, potentially an illustration of the labor-in-vain hypothesis (Nelson & Leonesio, 1988; see also Whatley & Castel, 2022). Specifically, once a participant studied a child's allergy for a certain amount of time, additional study time may not have improved memorability. However, as a result of older adults being more strategic in their allocation of study time, older adults selectively recalled the allergies relative to the dislikes to a greater extent than younger adults.

In Experiment 3, we investigated whether rushing participants would result in more strategic memory (see Middlebrooks et al., 2016b). Using a similar design to Experiment 2, we allowed participants to self-regulate how they distributed their study time of each child's food preferences. However, on the first half of the task (i.e., the first three lists), participants were given 30 seconds to study the food preferences of each child but on the second half of the task (i.e., the last three lists), study time was reduced to 15 seconds per child. Results largely replicated Experiment 2 and our manipulation of study time generally did not impact strategic processes, suggesting that even under limited time constraints, learners prioritize important information in how they regulate their studying and in what they recall.

Together, the present results suggest that both younger and older adults engage in *responsible remembering* such that they can prioritize important information over less important information to minimize the consequences of forgetting (Murphy & Castel, 2020, 2021a, 2021b, 2022a, 2022b, 2023; Murphy et al., 2022a; Murphy & Knowlton, 2022; Murphy, 2023). Further, our findings suggest that, under certain conditions, older adults (despite age-related deficits in associative memory; Naveh-Benjamin, 2000; Naveh-Benjamin et al., 2003; Old & Naveh-Benjamin, 2008) may even be better responsible rememberers than younger adults. Although older adults had inferior memory overall compared to younger adults, the relative disparity in the allocation of study time and recall performance between allergies and other preferences was more pronounced in older adults. Thus, considering age-related differences in memory capacity, older adults better optimized their memory for the allergies by devoting less study time and encoding fewer liked and disliked foods, whereas younger adults displayed relatively less selectivity in study time allocation and recall for the allergies.

Notably, based on their total memory output (across experiments, younger adults recalled an average of around five or six items per list), younger adults could have remembered all four allergies per list, indicating sufficient memory capacity to retain all allergies along with at least one additional item. Consequently, younger adults could have exhibited a higher degree of responsible remembering. While older adults could also have exercised greater responsible remembering by selectively encoding and studying only the allergies (average recall for older adults was around three items per list so they could not have gotten all of the allergies), their recall for allergies surpassed that of other preferences to a greater extent compared with younger adults. Therefore, we conclude that older adults can outperform younger adults in responsible remembering in a task that utilizes associative memory with potential real-world implications. This could suggest that, unlike younger adults, some older adults may use responsible remembering to compensate for memory impairments especially when under pressure/time constraints; however, future research is needed to better understand the situations in which this is adaptive.

In some of our prior work, we demonstrated that the location of the preferences on the screen impacts memorability (i.e., the top-most item receives a memory benefit, see Murphy & Castel, 2021a, see also Murphy et al., 2022a, 2022b). Consequently, in the current study's paradigm, when participants were presented with each child's information, the likes were on the top of the screen, the dislikes beneath the likes, and the allergies appeared at the bottom of the screen, and this order of items was intentional to avoid allergies being prioritized because of the habitual reading bias or a primacy effect (Ariel et al., 2011). Thus, we theorized that if participants focused on and best remembered the allergies despite their suboptimal location on the screen, this would indicate responsible remembering rather than habitual biases. In the current study, we expected participants to initially show a habitual reading bias by focusing on and best remembering the information presented on the top-left of the screen (likes). However, as participants gained experience, we expected that responsible remembering would take precedence over habitual processes and participants (particularly older adults) would begin to systematically focus on and recall the critical information (the children's allergies) to maximize memory utility (Ariel & Dunlosky, 2013), and the results largely supported this hypothesis.

