Subjective Semantic Search Space as an Estimate of Prior Knowledge Predicts Curiosity to Learn Among Younger and Older Adults

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Abstract

Although aging is associated with changes in cognitive functioning, older adults can show an intact ability to remember information that they are curious to know about. Some research suggests that older adults may exhibit greater states of curiosity during laboratory tasks compared to younger adults, as larger semantic networks characteristic of older age (e.g., more prior knowledge) may support learning and motivation. Still, what exactly constitutes prior knowledge remains ambiguous, raising the question of whether curiosity may be the outcome of an inferential appraisal whereby one estimates the number of answer candidates in their search space. In two experiments, younger and older adults saw a series of trivia questions, reported how many answer candidates were accessible, and rated their confidence and curiosity to learn the correct answer. We found that older adults were more likely to endorse having one answer candidate, but the presence of multiple (e.g., two, three or more) answer candidates was associated with high states of curiosity and low confidence across both age groups. Therefore, observed age-related differences in state curiosity may stem less from differences in search space and more from a general motivation to learn. Overall, while curiosity may manifest differently across the lifespan, subjective semantic search space as an inferred estimate of prior knowledge appears to be a reliable predictor of one's desire to learn among younger and older adults.

Keywords: curiosity, metacognition, motivation, aging, memory

Public Significance Statement

In the present study, we established that subjective semantic search space, the number of answer candidates one has, may represent a type of prior knowledge that younger and older adults rely on when assessing their curiosity to learn. Our findings provide insight into the metacognitive nature of curiosity and age-related differences in motivation, potentially informing strategies to support lifelong learning and areas of research such as pedagogy and healthy aging.

Subjective Semantic Search Space as an Estimate of Prior Knowledge Predicts Curiosity to Learn Among Younger and Older Adults

Age-related changes in cognitive functioning are typically accompanied by declines in memory abilities (e.g., episodic memory, working memory), which can lead to negative self-perceptions of aging. Yet, certain aspects of memory remain intact; for instance, older adults can engage in selective learning, strategically encoding and retrieving valuable information at the expense of less important information (Castel, 2024; Knowlton & Castel, 2022; Middlebrooks et al., 2016). Hence, aging does not appear to significantly detract from individuals' ability to identify and employ effective learning strategies, nor does it interfere with some goal-directed behaviors. Generally, there has been considerable interest in how cognition develops with age (Gignac & Zajenkowski, 2025), particularly with regards to motivational changes across the adult lifespan.

Curiosity, a desire to acquire novel information (Berlyne, 1950; Lowenstein, 1994), may support learning throughout the lifespan. It is often a short-lived experience (Donnellan et al., 2022; Hidi & Renninger, 2020); akin to an intense feeling of hunger, a small taste of information may increase individuals' desire for related information but only up until a point at which that hunger is fully satiated and curiosity extinguished (nothing new to learn). Accordingly, curiosity develops when individuals are momentarily motivated to pursue novel information, urgently seek resolution, and have clear stopping rules (e.g., search ends when answer is known; Murayama, 2022). Recent work has revealed that older adults may engage in various forms (e.g., state, trait) of curiosity that promote performance (McGillivray et al., 2015; Sobczak et al., 2025; Whatley et al., 2025).

The mnemonic effects of curiosity are consistent and robust, as evidenced by younger and older adults' improved recall for interesting information when tested post-study and after a delay (e.g., Fandakova & Gruber, 2021; Swirsky et al., 2021). Having an intrinsic motivation to learn may be adaptive, as it equips individuals with factual knowledge and a diverse set of skills that allows them to navigate various social dynamics and situations (Gottlieb et al., 2013). Indeed, being in a high state of curiosity can have widespread benefits, particularly in pedagogical (Engel, 2011; Hulleman & Harackiewicz, 2009), workplace (Chang & Shih, 2019; Mussel, 2013), and medical (Sakaki et al., 2018) settings.

Age-Related Changes in Motivated Cognition

The extent to which individuals experience curiosity may change as one ages, possibly reflecting a shift of goals and priorities (Swirsky et al., 2023; Whatley et al., 2022). Older adults may demonstrate less trait curiosity, a general propensity to experience curiosity (Loewenstein, 1994), which is consistent with observations that sensation-seeking behavior decreases with age (Giambra et al., 1992; Reio & Choi, 2004; Robinson et al., 2017). According to Socioemotional Selectivity Theory, older adults, who have a more limited time perspective, may be more focused on maintaining current states of functioning rather than actively seeking out opportunities for personal improvement or growth (Carstensen, 2021). In contrast, younger adults may be more willing to explore new ideas and sensory activities, demonstrating wide intellectual interests and an insatiable curiosity about their environments (Digman, 1990; McCrae & Greenberg, 2014). With age, one's priority may thus shift from the pursuit of rewards related to long-term goals (e.g., obtaining a college degree, securing a job) to those that satisfy current socioemotional needs (e.g., building close relationships, reaffirming sense of belonging or self-worth).

Having limited cognitive resources, older adults tend to be selective with the type of activities they pursue, forgoing novelty and variety in favor of accomplishing more important goals (selective optimization with compensation; Baltes et al., 1997). Such behavior, also described in selective engagement theory (Hess, 2014), indicates that shifts in motivation are common as one ages, and older adults may attempt to reduce task complexity by focusing on information that most efficiently helps them achieve their goals while compensating for deficits (e.g., offloading less important information). They can also engage in efficient, controlled processing, experiencing fewer age-related deficits when learning about personally relevant or familiar domains (e.g., health care; Germain & Hess, 2007; Umanath & Marsh, 2014).

In that case, older adults may display high state curiosity, a situational feeling of curiosity, in scenarios where valuable information gain is possible. According to Murayama et al. (2019), knowledge acquisition can initiate a positive feedback loop when learned knowledge is incorporated into individuals' knowledge base, increasing one's perceived competence or skillset in a domain. Having a vast store of information may help facilitate greater awareness of knowledge gaps, evoking intense feelings of curiosity when the semantic network is large (i.e., when there is a lot to learn). For example, consider an older adult who joins a birdwatching group. Initially, they learn to identify different bird species by sight and sound, but as their skills develop, their curiosity begins to grow. Soon, they wonder how local ecosystems and climate patterns may impact bird sightings, prompting them to explore these new topics and broaden their understanding. Hence, older adults may be driven to learn information that expands upon their existing knowledge, as it is less cognitively taxing to do so (Fastrich et al., 2024; Whatley et al., 2025).

Curiosity as a Metacognitive Appraisal of Prior Knowledge

Differences in prior knowledge may explain why older adults display greater state curiosity (curiosity in a specific situation) in laboratory tasks (Galli et al., 2018; McGillivray et al., 2015). As a metacognitive feeling, curiosity is based on one's ability to evaluate their current knowledge state and self-regulate future cognitive behaviors (Goupil & Proust, 2023; Flavell, 1979; Rhodes, 2019). Initiated by context-based (unexpected context change) and information-based (cognitive conflict from lack of knowledge) prediction errors, this appraisal process has individuals assess (1) their informational needs (is the answer known) and (2) whether valuable information gain is possible (is the answer attainable given expertise or resources). An inability to resolve uncertainty may produce feelings of anxiety, whereas the opposite may evoke curiosity and drive information search (Gruber & Ranganath, 2019; Kang et al., 2014; Silvia, 2008).

It is generally thought that curiosity is highly dependent on perceptions of prior knowledge, or familiarity within a content domain (Reichardt et al., 2023; Wade & Kidd, 2019), but what exactly constitutes prior knowledge remains ambiguous and may be hard to define (Castel et al., 2007; Hess & Slaughter, 1990; Ramey et al., 2024). If prior knowledge creates differences in state curiosity among younger and older adults, then there should be some effort made to quantify prior knowledge (Castel, 2007; Craik & Bosman, 1992). As such, we investigated how subjective semantic search space, the number of accessible answer candidates one has, may act as a form of prior knowledge that produces changes in state curiosity across the adult lifespan.

