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# Information Search and Decision Making: Effects of Age and Complexity on Strategy Use

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The impact of task complexity on information search strategy and decision quality was examined in a sample of 135 young, middle-aged, and older adults. We were particularly interested in the competing roles of fluid cognitive ability and domain knowledge and experience, with the former being a negative influence and the latter being a positive influence on older adults' performance. Participants utilized 2 decision matrices, which varied in complexity, regarding a consumer purchase. Using process tracing software and an algorithm developed to assess decision strategy, we recorded search behavior, strategy selection, and final decision. Contrary to expectations, older adults were not more likely than the younger age groups to engage in information-minimizing search behaviors in response to increases in task complexity. Similarly, adults of all ages used comparable decision strategies and adapted their strategies to the demands of the task. We also examined decision outcomes in relation to participants' preferences. Overall, it seems that older adults utilize simpler sets of information primarily reflecting the most valued attributes in making their choice. The results of this study suggest that older adults are adaptive in their approach to decision making and that this ability may benefit from accrued knowledge and experience.

*Keywords:* decision making, aging, strategy, information search

The ability to make effective decisions is an important component of everyday functioning at any point in life, but may take on increased importance in later adulthood. The effectiveness of decisions regarding finances, housing, and health care may affect independence and the need for external supports, with the impact of poor decision making perhaps being more consequential because of the reduced time and capabilities to recover.

Although there are several potential pathways of how aging may impact decision making, we were particularly interested in the roles of cognitive ability and adaptive functioning. Cognitive declines may negatively impact older adults' abilities to systematically search information, coordinate large amounts of information in working memory, and suppress the impact of irrelevant information (e.g., Henninger, Madden, & Huettel, 2010; Queen & Hess, 2010). As a counterweight, older adults may exhibit benefits from a lifetime of experience, which may foster the development of effective decision-making strategies and the acquisition of knowledge that facilitates identification and interpretation of decision-relevant content (e.g., Meyer, Talbot, & Ranalli, 2007). Thus, age-related losses might be compensated for by gains in knowledge and strategies and by maintenance of affective processes (Hess & Queen, in press; Peters, Hess, Västfjäll, & Auman, 2007).

The goal of the present study was to examine the interactions between age and task complexity in determining information search strategies and selection of choices consistent with preferences. Increases in task complexity may tax cognitive resources and lead individuals to use strategies that minimize the amount of information considered, with such effects perhaps being more probable in later life. Experience with the decision context may minimize the impact of complexity, however, with knowledge and strong preferences leading to a more focused, information-minimizing search. This may reflect an adaptive response to the demands of the task (Marewski, Gaissmaier, & Gigerenzer, 2010), which may not necessarily decline with age, perhaps attenuating the influence of cognitive ability on performance. Intrinsic motivational factors, such as need for cognition, may also compensate for cognitive losses, with more motivated individuals tending to select compensatory search strategies.

Previous research examining information search in decision tasks generally suggests that young and older adults use different strategies. For example, Johnson and colleagues (Johnson, 1990; Johnson & Drungle, 2000; Riggle & Johnson, 1996; Stephens & Johnson, 2000) found that when compared with young adults, older adults spent more time searching an information matrix, but viewed less information (see also Mata & Nunes, 2010). Older adults were also more likely to engage in an attribute-based search (i.e., comparing the same attributes across options), whereas young adults utilized an alternative-based search (i.e., comparing alternatives with each other; Johnson, 1990; Riggle & Johnson, 1996).

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Alternative- and attribute-based searches are consistent with the use of compensatory versus noncompensatory strategies (Payne, Bettman, & Johnson, 1993). In the former, negative attributes associated with a specific alternative may be compensated for by positive attributes on other dimensions. Thus, the most effective way to search and evaluate choices is to consider all the information associated with each alternative. In a noncompensatory search, individuals make decisions primarily on the basis of the presence or absence of values on important dimensions. Information search proceeds by comparing each alternative on the most important dimensions and eliminating those that do not contain desirable values. This approach is less exhaustive than is the compensatory strategy and may require fewer cognitive resources for effective utilization. This may help explain previous observations of older adults being more likely to use noncompensatory strategies such as satisficing (Mata, von Helversen, & Rieskamp, 2010; Mata, Schooler, & Rieskamp, 2007), in which the focus is on identifying an alternative that is "good enough" as opposed to the best (Riggle & Johnson, 1996). Alternatively, older adults' selection of simpler search strategies may reflect an experience-based adaptive approach that may not necessarily impact decision outcome. For example, Mata and colleagues (2007, 2010) found that older adults were just as sensitive as young adults to the decision context, exhibiting greater use of compensatory strategies when performance benefitted from their use. Similarly, Johnson and Drungle (2000) reported that age differences in amount of information searched diminished when familiarity with the task context increased. Johnson (1990; Riggle & Johnson, 1996) also found no evidence that age differences in information search were reflected in decision quality. This suggests that older adults engage in more efficient search in familiar decision contexts, perhaps similar to that observed with older chess experts (Charness, 1981).