In each experiment, we observed declines in total recall on later lists, likely the result of interference. Specifically, it is possible that as participants engaged in multiple learning trials, interference from previously encoded information impeded their ability to encode and recall new information. Previous work has shown that recall performance for high-value items typically increases over task blocks in value-directed remembering paradigms (e.g., Castel et al., 2002), but a buildup of interference can impair some forms of memory selectivity (see Murphy & Castel, 2022c, 2023 for effects of interference). While the current task shares similarities with these previous paradigms, there are also important differences, including the use of limited study time, the distribution of study time across multiple categories of information, the associative binding required, and the buildup of interference of items from one category (foods) rather than unassociated word lists—these differences may have contributed to the decline in recall performance on later lists. Despite this decline, the tendency for participants to selectively recall the allergies over the other preferences often increased with task experience, demonstrating that learners can overcome interference to engage in responsible remembering.

Throughout this paper, we have argued that responsible remembering involves prioritizing memory for the information with the most severe consequences for forgetting (i.e., allergies); however, prioritizing the study of liked foods may seem like an intuitive, efficient, and reasonably responsible strategy in the current tasks. Although not exemplifying responsible remembering (as forgotten allergies typically have worse consequences than forgotten preferred foods), focusing on the foods the children like could be considered an efficient strategy as it would only require remembering one of the food items per child (a task that appears much more manageable than remembering all food items). Additionally, remembering liked foods would spare one the anger, crying, and/or tantrums when taking care of a child (compared to serving disliked food). At the same time, we argue that this focus would be reasonably irresponsible: only knowing foods children like does not prevent allergic reactions if said foods contain ingredients the child is allergic to (i.e., a child could be allergic to apples but like pie). Thus, in the current experiments, older adults exhibited responsible remembering by shifting their allocation of cognitive resources and subsequently better remembering the child's allergies as a function of task experience; it would be interesting and important for future research to explore whether older adults remember critical information after a delay and/or after experiencing some consequences of forgetting valuable information that might then inform future learning strategies.

It would also be interesting to examine retrieval dynamics such as output order and how much time younger and older adults spent trying to recall foods from each category. For example, if the foods the children like (which were always presented at the top of the screen) were frequently recalled first, this would indicate more serial processing (see Murphy et al., 2022b). Moreover, if participants spent more time attempting to remember the foods the children were allergic to, this may indicate that learners are more effortful in the retrieval of these items which would be another indicator of responsible remembering, and something older adults may need to engage in to combat rapid forgetting of important information.

One limitation of the present study is that it was conducted in a laboratory/research context which does not reflect the real-world consequences of forgetting critical information. When completing online tasks for researchers, the consequences of forgetting are not as severe as they would be in real life, where forgetting crucial information could have serious implications. Moreover, the present study was based on hypothetical scenarios, such as babysitting children, which may not fully capture the complexities and uncertainties of real-world situations. For instance, a babysitter may have to deal with unexpected events that require quick decision-making, potentially impacting their ability to recall information accurately. We also recruited and tested older participants using an online platform that may favor the participation of relatively high-functioning people (see Greene & Naveh-Benjamin, 2022), and it would be important in future research to extend these findings to other groups (such as parents, grandparents, caregivers and/or health care providers) as well as a broader and more diverse population. Therefore, while the present study provides valuable insights into how learners, particularly older adults, prioritize important information when there are consequences for forgetting, the present findings should be interpreted with caution, as they may not generalize to real-world settings. Thus, future research could explore responsible remembering in more realistic and challenging scenarios to determine the extent to which learners can apply these strategies in everyday situations, and how external aids/offloading and writing down reminders could influence how older adults remember important information.