Subjective Semantic Search Space and Curiosity

Prior knowledge can be represented by a semantic network of interconnected ideas and concepts, whereby each concept is a network node and learned associations are encoded by paths stemming from the node (Collins & Loftus, 1975). Through mere exposure to information, the size of the network increases, albeit at the expense of efficiency and connectedness (Cosgrove et al., 2023; Wulff et al., 2019). In their cross-sectional study, Dubossarsky et al. (2017) inspected age-related changes in the mental lexicon, as measured by a word association task administered to over 8000 individuals between the ages of 10 and 84. Participants were presented with various cues, for which they had to provide three associations each (e.g., responding with *puppy*, *bark*, and *cat* to the cue *dog*). Using network analysis, the researchers found that older adults' semantic networks were less connected (smaller clustering coefficients) and efficient (higher average path length to other nodes) compared to that of younger adults. Additionally, older adults' networks were more distinct from each other, highlighting the diversity in acquired knowledge (Wulff et al., 2022), an advantage that older adults may utilize to understand language-based semantic knowledge tasks (e.g., Ichien et al., 2024). Such patterns may also be indicative of cognitive network enrichment, as memory degradation models fail to capture the sparsity of older adults' free association networks (Hills, 2025).

When answering a question, one may have to navigate through their subjective semantic search space, the set of possible solutions among which the real solution may reside. If older adults have larger semantic networks, they may be able to rely on additional pathways to access relevant information, facilitating learning (Brod et al., 2013). Yet, an increased number of nodes and pathways may decrease the rate of spreading activation and extend reaction time, although well-learned information should not be susceptible to interference (fan effect; Anderson, 1981).

As a result, concepts with many semantic connections may induce lower feelings of knowing (FOKs) when an extensive search process is required to navigate through the representation (e.g., I have many guesses but am unsure which is right; Siew et al., 2019). These metacognitive judgments may not necessarily be based on individuals' explicit access to information but rather be the outcome of an inferential process whereby they estimate the size of their search space.

The nature of the relationship between search space and FOKs has been debated, resulting in the partial-retrieval hypothesis and the competition hypothesis. The partial-retrieval hypothesis posits that FOKs depend on the accessibility of partial information, regardless of its correctness and the retrievability of the actual answer (Blake, 1973; Eysenck, 1979; Koriat, 1993). Cues that activate more nodes in the semantic network, as indicated by the presence of multiple answer candidates, will receive greater FOKs. The competition hypothesis, on the other hand, proposes that associated items compete with the target cue to produce interference, which should lower FOKs (Raaijmakers & Shiffrin, 1981). Relatedly, Schreiber and Nelson (1998) had participants make FOK ratings on unrecalled test items after being cued with a category (e.g., taxonomy, ending sounds), which had a large or small set size. For instance, a participant who could not remember the word *spoon* may have been presented with the category *eating utensil*, which had a small cue set size. The researchers found that FOKs were inversely related to set size; individuals were less likely to report knowing the answer when the cued category consisted of many members. According to Eakin et al. (2014), older adults often show strong FOKs that are indicative of later episodic and semantic memory recall of target information, suggesting intact metacognition in older age (Hertzog & Dunlosky, 2011) may play an important role in how one engages their search space.

Some work suggests that FOKs are positively correlated with curiosity and information search (e.g., Brooks et al., 2021; Litman et al., 2005). If true, then subjective semantic search space may predict curiosity, although this has not been examined in older adults. There are two possibilities: (1) Having multiple answer candidates may evoke intense feelings of curiosity when competition and uncertainty is high and there is a large knowledge gap to close. (2) A smaller search space may indicate that individuals "almost know" the answer or have the answer at the tip-of-their-tongues, a state that is often accompanied by a strong desire to learn (Metcalfe et al., 2020; Metcalfe, 2023). This is especially relevant for older adults who may have larger or more interconnected search spaces that are active when retrieving information.

When learning trivia, older adults may be more likely to access search spaces containing multiple answer candidates, as larger semantic networks characteristic of older age may facilitate broader activation of related concepts. Simultaneously, their expertise or familiarity within specific domains (e.g., history, geography) may enable them to efficiently narrow their search space to a smaller set of plausible candidates, which subsequently affects motivation. Overall, for search space to explain age-related differences in curiosity, older adults should more often exhibit the type of search space that evokes the strongest level of curiosity. We sought to verify these predictions by examining how younger and older adults access semantic search space in the context of curiosity and motivation.

The Current Study

In two experiments, we answered the following questions: (1) How does subjective semantic search space, defined as the number of potential answer candidates one believes they can generate to a question, affect motivation to learn? (2) Can differences in search space, if any, explain why older adults tend to be more state curious in laboratory tasks (e.g., McGillivray et al., 2015; Sobczak et al., 2025; Swirsky & Spaniol, 2024; Whatley et al., 2025)? In Experiment 1, participants saw a series of trivia questions, reported how many answer candidates they had in mind, and rated their confidence and curiosity to learn the correct answer. They completed a delayed cued-recall test for all answers 48 hours later. We expected that having multiple answer candidates would be correlated with low confidence but were unsure whether having a larger search space would elicit more or less curiosity.

In Experiment 2, we aimed to expand upon Experiment 1, additionally having participants rate their surprise and retroactively report whether they would have correctly guessed the answer. Surprise can be considered a type of prediction error, reflecting a mismatch between expectations (e.g., I think the answer is this) and reality (e.g., I did not expect the answer to instead be this; Marvin & Shohamy, 2016). Therefore, we were interested in seeing if items with multiple answer candidates would receive higher surprise ratings relative to items with no answer candidates or if the novelty of the topic was sufficient to evoke surprise.

Experiment 1

In Experiment 1, we explored whether semantic search space, a subjective measure of prior knowledge, predicts age-related differences in curiosity among younger and older adults. We expected that older adults would demonstrate a greater interest in learning trivia (see also McGillivray et al., 2015), and the more answer candidates one has in mind when presented with a novel question, the less confident they would be that they know the correct answer. Curiosity may be higher when individuals seek to resolve uncertainty between multiple, competing candidates or peak when they perceive that they almost have the answer (e.g., have one answer candidate in mind but unsure). Thus, the present study provides novel insight regarding how younger and older adults activate search space in the context of curiosity and motivation and how different levels of knowledge may influence performance.

Method

Transparency and Openness

The experiments reported in this article were not formally preregistered. The data were analyzed with Jamovi (The Jamovi Project, 2013), and figures were made using the “ggplot2” package in R Studio (v4.4.1; RStudio Team, 2023; Wickham, 2016). The stimuli, data, and analytic code needed to reproduce the analyses are available on the Open Science Framework here (n.d.).

Participants

After exclusions, we had a total of 145 participants, consisting of 71 younger adults (34 female, M_{age} = 25.77, SD_{age} = 3.12, ages 19 to 30) and 74 older adults (47 female, M_{age} = 68.82, SD_{age} = 3.95, ages 65 to 83). Participants were recruited from Prolific, an online data collection platform, and received monetary compensation for participating. Please refer to Table 1 for additional demographic information. Data collection took place between August 2024 and October 2024.

All participants were fluent in English and located in the United States. Participants were removed from analyses if they failed to complete the delayed recall test (35 participants were excluded), if they failed any of the three attention checks (12 participants were excluded), or if they self-reported cheating on the recall test (1 participant was excluded). Informed consent was acquired from all participants, and the two-part online experiment was conducted with approval from the University of California, Los Angeles (UCLA) Institutional Review Board.

There was no a priori sampling plan, but we ran a simulation with 1000 replications to estimate effect size in our mixed-effects model using the *simr* package in R (Green & MacLeod, 2016), which can handle non-normal response variables and accommodate a range of model specifications (i.e., fixed and random effects) in linear and generalized linear mixed models. With our sample size of 145 at level 2, sample size of 50 at level 1, alpha = .05, and power = .80, we were able to detect small to medium effects ($f^2 \geq 0.02$; Cohen, 1992).

Materials

Apart from the trivia task, participants completed the EC Questionnaire, which measures trait curiosity (a stable tendency to experience curiosity), and Short Boredom Proneness Scale. We expected that older adults would score lower on trait curiosity compared to younger adults, consistent with observations that sensation-seeking declines in older age (Carstensen, 2021; Sakaki et al., 2018; Whatley et al., 2025), but had no specific hypothesis about boredom. These data were collected for exploratory purposes.