Other studies have found age to be negatively related to choice quality in complex tasks, with cognitive ability accounting for substantial age-related variance (e.g., Finucane & Gullion, 2010; Finucane, Mertz, Slovic, & Schmidt, 2005; Henninger et al., 2010). This, along with the information search results, suggests that older adults' decision-making might be disproportionately affected by task complexity. Across a variety of decision tasks, however, Finucane and colleagues (2005) found little evidence of Age × Complexity interaction effects on decision outcomes. To our knowledge, no aging studies have examined the impact of complexity on information search.

Our primary interest was to explore the relationship between age and complexity in a decision-making task, with particular interest in the impact of these two factors on information search strategies and subsequent decision. Young, middle-aged, and older adults were asked to make purchasing decisions about a relatively common consumer product on the basis of information presented in two decision matrices differing in complexity.

Following the assumption that cognitive ability moderates successful processing of large amounts of information and engaging in systematic information search, we predicted that increased complexity—and the associated greater cognitive demands—would result in greater use of noncompensatory strategies. Task complexity was expected to disproportionately affect older adults' performance, with ability—in part—accounting for this effect. An alternative hypothesis based in adaptive views of decision making (e.g., Gigerenzer, 2008) is that domain-specific knowledge and experience would guide search behavior, potentially compensating for ability and complexity effects. For example, strength of preferences for specific attributes may result in individuals selectively searching through subsets of information in support of a decision. This use of noncompensatory strategies would be seen as adaptive, with little basis for making specific predictions about age effects in domains with no clear age-related bias in familiarity.

# Method

## Participants

We recruited 47 young (23 women; 25–44 years old), 46 middle-aged (30 women; 45–64 years old), and 42 older (19 women; 65–84 years old) community-dwelling adults from a laboratory participant database. Each received a $30 honorarium for their participation. Participant characteristics are presented in Table 1.

Table 1
*Participant Characteristics*

| | Age group | | | | | |
|---|---|---|---|---|---|---|
| | Young | | Middle-aged | | Old | |
| Measure | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Age* | 32.3 | 6.0 | 55.2 | 5.4 | 71.4 | 5.9 |
| Education | 15.9 | 2.3 | 15.7 | 2.0 | 16.4 | 2.0 |
| Physical health | 49.7 | 6.8 | 48.5 | 4.6 | 47.7 | 6.6 |
| Mental health* | 50.5 | 9.7 | 55.3 | 7.2 | 55.4 | 8.6 |
| Vocabulary | 47.3 | 10.7 | 51.4 | 9.6 | 50.8 | 9.1 |
| Digit–symbol substitution* | 86.9 | 16.8 | 76.6 | 14.9 | 63.8 | 15.0 |
| Letter–number sequencing | 11.6 | 3.7 | 11.6 | 2.7 | 10.8 | 2.7 |
| WCST perseverative errors* | 7.7 | 3.9 | 9.1 | 5.7 | 10.1 | 7.2 |
| Need for cognition | 4.3 | 0.7 | 4.1 | 0.8 | 4.3 | 0.8 |

*Note*. Age and education are in years. Health scores are normed T scores. Scores on the ability tests represent raw scores. Need for cognition score is the average response on a scale of 1 to 6 across all 18 items. WCST = Wisconsin Card Sort Task.
* Significant age group effect ($p < .05$).

## Materials

**Matrix construction.** Two matrices were constructed to present information about purchasing an automobile. The simple matrix contained 25 information cells (5 alternatives × 5 attribute dimensions) involving 10 potential between-alternatives contrasts, whereas the complex matrix contained 48 cells (8 alternatives × 6 attribute dimensions) with a possible 28 between-alternatives contrasts. Relevant attributes were identified through consumer ratings (Edmunds, 2010), and included comfort, design, fuel efficiency, reliability, and safety, with performance as the additional attribute in the complex matrix. Choice alternatives were labeled at the top of the columns in the matrix using fabricated model numbers, and attribute labels were listed for each row on the left side of the matrix.

Matrices were presented using Mouselab, an open-source process-tracing program (Willemsen & Johnson, 2011). Information within the cells was presented using plus or minus signs. Two plus signs indicated that an option rated much better than average on an attribute dimension, one plus sign indicated an above-average rating, one minus sign indicated a below-average rating, and two minus signs indicated that the choice rated much worse than average. The distribution of positive/negative attributes in the simple matrix is shown in Table 2. Note that each attribute dimension contained at least one of each of the four possible ratings across alternatives. Alternatives were counterbalanced across participants so that each one appeared in each position in the matrix a similar number of times.