Another limitation of the present experiments is that we did not include a measure of cognitive ability such as the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) or Mini-Mental State Examination (MMSE; see Tombaugh & McIntyre, 1992). As a result, it is possible that our samples include older individuals who fall below the typical cognitive ability cut-off for their age group. While the use of multilevel modeling (MLM) and clustering the data within individuals (as was employed in the present study) can partially account for individual differences in cognitive ability, it is important to acknowledge that older adults who would score below the typical threshold for healthy cognitive ability (as measured by their score on MoCA and/or MMSE) could be included in our analyses, unlike many healthy aging studies who often screen out such participants. As such, future research could include measures of cognitive ability to better control for individual differences in memory performance and explore the extent to which strategic memory processing accounts for age-related differences in memory performance. Future work could also benefit from larger sample sizes and/or include more learning trials as the complexity of our models made analyzing the power of the present experiments difficult.

When tasked with remembering information, older adults often show reduced recall (particularly for associative information) but demonstrate preserved selectivity for information with consequences if forgotten, particularly as they gain experience (e.g., McGillivray & Castel, 2011). Thus, while some cognitive functions may decline with age (Hess, 2005; Park & Festini, 2017; Salthouse, 2010), the strategic use of memory to focus on valuable information may remain intact. This may be especially true when older adults have sufficient task experience which would support the metacognition modifying attention processes (Castel et al., 2012). Specifically, with increased task experience, participants may shift their agendas (Ariel, 2013) and remember information with consequences if forgotten. In sum, both younger and older adults can learn to self-assess and prioritize the information that they need to remember, and despite memory deficits, older adults can learn to employ strategies that enhance the recall of important information, using metacognition and goal-directed remembering to engage in *responsible remembering*.

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Figure 1. Example of the study phase (a) and test phase (b) in Experiment 1.

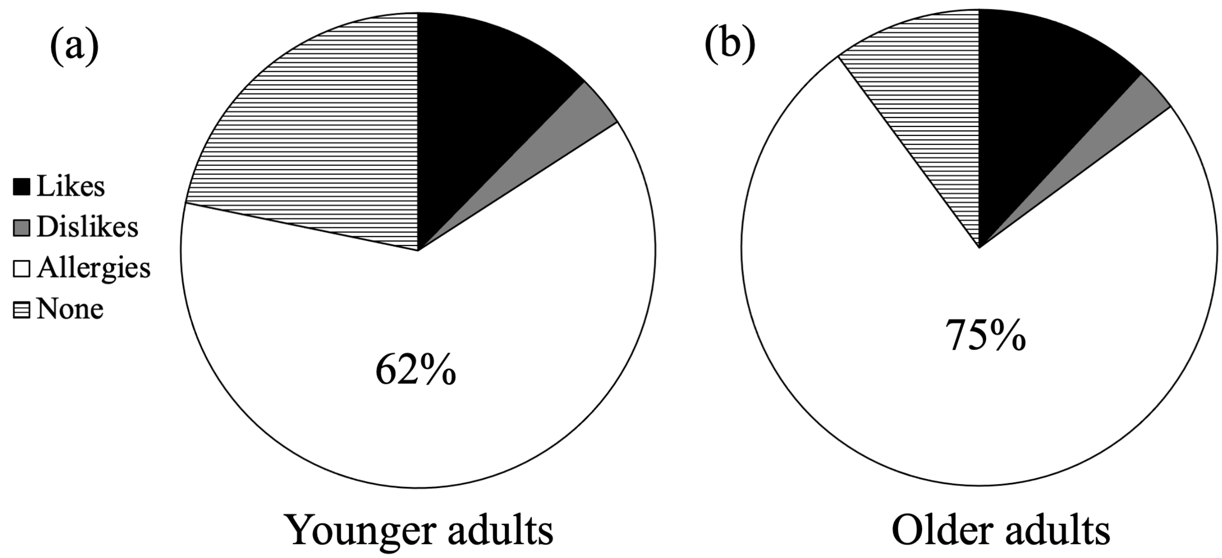

Figure 2. Younger (a) and older adults' (b) selections (across experiments) for which food category they felt was most important to remember.