Trivia Questions. Fifty trivia questions and their answers were sourced from the normed Fastrich et al. (2018) trivia database (see Appendix for all questions). Trivia questions, which spanned a range of topics (e.g., history, biology), had answers that were no more than two words long. We believed that trivia questions were appropriate for the purposes of our study as they have been shown to elicit varying levels of curiosity across individuals and hold little practical or personal value, meaning that measured curiosity may reflect an intrinsic desire to learn for the sake of gaining knowledge itself.

Epistemic Curiosity Questionnaire (EC Questionnaire). Epistemic curiosity (EC) refers to the feeling evoked by a desire for novel semantic information that motivates knowledge acquisition (Berlyne, 1954). Individuals high on epistemic curiosity are intrinsically motivated to learn new ideas and close existing knowledge gaps, reflecting a dispositional tendency towards positive information gain. Epistemic curiosity can be categorized as either interest-type (I-type) or deprivation-type (D-type; Litman, 2008; Litman & Spielberger, 2003). When experiencing I-type curiosity, individuals engage in long-term information seeking to deepen their understanding of a topic or domain. With D-type curiosity, individuals demonstrate a strong but temporary "need to know," and they actively search for specific information to resolve their ignorance.

Participants completing the EC Questionnaire read ten items and rated the way they generally felt about them. The items were rated on four-point scales (1 = *almost never*, 4 = *always*) and split into two subscales of five items each, one representing I-type curiosity (e.g., I enjoy exploring new ideas) and the other D-type curiosity (e.g., I spend hours on a problem because I can't rest without the answer). Participants could receive a minimum score of 10 and a maximum score of 40, with higher scores indicating greater epistemic or trait curiosity.

Short Boredom Proneness Scale (SBPS). The SBPS was designed to measure individuals' general tendency to experience boredom, a cognitive state that induces strong, negative affect due to environmental monotony or attentional deficits (Seiler & Dan, 2024; Struk et al., 2015). Curiosity and boredom are complementary states in that both typically involve a pursuit for novel information, although the latter may involve more non-goal-directed search.

Participants completing the SBPS rated the extent to which they agreed or disagreed with eight statements (e.g., I don't feel motivated by most things that I do), each on a seven-point scale (1 = *strongly disagree*, 7 = *strongly agree*). Participants could receive a minimum score of 8 and a maximum score of 56, with higher scores indicating a greater propensity to experience boredom.

Procedure

Part 1 of the experiment consisted of two sections, which were counterbalanced: a trivia task and a survey task (EC Questionnaire, SBPS). The order in which the two scales were completed was randomized. The survey task contained an attention check for which participants had to select "completely describes me" for the specific item. For the trivia task, which was modeled after the paradigm in Recht and Yeung (2024), participants had 8 s to read each question before indicating how many potential answers they had (0, 1, 2, 3+). They then rated how confident they were that the correct answer was one that they had in mind on a 10-point scale (1 = *not at all confident*, 10 = *extremely confident*). If participants had no answer candidate, they were instructed to submit "not applicable." Afterwards, they reported how curious they were to learn the answer on a 10-point scale (1 = *not at all curious*, 10 = *extremely curious*). Following the self-report ratings, which were self-paced, the question and correct answer were displayed for 5 s, and the process repeated for the remaining questions. Presentation order of the trivia questions was randomized.

After 25 questions, participants were given a two-minute break, during which they could get up, walk around, or drink water. They were explicitly told not to look up any answers to the questions, write down anything they saw, or use external aids to remember the presented information (this instruction was also given at the beginning of the experiment). Participants saw the remaining 25 trivia questions after the break.

Forty-eight hours later, participants began part 2 of the experiment, which consisted of a cued-recall test for all trivia answers. They could complete the test at their own pace but again were reminded not to look up any answers. Presentation order of the trivia questions was randomized. To ensure that participants were not mindlessly clicking through the task, we implemented two attention checks for which participants had to submit "trivia" and "study" as answers. At the end of parts 1 and 2, participants were asked if they looked up any of the questions or answers during the task (they were told that they would receive credit for their participation regardless of their answer).

Results

State Curiosity Across Age Groups

We computed state curiosity by averaging curiosity ratings across the 50 trivia questions for each participant. On average, older adults ($M = 7.92$, $SD = 1.87$, range = 1.98-10) were more curious to learn trivia answers compared to younger adults ($M = 6.77$, $SD = 2.10$, range = 1.08-10), $t(143) = -3.48$, $p < .001$, $d = -0.58$, $BF_{10} = 39.60$.

Effects of Subjective Semantic Search Space

Selection Proportion. To visualize the distribution of participants' search space, we calculated the selection proportion for zero ($M = 0.25$, $SD = 0.19$), one ($M = 0.53$, $SD = 0.22$), two ($M = 0.18$, $SD = 0.18$), and three or more ($M = 0.04$, $SD = 0.07$) answer candidates (Figure 1). We then assessed whether younger versus older adults were more likely to report having a specific number of answer candidates. Older adults ($M = 0.57$, $SD = 0.23$) reported having one answer candidate more often than younger adults ($M = 0.49$, $SD = 0.21$), $t(143) = -2.19$, $p = .030$, $d = -.36$, $BF_{10} = 1.59$. Individual comparisons for zero, two, and three or more answer candidates did not reach significance, all ps > .181 and $BF_{01} > 2.45$.

Curiosity Ratings. To test whether search space predicts relative differences in motivation, we cluster-centered curiosity by subtracting each participant's mean curiosity (their average rating across the 50 trivia items) from their individual ratings. Cluster-centering allows us to examine how curiosity varies within participants and whether a given rating reflects a meaningful deviation from a participant's average curiosity versus a tendency to use a particular range of the scale. In other words, by centering each participant's ratings around their own mean, we were able to assess how search space elicited relatively higher or lower curiosity among participants. Here, values below zero should be interpreted as being below participants' average curiosity. We also analyzed participants' raw curiosity ratings (see Supplementary Material section), and the general pattern of results match those described here.

We fit a random intercept mixed-effects model predicting cluster-centered curiosity from search space (sequential coded), age group (dummy coded), their interaction, and education (covariate; Figure 2). To control for inter-subject and inter-item variability, we included random intercepts for participants and items in the model. Results revealed that curiosity was comparable between zero and one answer candidate, $\beta = 0.10$, $SE = .06$, $t(7209) = 1.55$, $p = .120$. However, curiosity increased from one to two answer candidates, $\beta = -0.55$, $SE = .07$, $t(7219) = -7.76$, $p < .001$, and two to three or more answer candidates, $\beta = -0.28$, $SE = .14$, $t(7208) = -1.98$, $p = .048$. Cluster-centered curiosity was greater for younger versus older adults, $\beta = -0.15$, $SE = .06$, $t(7198) = -2.53$, $p = .011$, but this does not provide meaningful information about between-group differences in state curiosity. There was an interaction, $\beta = -0.32$, $SE = .09$, $t(7223) = -3.52$, $p < .001$, such that the contrast between zero and one answer candidate was significant for older but not younger adults. The difference in curiosity between one and two answer candidates was significant for younger but not older adults, $\beta = 0.43$, $SE = .10$, $t(7204) = 4.17$, $p < .001$.

Exploratory Findings

In addition to our main analyses, we explored whether aging was associated with declines in trait curiosity and how confidence varied by search space. Please refer to the Supplementary Material section if interested in our analyses of boredom proneness and recall across age groups.

Trait Curiosity Across Age Groups. Epistemic Curiosity (EC) Questionnaire scores were similar between younger (M = 28.39, SD = 6.01) and older adults (M = 27.08, SD = 6.27), $t(143) = 1.29$, $p = .200$, $d = 0.21$, $BF_{01} = 2.63$. There were no significant differences in I-type and D-type curiosity scores between age groups, all *p*s > .141 and $BF_{01} > 2.06$.

Confidence Ratings. We tested for differences in confidence across search space, excluding questions for which participants had zero answer candidates (Figure 3). Confidence ratings were cluster-centered before analysis—mean confidence was subtracted from participants' individual ratings. We fit a mixed-effects model predicting cluster-centered confidence from search space (sequential coded), age group (dummy coded), and their interaction. Additionally, we added education as a covariate and random intercepts for participants and items. Results revealed that confidence decreased from one to two answer candidates, $\beta = 0.35$, $SE = .09$, $t(5291) = 3.86$, $p < .001$, and remained stable from two to three or more answer candidates, $\beta = 0.32$, $SE = .18$, $t(5286) = 1.75$, $p = .080$. Cluster-centered confidence did not vary between younger and older adults, $\beta = -0.06$, $SE = .09$, $t(5281) = -0.60$, $p = .548$. All interactions did not reach significance, all *p*s > .598.