**Additional measures.** Two scales were included that assessed intrinsic motivational factors that could conceivably impact breadth of search and task engagement: Personal Need for Structure (PNS; Neuberg & Newsom, 1993) and Need for Cognition (NFC; Cacioppo, Petty, & Kao, 1984) scale. Domain knowledge was measured using five items assessing car ownership, possession of a driver's license, and knowledge, familiarity, and experience with purchasing a car. Preferences were assessed by having participants rate the importance of each of the six attribute dimensions. We measured processing speed, working memory, and verbal ability using the Digit–Symbol Substitution (DSS), Letter–Number Sequencing (LNS), and Vocabulary Subtests, respectively, from the Wechsler Adult Intelligence Scale—III (WAIS–III; Wechsler, 1997). The computerized version of the Wisconsin Card Sort Task (WCST; Heaton & P. A. R. staff, 2000) was used to obtain a general measure of executive functioning.

## Procedure

Prior to testing, participants were sent a package of questionnaires (a demographic form, SF36 health survey [Ware, 1993], and NFC and PNS scales). At their test session, participants were acquainted with the Mouselab program using a 3 (alternative) × 3 (attribute) practice matrix containing information about renting an apartment. The information within each cell was masked, and participants accessed this information one cell at a time by clicking on a cell to view the information and clicking again to close the box before viewing more information. After viewing the desired amount of information, participants selected one of the options.

After participants practiced navigating the matrix, they were asked to imagine that they were in the market for purchasing a new automobile and that the choices in the matrix were those they were considering. They were told that they could view as much or as little of the available information as they wished and that they were not required to view the whole matrix. Participants were also assured that there was no correct choice, because each of the options differed in several aspects. There was no time limit for the task. After selecting a choice, participants were given the vocabulary test followed by a 2-min break period. Participants were then presented with a second decision task and were told that the choices in this matrix were different from those in the first matrix.[1]

Approximately half of the participants in each age group viewed the simple matrix first, whereas the remaining participants viewed the complex matrix first. Upon completing the matrix tasks, participants were given the domain-specific knowledge/importance questionnaire, followed by the remaining ability tasks.

# Results

The results are organized into four sections. First, we examined the impact of age and task complexity on search-related responses. Second, we identified participants' search strategies and the relationship of these strategies to age and complexity. Third, we examined interrelationships between search behaviors or strategies and participant characteristics. Finally, we assessed consistency between participants' preferences and their decisions and examine the relationships to age, participant characteristics, complexity, and search behaviors.

## Search Characteristics

We calculated the (a) total time spent on search, (b) mean time spent studying an open cell, (c) proportion of cells opened at least once, (d) mean number of times a cell was reopened after initial viewing, and (e) the correlation between rated importance for an attribute dimension and the number of times that cells on that dimension were opened (see Table 3). This last variable assessed the degree to which the importance assigned to a particular attribute dimension influenced the amount of information sampled. Reisen, Hoffrage, and Mast (2008) found a strong relationship between the two, suggesting that information search is focused most on attribute dimensions valued by participants. We also calculated two Adjusted Ratio of Clustering (ARC; Roenker, Thompson, & Brown, 1971) scores using repetitions either on the same attributes (e.g., examining fuel efficiency of Car 1 and then for Car 2) or within alternatives (e.g., examining fuel efficiency followed by safety for Car 1). This allowed us to assess the degree to which participants were engaging in attribute-based versus alternative-based search. ARC scores are preferable over simple counts of repetitions because they adjust for chance on the basis of the amount of available information and the number of cells actually viewed.

[1] Skin conductance responses were also assessed during the task. Analysis of these data did not reveal anything informative, and thus are not presented. They are available from the authors upon request.

Table 2
*Matrix Contents for the Simple Condition*

| Attribute | Alternative 1 | Alternative 2 | Alternative 3 | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|
| Reliability | − | + | ++ | −− | + |
| Design | ++ | − | ++ | −− | + |
| Safety | + | −− | − | ++ | + |
| Comfort | + | ++ | −− | − | −− |
| Fuel efficiency | ++ | + | − | + | −− |

We performed 3 × 2 × 2 (Age Group × Presentation Order × Complexity) analyses of variance (ANOVAs) on these variables[2] (see Table 3). Significant main effects of age were observed for total search time, $F(2, 126) = 12.50$, $p < .001$, $\eta_p^2 = .17$, and mean time spent studying an opened cell, $F(2, 127) = 18.58$, $p < .001$, $\eta_p^2 = .23$. Thus, older adults took more time studying the whole matrix and individual cells. Search behaviors also differed by task complexity. Total search time, $F(1, 126) = 11.93$, $p = .001$, $\eta_p^2 = .09$, and attribute-based search, $F(2, 129) = 13.56$, $p < .001$, $\eta_p^2 = .10$, increased with increasing complexity, but proportion of cells sampled, $F(2, 128) = 151.14$, $p < .001$, $\eta_p^2 = .54$, repeat viewings, $F(2, 124) = 30.96$, $p < .001$, $\eta_p^2 = .20$, and correspondence between sampling and importance, $F(2, 128) = 12.98$, $p < .001$, $\eta_p^2 = .09$, decreased with complexity. Finally, presentation order interacted with complexity for both total viewing time, $F(2, 126) = 10.10$, $p = .002$, $\eta_p^2 = .07$, and mean study time per cell, $F(2, 127) = 84.64$, $p < .001$, $\eta_p^2 = .40$. In the former case, the aforementioned complexity effect was stronger when the complex matrix was presented first, whereas mean study time was longer for the first-presented matrix than for the second-presented matrix, regardless of complexity. No other main effects or interactions were significant.