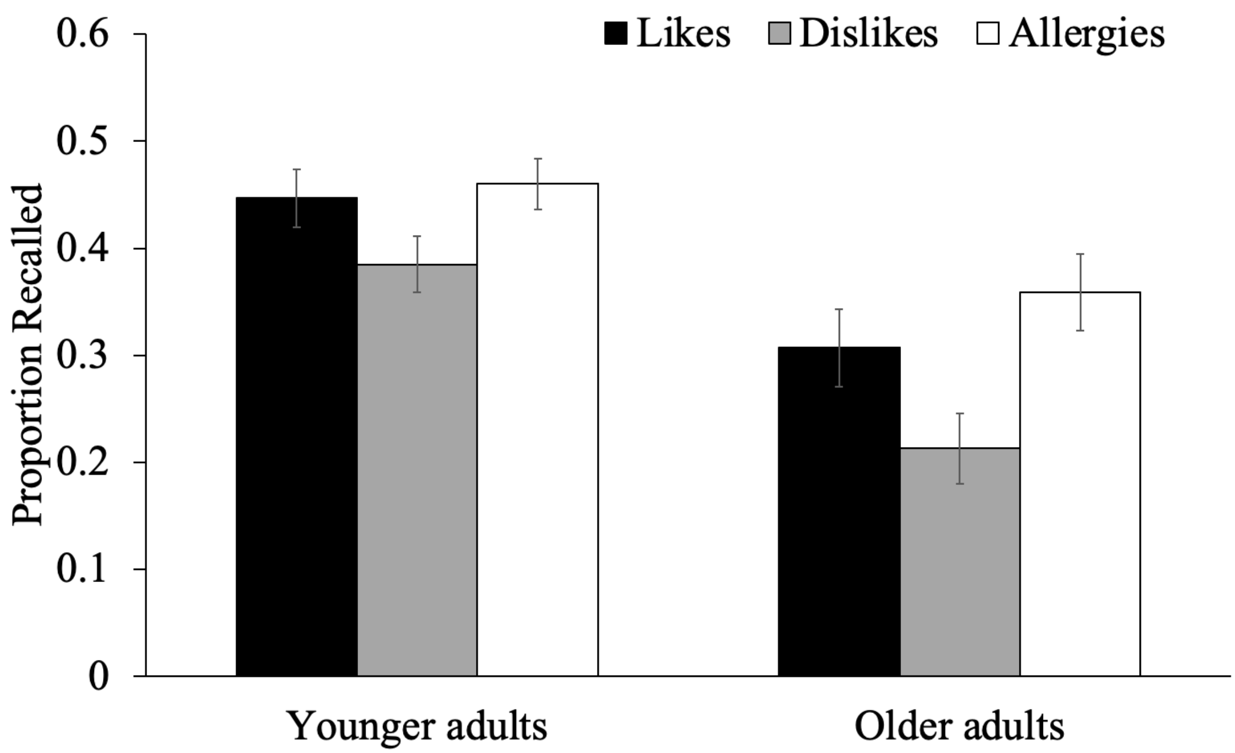

Figure 3. Recall as a function of age and food preference in Experiment 1. Error bars reflect the standard error of the mean.