Discussion

The extent to which one experiences curiosity is thought to be largely dependent on the perception of a knowledge gap, or the discrepancy between what one knows and what they seek to learn. We theorized that individuals may rely on search space, the number of answer candidates one has in mind, when estimating prior knowledge in a content domain, and that search space may explain why older adults tend to be more curious when learning trivia. It is important to note that this process is subjective, meaning that participants are not required to submit a guess; rather, retrieval fluency (i.e., how easy it feels to make a guess) may act as a heuristic by which individuals make these metacognitive judgments.

We found that older adults self-reported greater curiosity towards presented trivia questions and were more likely to endorse only having one answer candidate relative to younger adults. Yet, such search spaces were associated with low curiosity; the more answer candidates they had, the less confident but more curious they were to learn. Therefore, search space cannot fully account for observed age-related differences in state curiosity. Perhaps older adults were generally more motivated to deepen their existing knowledge, particularly since information gain was guaranteed in the trivia task. This may also explain why recall performance was similar between younger and older adults (see Supplementary Material section); although aging is associated with memory declines, older adults were able to selectively learn interesting information.

Nevertheless, our findings suggest that curiosity can be predicted based on search space, and that this relationship remains intact with age. Consider an individual with zero, one, or multiple answer candidates. An individual with no answer candidate may have insufficient prior knowledge to generate a prediction (impoverished or vacant search space), resulting in below-average curiosity (we did not measure confidence here). If the individual believes that they know the correct answer (dense, interconnected search space), an indication of which may be selecting the response option for one answer candidate, then their confidence should be high but curiosity low because there is no knowledge gap to close (Kang et al., 2009; Poli et al., 2014). Uncertainty arises when an individual has multiple answer candidates (broad or sparse search space), and the presence of competing possibilities may produce low confidence but high curiosity.

We did not collect confidence ratings for items that participants had zero answer candidates for, but participants may have experienced some subjective sense of knowing that was left uncaptured by the paradigm (e.g., tip-of-the-tongue or TOT state). Presumably, with no answer candidates, the perceived discrepancy between the reference point and goal state may surpass an individual's capacity for resolution, leading to minimal confidence and curiosity. There does remain the possibility that confidence may peak when individuals encounter an item that evokes a TOT (e.g., I don't have a specific guess, but I feel that I almost have the answer).

Experiment 2

An additional experiment was performed to evaluate whether the absence of an answer candidate would induce below-average confidence levels. Participants in Experiment 2 were required to provide confidence ratings for all trivia questions, including those that they did not have a guess for. We were interested in exploring how surprise may manifest across search space, given that items with multiple answer candidates may generate prediction errors of greater magnitude, and so we solicited ratings of how surprised one was after learning the answer (see also Sobczak et al., 2025). We also asked participants if they would have correctly guessed the answer had we told them to provide one guess prior to learning. The inclusion of these two measures was primarily for exploratory purposes.

Method

Participants

We aimed to recruit a similar sample size as that of Experiment 1, which was sufficiently powered to detect the primary effect of interest, namely the difference in curiosity for items with one versus two answer candidates. After exclusions, we had a total of 152 participants, consisting of 79 younger adults (40 female, M_{age} = 25.77, SD_{age} = 3.34, ages 18 to 34) and 73 older adults (49 female, M_{age} = 69.22, SD_{age} = 4.04, ages 65 to 80). Participants were recruited from Prolific and received monetary compensation for their participation. Please refer to Table 2 for additional demographic information. Data collection took place between October 2024 and January 2025.

All participants were fluent in English and located in the United States. Participants were removed from analyses if they failed to complete the delayed recall test (38 participants were excluded), if they failed any of the three attention checks (11 participants were excluded), or if they self-reported cheating on the test (no participants were excluded). Informed consent was acquired from all participants, and the two-part online experiment was conducted with approval from the UCLA Institutional Review Board.

Materials

We used the same materials from Experiment 1.

Procedure

We employed a similar procedure as that of Experiment 1, with the exception of a few changes. First, confidence ratings were required for all trivia questions, and participants were not given the option of selecting “not applicable” when they had zero answer candidates. Second, after each trivia answer was revealed, participants reported how much of a surprise the answer was on a 10-point scale (1 = *not at all surprising*, 10 = *extremely surprising*). Last, participants shared if they would have given the correct answer had we asked them to provide one guess before learning the answer (yes or no).

Results

State Curiosity Across Age Groups

On average, older adults (*M* = 7.87, *SD* = 1.86, range = 3.44-10) were more curious to learn trivia answers compared to younger adults (*M* = 6.72, *SD* = 1.86, range = 2.88-10), $t(150) = -3.82$, $p < .001$, $d = -.62$, $BF_{10} > 100$.

Effects of Subjective Semantic Search Space

Selection Proportion. We computed the mean proportion of times zero (*M* = 0.19, *SD* = 0.17), one (*M* = 0.57, *SD* = 0.21), two (*M* = 0.20, *SD* = 0.18), and three or more (*M* = 0.04, *SD* = 0.06) answer candidates were selected (Figure 4). Older adults (*M* = 0.66, *SD* = 0.20) were more likely to endorse having one answer candidate than younger adults (*M* = 0.48, *SD* = 0.19), $t(150) = -5.54$, $p < .001$, $d = -.90$, $BF_{10} > 100$. Individual comparisons for the remaining response options all reached significance, all *p*s < .038 and $BF_{10} > 1.30$, with younger adults selecting a greater proportion.

Curiosity Ratings. Again, we examined curiosity levels across search space (Figure 5), observing that cluster-centered curiosity increased from zero to one, $\beta = -0.19$, $SE = .07$, $t(7539) = -2.68$, $p = .007$, one to two, $\beta = -0.35$, $SE = .07$, $t(7580) = -5.08$, $p < .001$, and two to three or more answer candidates, $\beta = -0.27$, $SE = .13$, $t(7586) = -2.17$, $p = .030$. The effect of age group was not significant, $\beta = 0.05$, $SE = .06$, $t(7553) = 0.86$, $p = .390$. There was an interaction, $\beta = 0.31$, $SE = .11$, $t(7574) = 2.89$, $p = .004$, such that the difference in curiosity between zero and one answer candidate was significant for younger but not older adults. All other interactions did not reach significance, all *p*s > .895. Similar findings were obtained with participants' raw curiosity ratings, as detailed in the Supplementary Material section.

Exploratory Findings

As in Experiment 1, we looked at trait curiosity and confidence across search space for the two age groups. Since we collected confidence ratings for all items, we also tested for a non-monotonic relationship between confidence and curiosity, which has been observed in prior work (e.g., Dubey & Griffiths, 2020; Spitzer et al., 2024; Theobald et al., 2022). Such findings align with information gap theory, which proposes that intense feelings of curiosity are experienced when individuals have moderate levels of confidence or prior knowledge, resulting in an inverted U-shape function (Kang et al., 2009). Details on how surprise and recall were related to search space and how boredom proneness differed by age group can be found in the Supplementary Material section.

Trait Curiosity Across Age Groups. EC Questionnaire scores were comparable among younger ($M = 28.27$, $SD = 5.05$) and older adults ($M = 26.66$, $SD = 5.68$), suggesting a similar, stable propensity to experience curiosity, $t(150) = 1.85$, $p = .067$, $d = .30$, $BF_{01} = 1.20$. There were no significant differences in younger and older adults' I-type curiosity scores, $t(150) = 0.81$, $p = .418$, $d = .13$, $BF_{01} = 4.23$, but younger adults reported greater D-type curiosity, $t(150) = 2.30$, $p = .023$, $d = .37$, $BF_{10} = 1.94$.