In summary, the amount of information sampled and resampled decreased with increased complexity. An alternative-based search did not vary across levels of complexity, but attribute-based search increased with complexity. These results are suggestive of a complexity-related shift from compensatory to noncompensatory search (i.e., less information sampled with a focus on attribute-based comparisons). There was also some evidence that increased complexity was disruptive to systematic search in that the concordance between attribute sampling and rated importance declined with complexity. It may be possible that important attributes are more memorable and thus are less likely to be revisited. If true, however, it would be expected that such memorability effects would be stronger when fewer alternatives are being considered, and accuracy of linking specific attributes to specific alternatives is likely to be greater. Somewhat surprisingly, there was no evidence that age alone influenced search behavior or that the responses of older adults were disproportionately influenced by task complexity.

## Search Strategy

We next attempted to identify search strategies more precisely using an algorithm developed by Riedl, Brandstätter, and Roithmayr (2008). To identify the use of six different search strategies, this algorithm uses three types of information obtained from the MouseLab program: alternative-based versus attribute-based repetitions, time spent on each alternative, and the order and number of cells viewed for each attribute.[3] The majority of participants were classified as using one of two search strategies: satisficing (simple 48.9%, complex 65.2%), a noncompensatory search strategy, and variants of weighting strategies (simple 46.7%, complex, 30.4%) representing a compensatory strategy. A small number of participants engaged in other types of compensatory strategies (simple 0.7%, complex 0.7%) and noncompensatory strategies (simple 3.7%, complex 3.7%). Thus, participant use of compensatory versus noncompensatory strategies was relatively equal with the simple matrix (52.6% vs. 47.4%), whereas noncompensatory strategies were used more with the complex matrix (68.9% vs. 31.1%). In line with expectations, the impact of complexity on strategy use was significant, $\chi^2(1) = 7.42$, $p < .01$; however, there were no age differences in strategy use for either matrix ($p$s > .30). Consistency in strategy use across arrays was relatively high, with 77.3% of participants using the same type of search in both. When participants did switch strategies, it was in the anticipated direction: 20% of the participants went from using a compensatory strategy in the simple array to use of a noncompensatory strategy in the complex array, whereas only 3.7% of participants exhibited the reverse pattern. There was a trend between age and strategy switching, $\chi^2(2) = 4.85$, $p = .09$, with both middle-aged (29.5%) and older (31.0%) adults being more likely to switch strategies than were younger adults (13.0%).

## Predictors of Strategy Use

We next attempted to identify what distinguished participants using each type of strategy from each other. To this end, we used discriminant analyses to determine the most important participant characteristics associated with strategy use for each matrix. We were particularly interested in factors that might limit or encourage

[2] Statistical outliers were removed from each analysis, with the data of 0 to 5 participants being excluded from the analysis of each dependent measure.

[3] To ensure the validity of the Riedl et al. algorithm, we examined the relationship between the search strategies identified by the algorithm and specific search behaviors. Participants classified as using a compensatory strategy exhibited significantly higher alternative-based search, lower attribute-based search, sampling of more available information, less differential sampling of information based on attribute importance, less resampling, and more time spent searching than those classified as using noncompensatory strategies. These differences are consistent with distinctions drawn between the two categories of strategies, indicating that the algorithm does a good job of distinguishing between people on the basis of search strategies.

Table 3
*Search Indices as a Function of Age Group and Matrix Complexity*

| | Simple matrix | | | Complex matrix | | |
|---|---|---|---|---|---|---|
| Measure | Young | Middle-aged | Old | Young | Middle-aged | Old |
| Study time per cell (ms)[b] | 1084 | 1418 | 1773 | 1075 | 1317 | 1761 |
| Total study time (s)[a,b] | 84.7 | 106.7 | 146.6 | 91.7 | 131.6 | 171.4 |
| Proportion cells sampled[a] | 0.78 | 0.85 | 0.85 | 0.59 | 0.66 | 0.62 |
| Repeat viewings[a] | 0.9 | 0.8 | 1.0 | 0.5 | 0.5 | 0.6 |
| *r* importance × views[a] | 0.57 | 0.50 | 0.51 | 0.46 | 0.43 | 0.33 |
| ARC alternative | 0.39 | 0.46 | 0.47 | 0.48 | 0.50 | 0.44 |
| ARC attribute[a] | 0.27 | 0.27 | 0.24 | 0.39 | 0.34 | 0.34 |