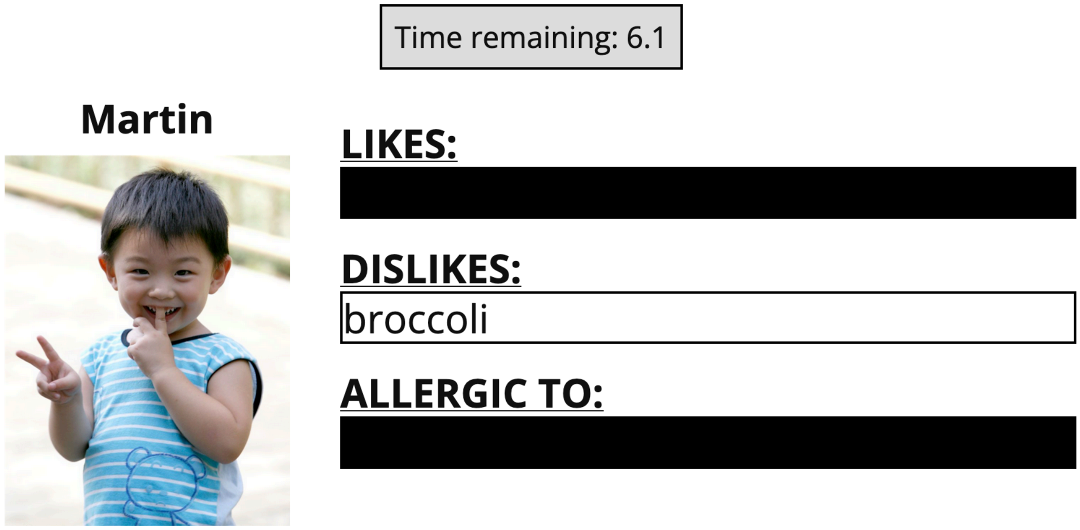

Figure 4. Example of the study phase in Experiments 2 and 3.

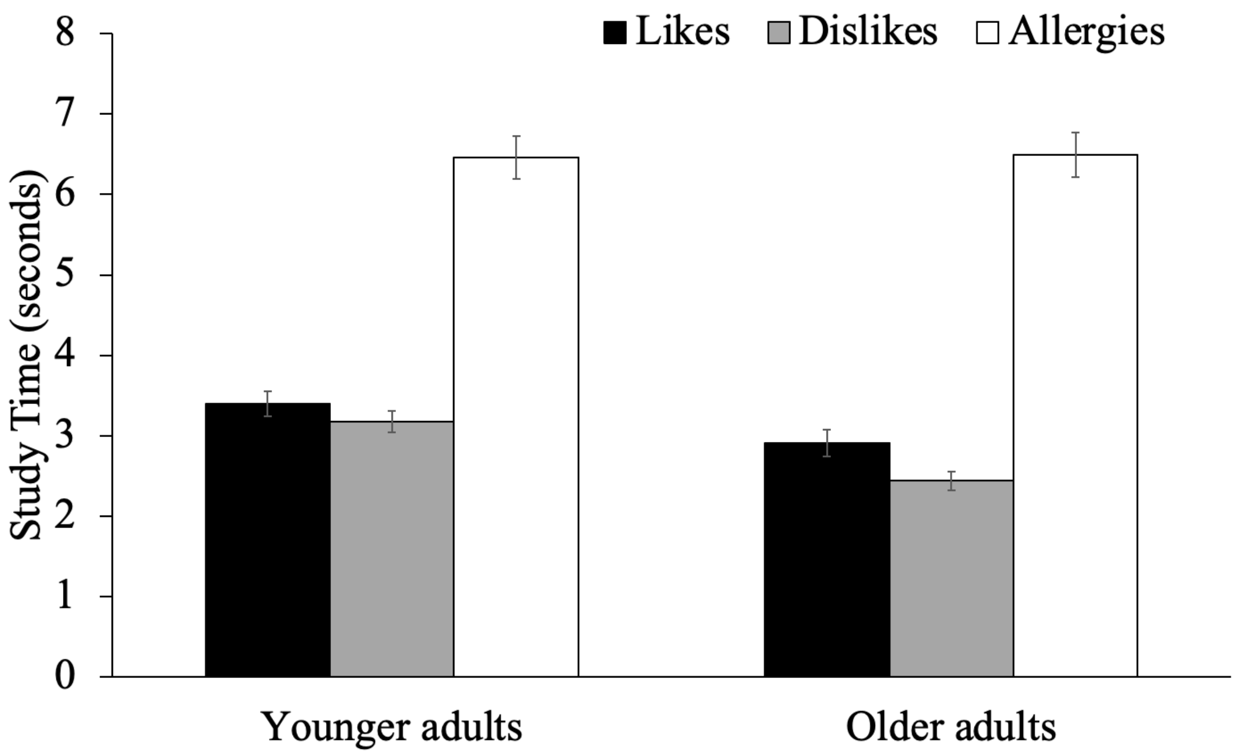

Figure 5. Study time as a function of age and food preference in Experiment 2. Error bars reflect the standard error of the mean.