Confidence Ratings. We tested for changes in confidence across search space (Figure 6), including questions with zero answer candidates. We observed a significant increase in cluster-centered confidence between zero and one answer candidate, $\beta = -3.08$, $SE = .09$, $t(6452) = -35.31$, $p < .001$. Confidence decreased from one to two answer candidates, $\beta = 0.60$, $SE = .09$, $t(5463) = 6.91$, $p < .001$, and two to three or more answer candidates, $\beta = 0.64$, $SE = .15$, $t(7511) = 4.23$, $p < .001$. Cluster-centered confidence was greater for younger compared to older adults, $\beta = -0.27$, $SE = .09$, $t(312) = -2.93$, $p = .004$. There was an interaction, $\beta = 0.35$, $SE = .13$, *t*(6438) = 2.61, $p = .009$, such that the difference in confidence between zero and one answer candidate was larger for younger adults. All other interactions did not reach significance, all *p*s > .513.

Confidence and Curiosity Ratings. In inspecting the relationship between confidence and curiosity (Figure 7), we fit a mixed-effects model with a first-order polynomial term for confidence, which was recalculated to range from 0 to 1 (see Kang et al., 2009). We added education as a covariate and random intercepts for subjects and items to the model as well. Cluster-centered curiosity declined as confidence increased, $\beta = -0.25$, $SE = .09$, $t(7513) = -2.88$, $p = .004$, and we did not find evidence of an effect of age group, nor an interaction between confidence and age, all *p*s > .278.

We then fit a similar model with the addition of a second-order polynomial term. The confidence coefficient was significantly different from zero, $\beta = 2.74$, $SE = .27$, $t(7586) = 10.05$, $p < .001$, as was the negative quadratic confidence coefficient, $\beta = -3.37$, $SE = .29$, $t(7589) = -11.50$, $p < .001$. To assess goodness of fit, we compared each model's Bayesian Information Criterion (BIC; Burnham & Anderson, 2002) and looked for BIC differences greater than 10, which signals that the model with the smaller criterion value be selected. Given that model 1 had a BIC of 30059.87, and model 2 had a BIC of 29897.82, the addition of the second-order polynomial term increased model fit.

Discussion

Subjective semantic search space predicted younger and older adults' confidence and their subsequent curiosity to learn the answer. However, younger adults were more likely to report having zero, two, and three or more answer candidates relative to older adults; rather than reflect a shift in younger adults' response distributions, these patterns likely emerged due to older adults' increased selection of the one-answer-candidate option, which altered the relative distribution of responses across the remaining categories. We suspected that older adults may have known (or were generally more familiar with) some trivia answers prior to learning, as suggested by their above-average confidence for items with one answer candidate and their high endorsement of that response category. In an exploratory analysis, we removed questions that participants self-reported they would have correctly answered prior to learning. Because this information was collected after the correct answer was revealed, participants' judgments may have been strongly affected by hindsight bias (e.g., I knew it all along); accordingly, results (see Supplementary Material section) should be interpreted with caution. Generally, items that had two or three or more answer candidates evoked more curiosity than items with zero or one answer candidate. Thus, it appears that larger search spaces may support curiosity-driven learning across the adult lifespan, informing strategies to support memory and motivation, which has implications for areas of research such as pedagogy and healthy aging. For instance, interventions that scaffold learning by targeting the structure of individuals' search space (e.g., providing strategic prompts or hints; Shin et al., 2024) may be especially effective at enhancing curiosity while maintaining an optimal level of uncertainty.

General Discussion

Curiosity occurs when individuals exhibit strong preferences for stimuli and situations unlike those they had encountered before (Barto et al., 2013; Jaegle et al., 2019). Although novelty-seeking behavior may decline with age (Giambra et al., 1992; Zuckerman et al., 1978), older adults may display greater state curiosity (situational type of curiosity in response to certain stimuli; Galli et al., 2018; McGillivray et al., 2015), indicating that the relationship between age and curiosity may be more nuanced than previously thought. If feelings of curiosity are dependent on how much prior knowledge an individual has in a content domain (see Sakaki et al., 2024 for a review), or the size of the gap between one's present understanding and goal state (Loewenstein, 1994), then the general knowledge one acquires across their lifespan may act as a source of motivation. In other words, differences in prior knowledge may explain why older adults express a stronger situational desire to learn compared to younger adults.

But, the definition of prior knowledge remains ambiguous, especially in the context of how curiosity and motivation may relate to the access of domain-specific knowledge: does it refer to the amount of factual information one possesses in a content domain (size of the entire semantic network), the confidence one has when faced with a novel question, or the ease with which one can make a guess? We tested the idea that subjective semantic search space may represent a type of prior knowledge that individuals rely on when making metacognitive judgments, which may be particularly relevant for older adults who often have high levels of knowledge and state curiosity.

Curiosity and Search Space Across the Adult Lifespan

Consistent with prior literature, older adults were more curious to learn trivia answers than younger adults. Materials that require semantic knowledge may evoke increasing feelings of curiosity as individuals accumulate information and establish a wide knowledge base across their lifespan. Specifically, older adults who make connections between prior knowledge and to-be-learned information may be highly motivated to learn (e.g., a nature documentary enthusiast may be curious to know the answer to a trivia question about plants and animals), and motivation may be related to semantic search space capabilities.

In visualizing the distribution of individuals' search space, or the mean proportion of times each search space response option (0, 1, 2, 3+) was chosen, we discovered that participants were most likely to report only having one answer candidate in mind, particularly older adults. We also found evidence of a positive relationship between search space and curiosity—items with multiple (e.g., two, three or more) answer candidates tended to elicit more curiosity, and this was generally true for both younger and older adults. While a larger search space may introduce competition amongst candidates, the uncertainty arising from semantically related concepts in that network may have stimulated deeper engagement and intense curiosity. However, in cases where there was little to no prior knowledge (zero or one answer candidate) or the answer was already known (one answer candidate), motivation to learn decreased.

Search Space and Age-Related Differences

Interestingly, search space could not explain why older adults were more state curious about trivia answers. If having multiple answer candidates is associated with greater curiosity, then older adults should have selected those response options more often. Indeed, curiosity was greater for items with two and three or more answer candidates, even after removing items that participants self-reported knowing prior to learning. Motivational factors (e.g., how much individuals enjoy learning) may have a stronger impact on state curiosity compared to how many answer candidates are accessible during retrieval. Moreover, older adults being less susceptible to boredom proneness (see Supplementary Material section) may explain their stronger interest in learning, an important avenue for future research. Hence, although some individuals may hold negative perceptions of aging, it appears that older adults possess a natural sense of curiosity, if not to a greater extent than younger adults, which may serve an adaptive function as they seek out instrumental information relevant to their goals and personal well-being.

Although our study mainly focused on the size of search space across age groups, as inferred by the number of answer candidates, it is important to consider the density of the accessed semantic network or strength of activated concepts. Presumably, items that produce more answer candidates would recruit broad and less efficient networks, whereas items with one answer candidate would recruit dense and interconnected networks (I know the answer). While aging is associated with increased network modularity and segregation, an indication of cognitive enrichment (Hills, 2025), the semantic networks used for trivia may be efficient and well-integrated, as expected when learning familiar information that builds upon existing knowledge. Having participants submit their guesses may allow us to model these relationships, but for the purposes of our study, we did not believe that it was necessary to have individuals provide an answer (pretest), as curiosity is driven more by subjective rather than objective feelings of knowing (Wade & Kidd, 2019). Pretesting may also elicit a type of curiosity distinct from that measured in our study; in particular, individuals may be more curious to verify their guess and less curious to learn for the sake of learning itself (see Chen et al., 2025). Nevertheless, these remain interesting questions for future follow-up studies.

Limitations and Considerations

Given our paradigm, it is difficult to confirm the exact nature of the relationship between search space and feelings of knowing (FOKs). Although curiosity was greater for search spaces with multiple answer candidates (i.e., two, three or more), it seems unlikely that FOKs or curiosity would increase linearly with each additional answer candidate without some stopping point or threshold. For instance, an individual considering 15 potential answer candidates may not be meaningfully closer to knowing the correct answer compared to when having 14 candidates. Therefore, the relationship between search space and FOKs or curiosity may be non-linear; in other words, optimal states of uncertainty associated with intense curiosity may be restricted to a relatively small number of answer candidates.