*Note*. Means exclude outliers. ARC = adjusted ratio of clustering.
[a] Significant complexity effect. [b] Significant age effect.

the use of compensatory or noncompensatory strategies. Cognitive ability (LNS, DSS, and WCST perseverative error scores) and health (SF36 physical and mental health scores) were included because of their relationship to age and the possibility that decrements in these domains might limit the use of more complex compensatory strategies. We also included factors that we assumed would tap into general (education, vocabulary) and task-specific (domain knowledge, attribute preferences[4]) knowledge, which we reasoned might be used to guide search and perhaps be reflected in positive associations with noncompensatory strategy use. Finally, we also included our two measures of intrinsic motivation. We expected that NFC—which is reflective of a motivational factor reflecting the degree of enjoyment associated with engaging in cognitively demanding activities (Cacioppo, Petty, Feinstein, & Jarvis, 1996)—would be associated with more elaborate processing, whereas PNS—reflecting the need for simple structures (Neuberg & Newsom, 1993)—would be associated with the use of simpler strategies. We used a forward stepwise procedure to identify the variables with the clearest relationships to strategy use.

For the simple matrix, the function included only education, Wilks' $\lambda = .95$, $\chi^2(1) = 7.42$, $p = .006$. Consistent with the previous analyses, noncompensatory strategy use was positively associated with this function (.23), and compensatory strategy use was negatively associated (−.25). For the complex matrix, a stronger and more complex function was obtained, Wilks' $\lambda = .81$, $\chi^2(4) = 27.41$, $p < .001$, presumably reflecting the greater impact of individual characteristics as task demands increased. The function contained positive loadings on physical health (.58), LNS (.45), and preferences (.49), and a negative loading for NFC (−.59). Noncompensatory strategy users had high scores on this function (.28), whereas compensatory strategy users had low scores (−.63).

These results provide a different perspective on strategy use than might be expected simply on the basis of ability. Specifically, instead of noncompensatory strategy use being observed in older adults and those of lower ability, we found that it was more typically displayed in individuals with higher levels of education, physical health, and ability. It was also more likely to be found in those with stronger preferences regarding the importance of attributes. Compensatory strategies were more likely in those with higher levels of NFC, which may be related to the fact that these strategies are more complex and fit well with these individuals' preferences for such activities.

## Choice

Our final set of analyses examined the consistency of chosen alternatives with rated preferences, and the impact of age, complexity, and strategy on consistency. To assess consistency, we focused on the expected value of the alternatives chosen by each participant. Following Lohse and Johnson (1996), we calculated ratio scores that reflect the expected value (EVR) of the chosen alternative in relation to that of the alternative in the set that had the highest expected value on the basis of participant preferences. This allowed us to determine the degree to which choices were consistent with stated preferences (i.e., the importance assigned to specific attribute dimensions). Higher scores reflect greater consistency. EVRs were calculated using weighted values (Cell value × Importance rating) using only values of inspected cells. This allowed us to take into account not only the information presented in the matrix, but also the value placed on that information by participants. Excluding information from uninspected cells also resulted in scores based only on information actually viewed. Whereas the EVR score calculated in this fashion might be higher or lower than that used when all cells are considered, it is reflective of the constraints associated with the different information search strategies used by participants. The obtained EVR scores were then examined using an Age × Complexity ANOVA. (Two middle-aged participants were statistical outliers.) EVRs were significantly higher for the simple ($M = .74$) than for the complex ($M = .68$) matrix, $F(2, 130) = 5.21$, $p = .02$, $\eta_p^2 = .04$, suggesting that participants' decisions were more closely tied to preferences in situations involving less information. No significant age effects were observed in either case.

We next examined whether EVRs were related to strategy type using separate Age × Strategy (Compensatory × Noncompensatory) ANOVAs at each level of complexity. (Two older participants were statistical outliers.) For the simple matrix, neither strategy nor age was significantly related to EVR (*p*s > .17). In contrast, EVR scores were significantly greater for compensatory ($M = .76$) than for noncompensatory ($M = .66$) strategies with the complex matrix, $F(2, 127) = 5.45$, $p = .02$, $\eta_p^2 = .04$. Thus,

[4] The standard deviation of importance ratings for the six dimensions used in the study was used to assess the degree to which participants exhibited preferences for some attribute dimensions over others. Greater standard deviations would indicate greater degrees of preference.

although the use of noncompensatory strategies was more prevalent in those individuals of higher ability, their use was associated with choices that were less consistent with stated preferences—given the information sampled—than were those associated with use of compensatory strategies.