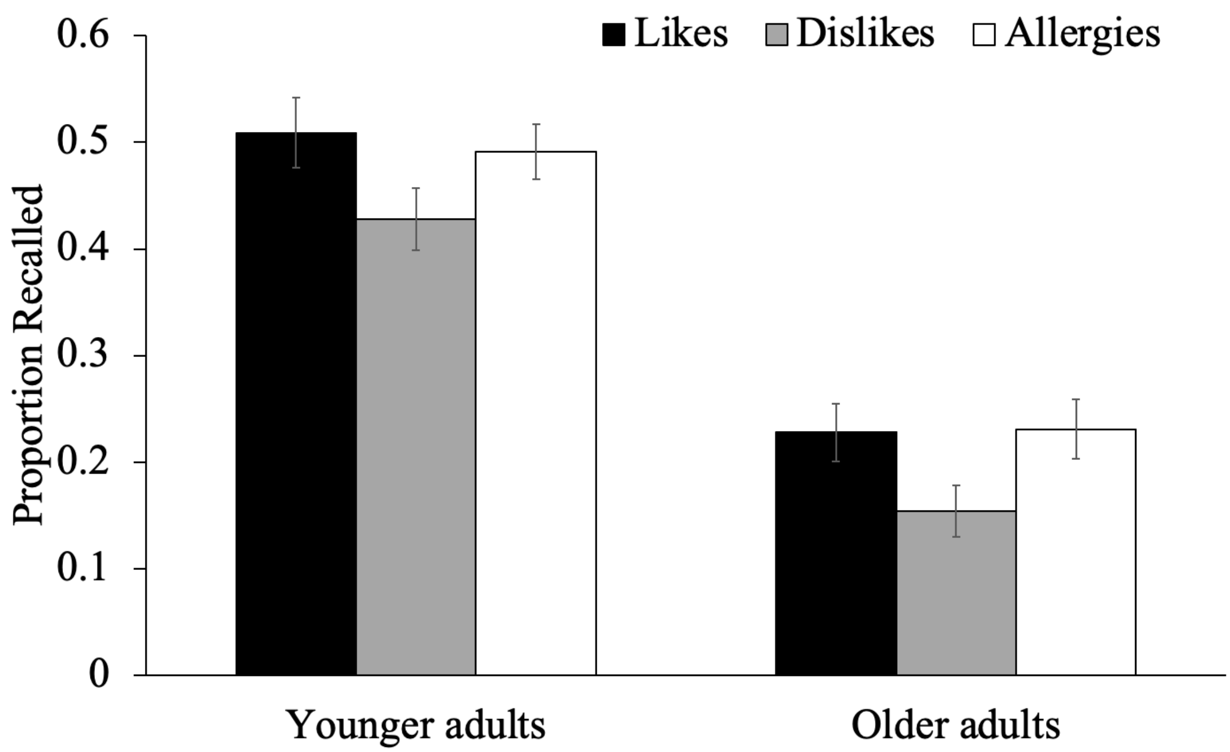

Figure 6. Recall as a function of age and food preference in Experiment 2. Error bars reflect the standard error of the mean.