Since it may be challenging for individuals to estimate the exact number of potential answer candidates in their search space, we only provided four response options (0, 1, 2, 3+) to simplify the task. It is possible that individuals evaluated their entire search space when presented with the trivia questions, but the distribution of response options was skewed towards items with only one answer candidate, with the smallest mean proportion being that of three or more answer candidates. Rather than consider every candidate in a semantic category, individuals may have instead focused on local areas of their semantic networks. For example, if asked what animal can turn its stomach inside out, participants may not have considered *dog* or *cat* as potential answers, despite them both being category exemplars. As such, the plausibility of an answer may constrain the search space accessed during information search, although the exact process by which this happens warrants further investigation.

We recognize that the experimental task may not capture the actual process by which individuals estimate their curiosity to learn, as it is unlikely that individuals consciously sum the total number of answer candidates in search space when faced with a novel question. Nonetheless, given that participants did not make any guesses before learning, we believe that our trivia task captured the subjective appraisal process that drives curiosity (see Gruber & Ranganath, 2019). In other words, the extent to which curiosity is elicited may be more dependent on individuals' perception of knowing (i.e., do I generally feel that I can produce a guess) rather than how many items specifically are within search space. Querying participants on how they estimated their search space may provide insight into the mechanisms underlying their decision-making.

We speculated that motivational factors and personality traits (e.g., boredom proneness) may have contributed to differences in state curiosity (see also Swirsky & Spaniol, 2024). We may have oversampled older adults who were naturally more curious, as evidenced by younger and older adults scoring similarly on the Epistemic Curiosity Questionnaire. According to Greene and Naveh-Benjamin (2022), older adults who participate in research studies may be more intrinsically motivated to advance the field of science, learn more about their own cognitive health (e.g., maintain positive image of cognitive capabilities by performing well on task), and tend to be more highly educated and wealthier. In fact, in a large lifespan sample of 1,218 adults, Whatley et al. (2025) observed that while chronological age and trait curiosity were negatively correlated, trait curiosity was positively predicted by level of education. Therefore, our study's older adults may not necessarily represent a broader aging population, scoring fairly high on the EC Questionnaire and being relatively healthy.

Summary and Conclusion

In two experiments, we sought to determine whether subjective semantic search space, defined as the number of answer candidates one has, represents prior knowledge that accounts for age-related differences in curiosity. While search space predicted curiosity among younger and older adults, such that higher states of curiosity were associated with multiple answer candidates, older adults most often reported having one answer candidate. Consequently, while continual information gain may alter the structure of individuals' semantic networks, similar characteristics of search space may be used to gauge curiosity, suggesting that older adults' greater curiosity towards trivia may stem less from differences in search space and more from a general motivation to learn. In sum, while curiosity manifests itself differently across the lifespan, individuals may rely on the same inferred information when assessing their curiosity, specifically that pertaining to the scope of their search space, providing novel evidence of how prior knowledge influences curiosity in younger and older adults.

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Appendix

Complete list of trivia questions and their answers.

#	Question	Answer
1	What do birds rely on to swallow?	Gravity
2	What is the only country in the world that has a bible on its flag?	Dominican Republic
3	Which planet in our solar system was the last to be discovered?	Neptune
4	What is the name of the instrument used to measure wind speed?	Anemometer
5	What is the name of the biggest constellation in the sky?	Hydra
6	What is the fastest healing body part on a human?	Tongue
7	What is the name of the brightest star in the sky, excluding the sun?	Sirius
8	Which is the only continent without a desert?	Europe
9	Which drink gets its name from a town on the Red Sea coast of Yemen?	Mocha
10	Which planet in the solar system is the only one that rotates clockwise?	Venus
11	Which city was the first in the world to have a public bus service?	Paris
12	What is the correct term for a female elephant?	Cow
13	What disability did Thomas Edison suffer from?	Deafness
14	What is the name of the largest desert on earth?	Antarctica
15	What is the largest temple in Egypt?	Karnak
16	What island country lies off the south-east coast of India?	Sri Lanka
17	What body part is low-density lipoprotein most likely to clog?	Arteries
18	Which animal sleeps with one eye open?	Dolphin
19	Who is the Greek God of music?	Apollo
20	What wild animal in Africa has killed the most people?	Hippo
21	What taste are cats unable to detect?	Sweet
22	Which popular Greek philosopher is said to have tutored Alexander the Great?	Aristotle
23	What body of water does the Danube River flow into?	Black Sea
24	What is the last name of the scientist who discovered radium?	Curie
25	Copper and what else are the two main constituents of bronze?	Tin
26	What is the last name of the first person to complete a solo flight across the Atlantic Ocean?	Lindbergh
27	What flavor is the extract of fermented and dried pods of several species of orchids?	Vanilla
28	What nation started giving gas masks to its citizens before the Persian Gulf War?	Israel
29	Which land mammal has the highest blood pressure?	Giraffe
30	What is the country with the highest population density?	Monaco
31	What water-dwelling creature can make a sound loud enough to break glass?	Pistol Shrimp

32	Which country has a national anthem that consists of only 32 syllables?	Japan
33	Which animal tastes with its feet?	Butterfly
34	South America first saw the cultivation of what vegetable in 200 A.D.?	Potato
35	What spice is extremely poisonous if injected intravenously?	Nutmeg
36	What Spanish city is the capital of Catalonia?	Barcelona
37	What is the only rock that floats in water?	Pumice
38	In which country are the ruins of the City of Carthage situated?	Tunisia
39	What was the original Dutch name of New York City?	Amsterdam
40	Who was first to publish the theory that the Earth revolves around the sun?	Copernicus
41	What is the only internal human organ capable of natural regeneration of lost tissue?	Liver
42	Who was the first ruler of the Holy Roman Empire?	Charlemagne
43	What is the only animal that can turn its stomach inside out?	Starfish
44	Which poisonous snake secretes an odor like cucumbers?	Copperhead Snake
45	What color flag was historically first displayed to indicate sickness aboard a ship?	Yellow
46	What is the longest venomous snake?	King Cobra
47	What chemical compound comes from the Greek word for ‘primary’?	Protein
48	What is the fastest creature on two legs?	Ostrich
49	The title of what animal literally means ‘Terrible lizard’?	Dinosaur
50	What is the largest bear on earth?	Polar Bear

Table 1

Participants' Demographic Information in Experiment 1

	Younger Adult		Older Adult	
	n	%	*n*	%
Number of participants	71	100	74	100
Race				
White	35	49	59	80
Black/African American	24	34	12	16
Asian/Pacific Islander	11	16	0	0
Hispanic/Latino	0	0	2	3
More than one race	1	1	1	1
Education				
Graduate degree (e.g., masters, doctorate)	9	13	24	32
Bachelor's degree	33	46	22	30
Associates degree	4	6	12	16
Some college but no degree	16	23	10	14
High school degree	8	11	5	7
Less than high school	1	1	1	1