One way to view these results is in terms of the goals of satisficing, which was the dominant noncompensatory strategy identified using the Riedl and colleagues (2008) algorithm. Satisficing typically involves identifying a choice that is "good enough" rather than the best choice, and thus it may not be surprising that EVRs were somewhat lower when using this strategy. Note also that true satisficers are likely to consider only a few important attribute dimensions; therefore scores calculated based on all attributes are likely to be biased against satisficers. To this end, we recalculated EVR scores using only information from the attribute dimension(s) that was (were) rated highest by the participant and then examined the recalculated EVR scores using a 3 $\times$ 3 (Age Group $\times$ Strategy) ANOVA. In essence, this compared consistency of choice with preferences when selection was based only on information on the attribute dimensions—or dimensions, in case of ties—valued most by the participant. The strategy effect was not significant, $F(2, 122) = 2.87$, $p = .09$, $\eta_p^2 = .02$, but those using compensatory search still had somewhat higher scores than did those using noncompensatory search (.70 vs. .61). These satisficing-based EVR scores were, however, significantly higher for older adults (.76) than for young or middle-aged adults (*M*s = .61), $F(2, 122) = 3.66$, $p = .03$, $\eta_p^2 = .06$. A similar analysis with the simple matrix revealed no age effects ($p = .64$). Taken together, these two analyses suggest that although strategy differences are not evident across age groups, older adults, when presented with complex information, appear to utilize simpler sets of information that primarily reflect the most valued attributes in making their choice.

## Discussion

The present study was designed to examine adult age differences in information search strategies and decision quality in a consumer decision-making task. Of interest was the extent to which task complexity affected both factors, with a particular focus on the possibility that complexity would become more consequential with increasing age. From the viewpoint of later life as a time of diminished cognitive resources, the results of our study were surprising in that they suggest that different-aged adults approach the search of complex decision information in a similar manner. Contrary to expectations, older adults were not more inclined than younger adults to engage in information-minimizing behaviors as the complexity of the decision-making task increased. Participants of all ages adjusted their search behavior when complexity increased by favoring noncompensatory search strategies (e.g., satisficing) when task demands were high. In direct contradiction to the notion that reduced cognitive resources would be associated with information-minimizing search, higher education and better working memory were associated with preference for a noncompensatory strategy, particularly in the complex matrix condition. The fact that degree of preferences for some attribute dimensions over others was also predictive of noncompensatory strategy selection suggests that older adults' search of complex decision information is more strongly related to experience and preference construction than cognitive functioning, consistent with an adaptive functioning view of aging and decision making.

Although we did not observe age differences in search behavior, the results of this study are not inconsistent with previous findings. For instance, Mata and colleagues (2007) found that although older adults tended to favor noncompensatory search strategies, they were just as adept as younger adults at adjusting their search behavior to the demands of the task. Mata and colleagues suggested that the lack of age differences in strategy adaptation is consistent with the idea that decision makers possess an adaptive toolbox of strategies that allows for maintenance of performance under a variety of environments (see Gigerenzer & Brighton, 2009; Payne et al., 1993). Similar sensitivity to task characteristics across age groups in a somewhat different context was observed by Hess, Queen, and Patterson (2012) and Queen and Hess (2010). Although age-related cognitive declines may result in older adults engaging in simpler information searches, accrued decision-making experience may help guide optimal strategy selection across environments.

Our findings regarding ability also appear to be consistent with work by Bröder (2003), who suggested that the relationship between ability and strategy selection may be in a less intuitive direction. Bröder found that higher intelligence (as defined by a measure of *g* and working memory) was associated with use of a simpler heuristic. We found that participants choosing such strategies also had stronger preferences regarding attribute dimensions defining choices, which perhaps guided their search to focus on only what they deemed the most important choice attributes. These findings suggest that those of higher ability may be more skilled in engaging in a guided search.

Our examination of the nature of choices made by participants was more perplexing. In contrast to what might be expected on the basis of our foregoing analysis, we found that participants who engaged in compensatory search produced decisions that were more consistent with their preferences. Further examination revealed that this was primarily the case when the consistency of participants' decisions with their preferences was based on all attribute dimensions inspected for each alternative. Consideration of all information available is more consistent with the compensatory approach than with the noncompensatory approach. Thus, it may make sense that use of a choice metric based on more complete information would favor those using compensatory strategies. When a metric was devised that was more consistent with satisficing, the differences between strategy groups disappeared. It should be noted that satisficing is associated with a "good enough" choice, and thus it may also not be surprising that this, in essence, characterized the choices of those using noncompensatory strategies. The only age difference that emerged occurred when the satisficing-based EVR measures were used, with older adults exhibiting higher choice-preference consistency than either middle-aged or younger adults. This may suggest that even though strategy differences were not evident between age groups, older adults may still base their ultimate decisions on less information, a finding that appears consistent with that of Mata and colleagues (2007).

A few limitations of this study should be addressed. One possible explanation for the lack of age effects in response to task complexity may be the content of the decision matrices. Following Löckenhoff and Carstensen (2008), we described the attributes of each of the options by global attractiveness ratings rather than by specific information. Although this method may be beneficial in understanding individuals' affective responses to choice options, perhaps this mode of presentation minimizes the processing demands of the search task, decreasing the probability of finding age differences. We chose this method because of the difficulties in calculating objective evaluations when more detailed descriptions of choice attributes.