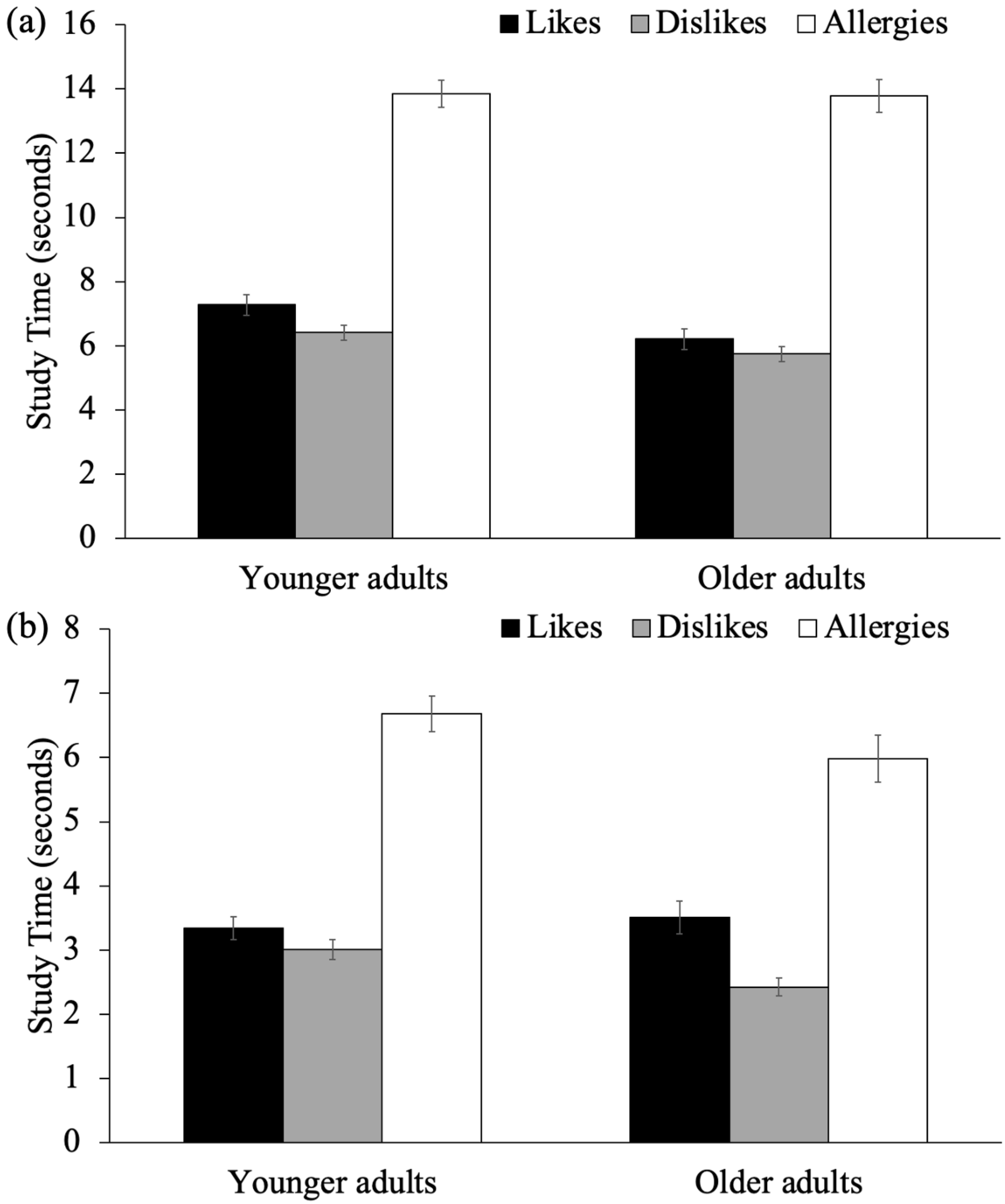

Figure 7. Study time as a function of age and food preference on Lists 1-3 (a) and on Lists 4-6 (rushed lists; b) in Experiment 3. Error bars reflect the standard error of the mean.