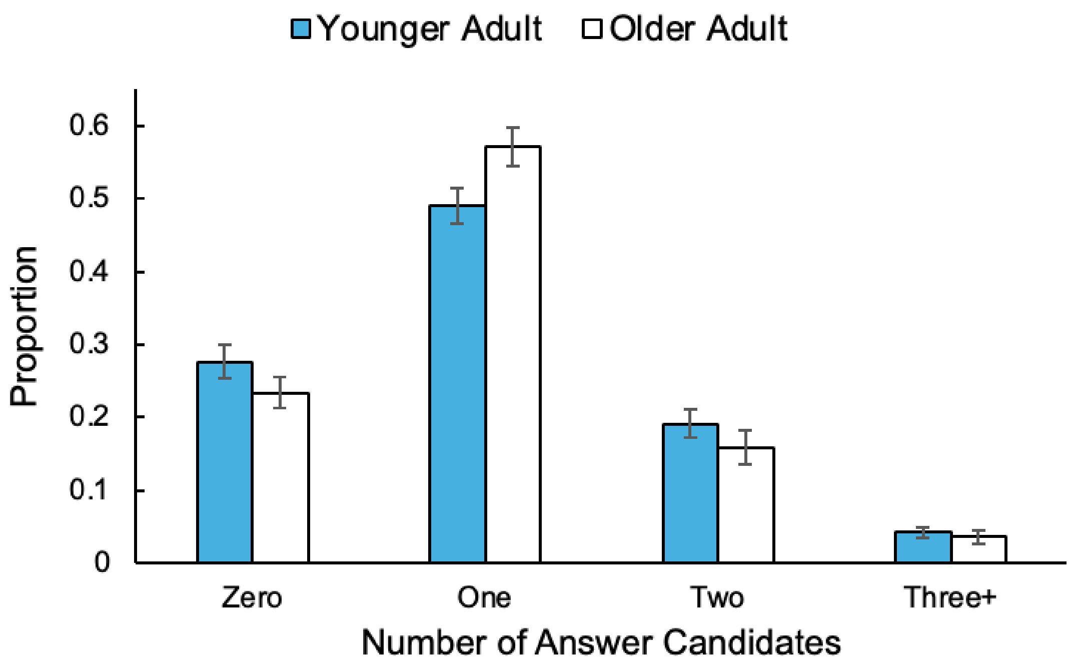
Table 2

Participants' Demographic Information in Experiment 2

	Younger Adult		Older Adult	
	n	%	*n*	%
Number of participants	79	100	73	100
Race				
White	36	46	64	88
Black/African American	20	25	6	8
Asian/Pacific Islander	12	15	1	1
Hispanic/Latino	5	6	1	1
More than one race	6	8	1	1
Education				
Graduate degree (e.g., masters, doctorate)	19	24	15	21
Bachelor's degree	23	29	20	27
Associates degree	8	10	13	18
Some college but no degree	16	20	18	25
High school degree	13	16	7	10
Less than high school	0	0	0	0

Figure 1

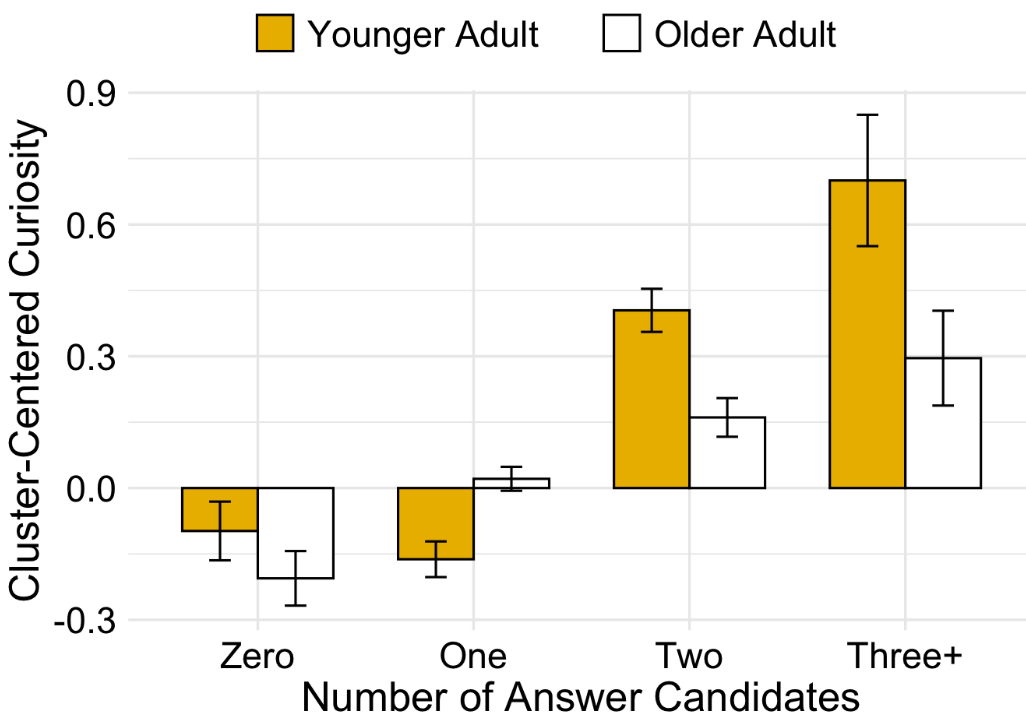
Selection Proportion of Search Space Across Age Group in Experiment 1



Note. Mean proportion of times each search space response option was chosen, split by age group, in Experiment 1. Error bars represent the standard error of the mean.

Figure 2

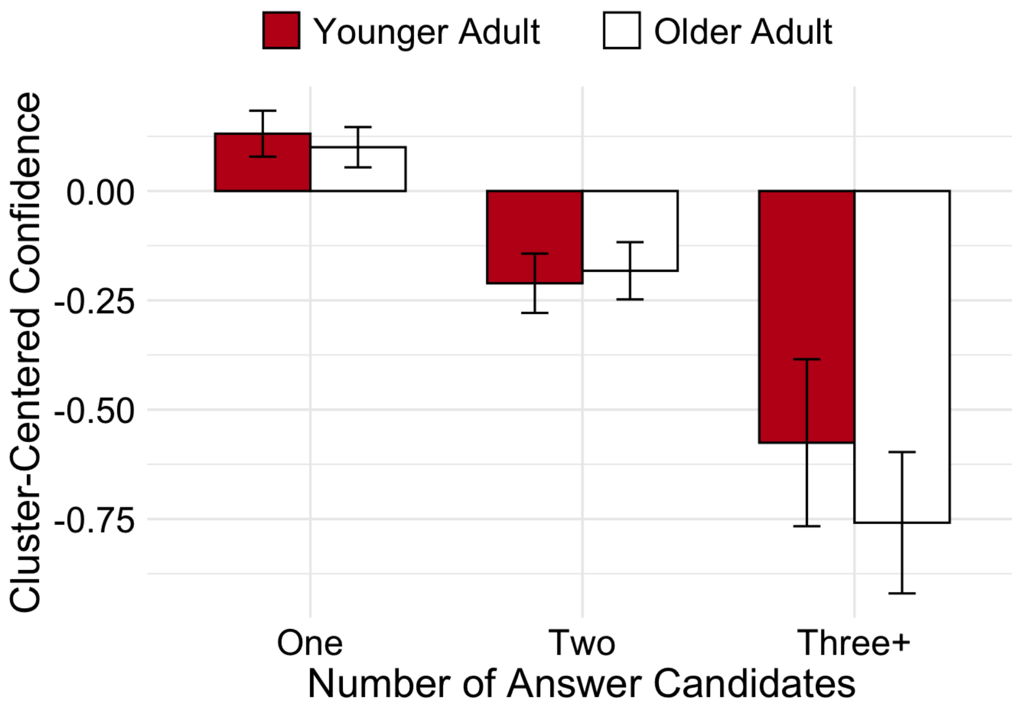
Cluster-Centered Curiosity Across Search Space, Split by Age Group, in Experiment 1



Note. Values represent group-level averages of within-participant deviations. Error bars represent the standard error of the mean.

Figure 3

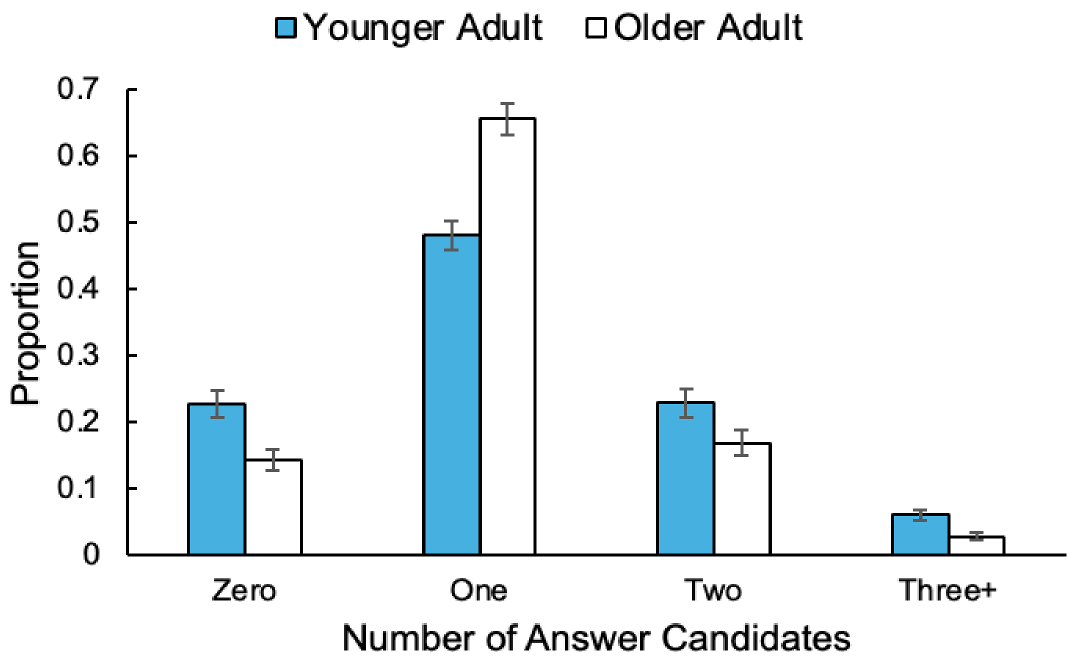
Cluster-Centered Confidence Across Search Space, Split by Age Group, in Experiment 1



Note. Values represent group-level averages of within-participant deviations. Error bars represent the standard error of the mean.