It is also possible that there was not enough differentiation in the size of the matrices in order to achieve a successful manipulation of task complexity. Our selection of 25 cells and 48 cell matrices was determined on the basis of previous studies examining search patterns within information arrays (see Johnson, 1990; Johnson & Drungle, 2000). It may be that the larger matrix was not complex enough to identify age or ability differences in strategy selection and search behavior. Note, however, that increased complexity was associated with reductions in both the amount of information sampled and the manner of sampling. In addition, if we simply consider the number of possible pairwise comparisons across the 5- and 8-alternative matrices—10 versus 28—it can be seen that the task demands are substantially greater in the latter case.

Finally, this is the first experimental study to our knowledge that has applied the strategy algorithm developed by Riedl and colleagues (2008). Although we reported strong expected relationships between search behavior and strategy, the algorithm should be further validated in future studies.

## Conclusion

Previous research suggests a complex effect of aging on decision-making processes, with several studies reporting deficiencies in decision-making ability in older age (e.g., Henninger et al., 2010) and others reporting preservation of functioning (e.g., Mata et al., 2007). The results of the current study present evidence for the adaptivity of this ability in older age. Knowledge-based factors may be more important determinants of information search and the associated decision outcomes than is ability. This conclusion resonates with previous work demonstrating that age differences in decision-making behavior are strongly related to domain knowledge (e.g., Kim & Hasher, 2005; Meyer, Russo, & Talbot, 1995; Meyer et al., 2007; Tentori, Osherson, Hasher, & May, 2001) and echo the need to maintain a contextual approach in understanding the impact of age on decision making instead of relying on age as a predictor of decline on such tasks. Our findings also reemphasize the complexity and multidimensional nature of the decision-making process.

## References


Bröder, A. (2003). Decision making with the "adaptive toolbox": Influence of environmental structure, intelligence, and working memory load. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 611–625. doi:10.1037/0278-7393.29.4.611

Cacioppo, J. T., Petty, R. E., Feinstein, J. A., & Jarvis, W. B. G. (1996). Dispositional differences in cognitive motivation: The life and times of individuals varying in need for cognition. *Psychological Bulletin, 119,* 197–253. doi:10.1037/0033-2909.119.2.197

Cacioppo, J. T., Petty, R. E., & Kao, C. F. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48,* 306–307. doi:10.1207/s15327752jpa4803_13

Charness, N. (1981). Search in chess: Age and skill differences. *Journal of Experimental Psychology: Human Perception and Performance, 7,* 467–476. doi:10.1037/0096-1523.7.2.467

Edmunds. (2010). *Consumer ratings index.* Retrieved November 12, 2010, from http://www.edmunds.com/apps/ratings/ratingsRedirect.jsp?op=1&nu=used&year=2009&make=&model=

Finucane, M. L., & Gullion, C. M. (2010). Developing a tool for measuring the decision-making competence of older adults. *Psychology and Aging, 25,* 271–288. doi:10.1037/a0019106

Finucane, M. L., Mertz, C. K., Slovic, P., & Schmidt, E. S. (2005). Task complexity and older adults' decision-making competence. *Psychology and Aging, 20,* 71–84. doi:10.1037/0882-7974.20.1.71

Gigerenzer, G. (2008). Why heuristics work. *Perspectives on Psychological Science, 3,* 20–29. doi:10.1111/j.1745-6916.2008.00058.x

Gigerenzer, G., & Brighton, H. (2009). Homo heuristicus: Why biased minds make better inferences. *Topics in Cognitive Science, 1,* 107–143. doi:10.1111/j.1756-8765.2008.01006.x

Heaton, R. K., & P. A. R. Staff. (2000). *Wisconsin Card Sorting Test® computer version 4 research edition.* Lutz, FL: Psychological Assessment Resources, Inc.

Henninger, D. E., Madden, D. J., & Huettel, S. A. (2010). Processing speed and memory mediate age-related differences in decision making. *Psychology and Aging, 25,* 262–270. doi:10.1037/a0019096

Hess, T. M., & Queen, T. L. (in press). Aging influences on judgment and decision processes: Interactions between ability and experience. In P. Verhaeghen & C. Hertzog (Eds.), *The Oxford handbook of emotion, social cognition, and everyday problem solving during adulthood.* New York, NY: Oxford University Press.

Hess, T. M., Queen, T. L., & Patterson, T. (2012). To deliberate or not to deliberate: Interactions between age, task characteristics, and cognitive activity on decision making. *Journal of Behavioral Decision Making, 25,* 29–40. doi:10.1002/bdm.711

Johnson, M. M. S. (1990). Age differences in decision making: A process methodology for examining strategic information processing. *Journal of Gerontology: Psychological Sciences, 45,* 75–78.