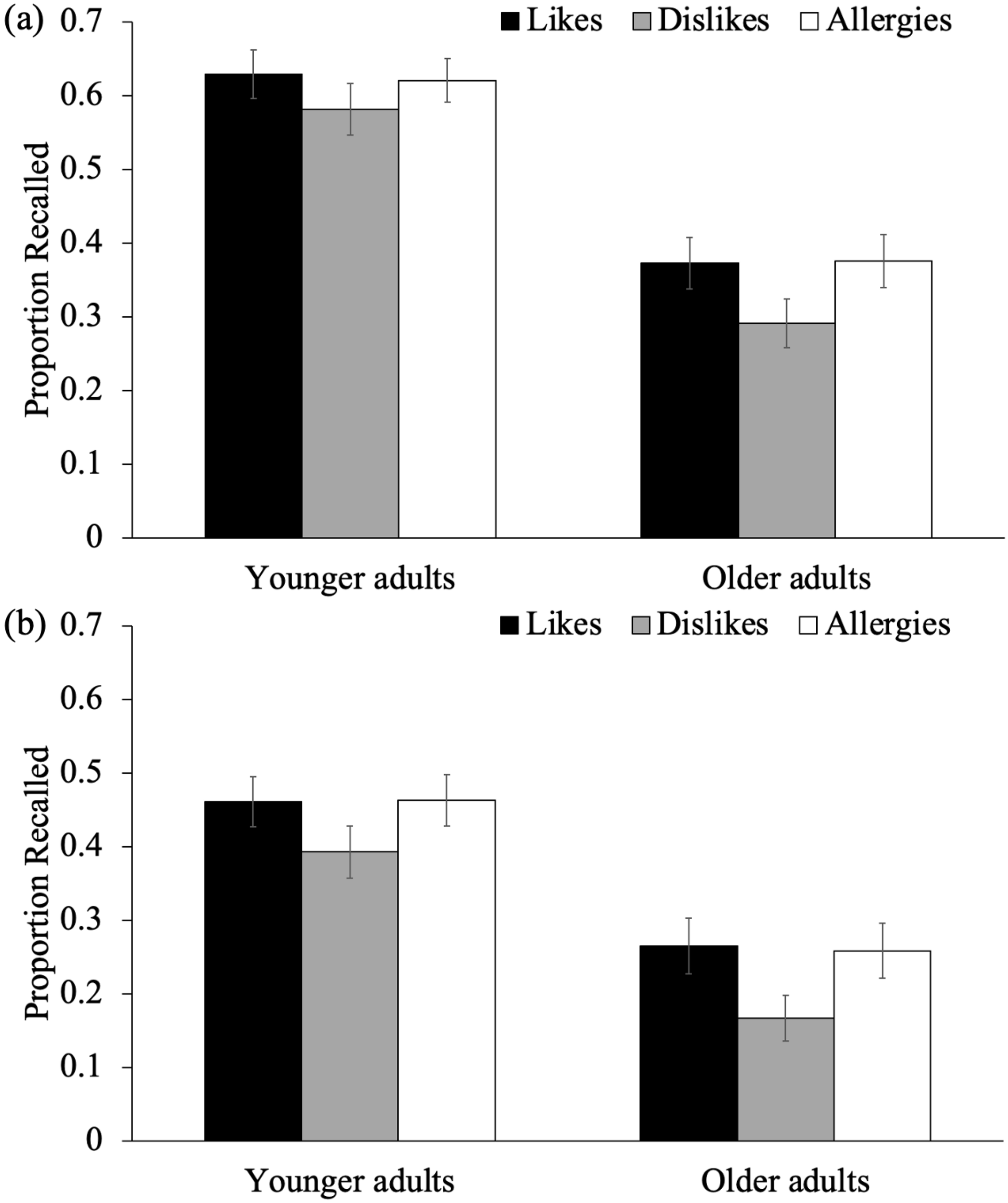

Figure 8. Recall as a function of age and food preference on Lists 1-3 (a) and on Lists 4-6 (rushed lists; b) in Experiment 3. Error bars reflect the standard error of the mean.