Figure 4

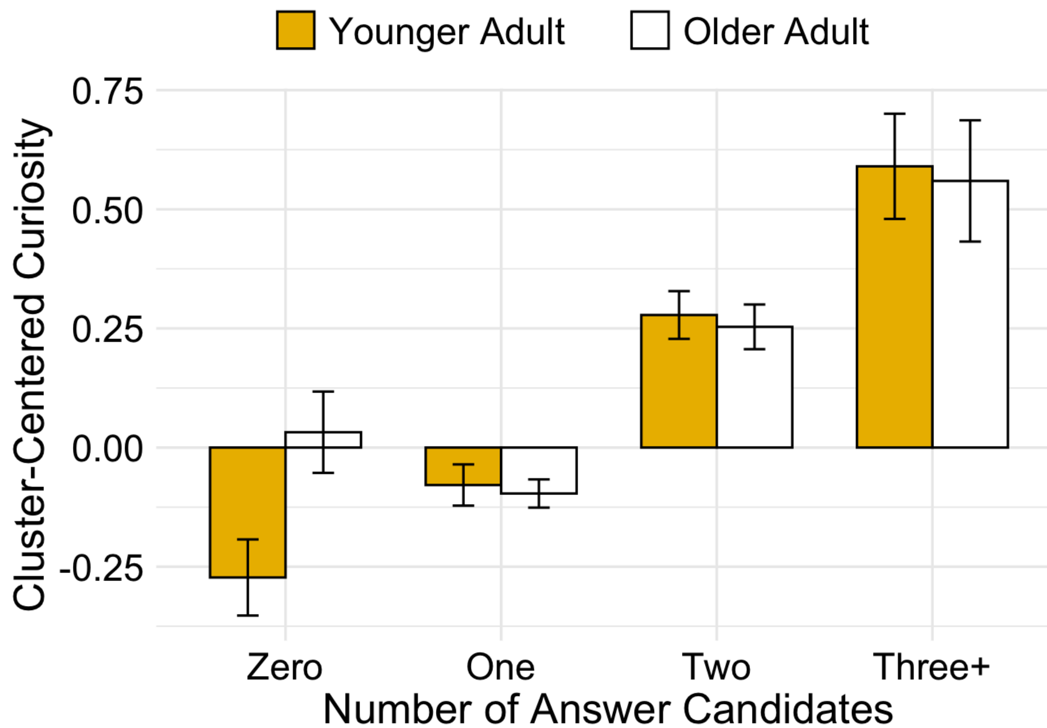
Selection Proportion of Search Space Across Age Group in Experiment 2



Note. Mean proportion of times each search space response option was chosen, split by age group, in Experiment 2. Error bars represent the standard error of the mean.

Figure 5

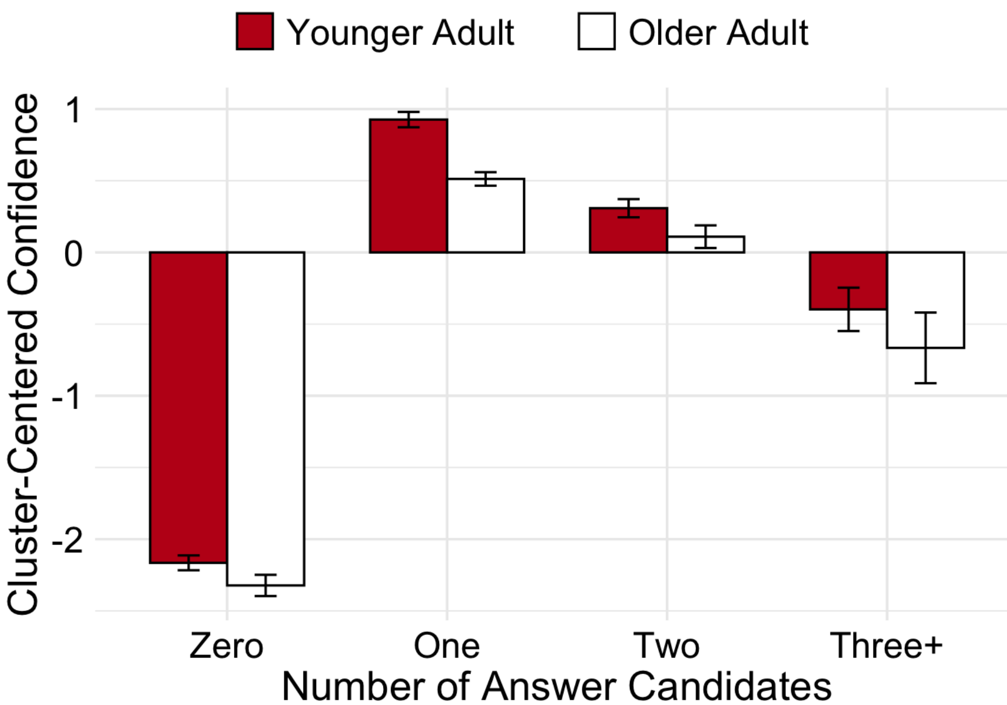
Cluster-Centered Curiosity Across Search Space, Split by Age Group, in Experiment 2



Note. Values represent group-level averages of within-participant deviations. Error bars represent the standard error of the mean.

Figure 6

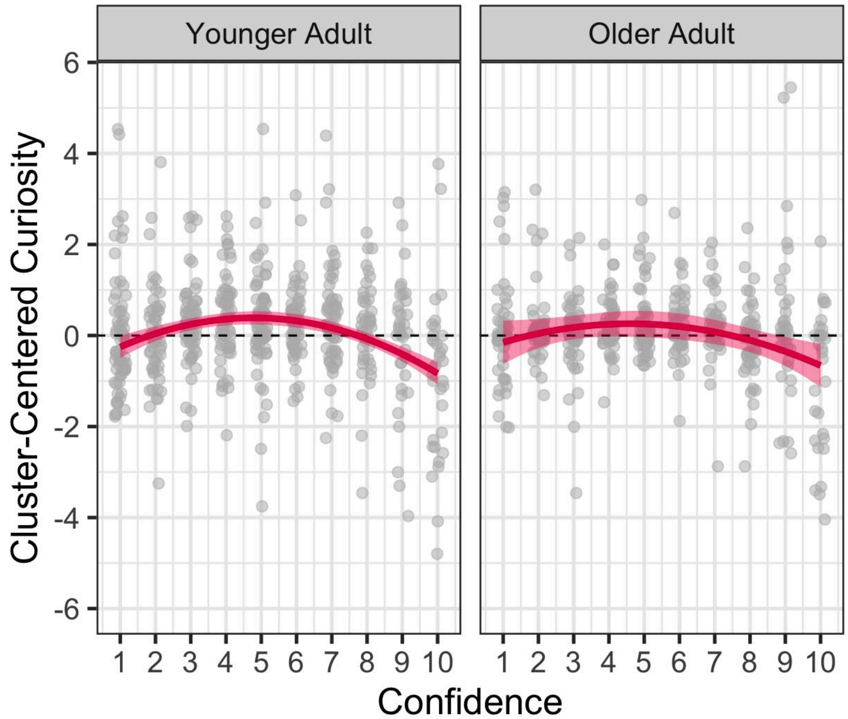
Cluster-Centered Confidence Across Search Space, Split by Age Group, in Experiment 2



Note. Values represent group-level averages of within-participant deviations. Error bars represent the standard error of the mean.

Figure 7

Cluster-Centered Curiosity as a Function of Confidence and Age Group in Experiment 2



Note. Shaded areas represent the standard error of the mean.