Johnson, M. M. S., & Drungle, S. C. (2000). Purchasing over-the-counter medications: The impact of age differences in information processing. *Experimental Aging Research, 26,* 245–261. doi:10.1080/036107300404886

Kim, S., & Hasher, L. (2005). The attraction effect in decision making: Superior performance by older adults. *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 58*A, 120–133. doi:10.1080/02724980443000160

Löckenhoff, C. E., & Carstensen, L. L. (2008). Decision strategies in health care choices for self and others: Older but not younger adults make adjustments for the age of the decision target. *Journals of Gerontology: Series B. Psychological Sciences, 63*B, P106–P109. doi:10.1093/geronb/63.2.P106

Lohse, G. L., & Johnson, E. J. (1996). A comparison of two process tracing methods for choice tasks. *Organizational Behavior and Human Decision Processes, 68,* 28–43. doi:10.1006/obhd.1996.0087

Marewski, J. N., Gaissmaier, W., & Gigerenzer, G. (2010). Good judgments do not require complex cognition. *Cognitive Processing, 11,* 103–121. doi:2010-08597-00210.1007/s10339-009-0337-0

Mata, R., & Nunes, L. (2010). When less is enough: Cognitive aging, information search, and decision quality in consumer choice. *Psychology and Aging, 25,* 289–298. doi:10.1037/a0017927

Mata, R., Schooler, L. J., & Rieskamp, J. (2007). The aging decision maker: Cognitive aging and the adaptive selection of decision strategies. *Psychology and Aging, 22,* 796–810. doi:10.1037/0882-7974.22.4.796

Mata, R., von Helversen, B., & Rieskamp, J. (2010). Learning to choose: Cognitive aging and strategy selection learning in decision making. *Psychology and Aging, 25,* 299–309. doi:10.1037/a0018923

Meyer, B. J. E., Russo, C., & Talbot, A. (1995). Discourse comprehension and problem solving: Decisions about the treatment of breast cancer by women across the life span. *Psychology and Aging, 10,* 84–103. doi: 10.1037/0882-7974.10.1.84

Meyer, B. J. E., Talbot, A. P., & Ranalli, C. (2007). Why older adults make more immediate treatment decisions about cancer than younger adults. *Psychology and Aging, 22,* 505–524. doi:10.1037/0882-7974.22.3.505

Neuberg, S. L., & Newsom, J. (1993). Individual differences in chronic motivation to simplify: Personal need for structure and social–cognitive processing. *Journal of Personality and Social Psychology, 65,* 113–131. doi:10.1037/0022-3514.65.1.113

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker.* New York, NY: Cambridge University Press.

Peters, E., Hess, T. M., Västfjäll, D., & Auman, C. (2007). Adult age differences in dual information processes and their influence on judgments and decisions: A review. *Perspectives on Psychological Science, 2,* 1–23. doi:0.1111/j.1745-6916.2007.00025

Queen, T. L., & Hess, T. M. (2010). Age differences in the effects of conscious and unconscious thought in decision making. *Psychology and Aging, 25,* 251–261. doi:10.1037/a0018856

Reisen, N., Hoffrage, U., & Mast, F. W. (2008). Identifying decision strategies in a consumer choice situation. *Judgment and Decision Making, 3,* 651–658. 2009–00290-005.

Riedl, R., Brandstätter, E., & Roithmayr, F. (2008). Identifying decision strategies: A process- and outcome-based classification method. *Behaviour Research Methods, 40,* 795–807. doi:10.3758/BRM.40.3.795

Riggle, E. D. B., & Johnson, M. M. S. (1996). Age difference in political decision making: Strategies for evaluating political candidates. *Political Behavior, 18,* 99–118. doi:1996-03406-00410.1007/BF01498661

Roenker, D., Thompson, C., & Brown, S. (1971). Comparison of measures for the estimation of clustering in free recall. *Psychological Bulletin, 76,* 45–48. doi:10.1037/h0031355

Stephens, E. C., & Johnson, M. M. S. (2000). Dr. Mom and other influences on younger and older adults' OTC medication purchases. *Journal of Applied Gerontology, 19,* 441–459. doi:10.1177/073346480001900405

Tentori, K., Osherson, D., Hasher, L., & May, C. (2001). Wisdom and aging: Irrational preferences in college students but not older adults. *Cognition, 81,* B87–B96. doi:10.1016/S0010-0277(01)00137-8

Ware, J. E., Jr. (1993). *SF-36 health survey.* Boston,MA: Health Institute, New England Medical Center.

Wechsler, D. (1997). *Wechsler Adult Intelligence Scale* (3rd ed.). New York, NY: Psychological Corporation.

Willemsen, M. C., & Johnson, E. J. (2011). Visiting the decision factory: Observing cognition with MouselabWEB and other information acquisition methods. In M. Schulte-Mecklenbeck, A. Kühberger, & R. Ranyard (Eds.), *A handbook of process tracing methods for decision research: A critical review and user's guide* (pp. 21–42). New York, NY: Psychology Press.

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