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# When Less Is Enough: Cognitive Aging, Information Search, and Decision Quality in Consumer Choice

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We conducted a meta-analysis of age differences in predecisional information search ($N = 1{,}304$) that suggests that aging is associated with a small but significant decrease in predecisional information search (Hedges's $g = -0.30$). In addition, we investigated the consequences of limited information search for decision quality in real-world consumer environments using simulation methods. Overall, the results suggest that the aging decision maker can afford to neglect information because this leads to small losses in decision quality. In other words, less may be enough for the aging consumer.

*Keywords:* decision making, strategy, meta-analysis, search

Life expectancy has increased remarkably over the past century (Oeppen & Vaupel, 2002), leading more and more people to make important health-related, financial, and consumer decisions in later stages of their life span. Reviews of aging and decision making have suggested that reduced predecisional information search with increased age is the "most frequently replicated age difference in decision making" (Mather, 2006, p. 146; Yoon, Cole, & Lee, 2009). For example, studies investigating choice of consumer products suggest that older adults tend to consider fewer pieces of nutritional information when buying cereals (Cole & Balasubramanian, 1993) and search for fewer brands, dealers, and models when purchasing automobiles (Lambert-Pandraud, Lapersonne, & Laurent, 2005). Also, older adults prefer to have fewer options to choose from (Reed, Mikels, & Simon, 2008) and, in some circumstances, less variety in their choices (Novak & Mather, 2007). But how large and consistent are these differences across different decision tasks? More important, how much do they impact the quality of older adults' decisions? Some studies have suggested that "there is no correlation between the amount of information sought and the quality of decisions" (Mather, 2006, p. 165), whereas others encouraged researchers to address "the conditions under which adults' restricted search leads to more efficient search and better outcomes" (Yoon et al., 2009, p. 11). In this article, we attempt to address these issues by quantifying age-related changes in information search and the subsequent impact on decision quality in the consumer choice domain.

Two aspects are crucial to understand the impact of age-related decline in information search on decision quality. First, one requires a reliable estimate of age differences in information search. An estimate of age differences in information search can be obtained by observing younger and older adults' decision-making behavior and comparing the two groups on measures of predecisional information search, such as how many pieces of information they observe before making a decision. Reliable generalization requires pooling observations of different samples under different conditions. Consequently, we identified a number of relevant studies and used meta-analytic methods to assess age-related differences in information search. Second, to estimate the impact of age differences in search on decision quality one needs a proper description of the relation between information search and quality of choice. This step requires data about the quality of younger and older adults' decisions in real-world settings for which there is an objective criterion to evaluate the accuracy of choices. Unfortunately, relevant data are lacking. In a recent meta-analysis, Thornton and Dumke (2005) identified articles dealing with age differences in everyday problem-solving and decision-making abilities. However, inspection of these references revealed a striking lack of data concerning age differences in decision quality in real-world environments. In this article, we circumvent this gap by using real-world data about the quality of consumer products and estimating decision quality from simulations of younger and older consumers' decision processes. One advantage of such an approach is that formal decision-making models can be used to make new predictions that can guide future empirical work with younger and older adults.

Previous work in the decision-making domain suggests that there are a number of task characteristics that influence information search and strategy use. Decision makers tend to consider proportionally less information and rely on simpler strategies when there are many pieces of information available (Ford, Schmitt, Schechtman, Hults, & Doherty, 1989; Payne, Bettman, & Johnson, 1993), they are under time pressure (Rieskamp & Hoffrage, 2008; Svenson & Maule, 1993), monetary costs of information search are high (Bröder, 2000; Newell & Shanks, 2003), or information must be retrieved from memory (Bröder & Schiffer, 2003). Conse-

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quently, these task characteristics can potentially exacerbate age differences in information search by increasing task demands. Although most studies investigating age differences in information search were likely not designed to test the effect of these characteristics on younger versus older adults' decision making, an analysis of the impact of such characteristics on search is warranted.

In the remainder of this article we first report a meta-analysis aimed at estimating age differences in the amount of predecisional information search and conduct an exploratory analysis of how task characteristics impact age differences on information search. We then go on to estimate the expected impact on decision quality by simulating the effects of limited search on decision quality.

## Age Differences in Information Search: A Meta-Analysis

We conducted a meta-analysis to provide a quantitative estimate of age differences in the amount of predecisional information search. We specifically searched for studies that gave both younger and older adults the opportunity to search for a limited set of pieces of information before making a decision and then observed their search behavior—in particular, the amount of information searched. Table 1 presents the 12 studies and their respective research questions. Table 2 shows more detailed characteristics of the 24 age comparisons included in the meta-analysis, corresponding to a total of 1,304 participants (658 older adults), which we used to obtain a quantitative estimate of age differences in predecisional information search.

### Method

**Literature search.** We conducted a search for empirical reports on decision making and aging that were available by October 2008. We initially searched abstract databases (e.g., PsycINFO, EBSCO, ScienceDirect) using the combination of keywords *decision making* and *aging*, *problem solving* and *aging*, *choice* and *aging*, and *information search* and *aging*. We checked the reference lists of a meta-analysis on age differences in problem solving and decision making by Thornton and Dumke (2005), as well as reviews of decision making and aging (Hanoch, Wood, & Rice, 2007; Mather, 2006; Yoon et al., 2009). We also checked the indices of publications on aging, including *Psychology and Aging* (1986–2008), *Experimental Aging Research* (1998–2008), *Aging, Neuropsychology, and Cognition* (1998–2008), and *The Gerontologist* (1995–2008). Finally, a backward search of the reference lists of each article found provided additional studies.

**Inclusion criteria.** We were interested in age differences in predecisional information search, given a limited set of options and cues that could be observed. All studies found were inspected to ensure that they met the following criteria for inclusion in the meta-analysis.

1. Studies were included if they allowed at least one age group comparison between younger (19–36) and older (>60) adults. The operational definitions for younger and older groups are similar to those of related work on age differences in everyday problem solving and decision making (e.g., Thornton & Dumke, 2005), and we thus hoped to be able to compare previous findings with our results.

2. The studies chosen had to involve information search and provide a measure of the proportion of information searched or, alternatively, the absolute value of information searched and total information available. The task involving information search had to include only a limited set of information that participants could choose to search. This criterion led to the exclusion of studies (or conditions) that asked participants to imagine what kind of information they would search in a given situation (Berg, Meegan, & Klaczynski, 1999; Meyer, Talbot, & Ranalli, 2007; Streufert, Pogash, Piasecki, & Post, 1990).

3. The studies chosen had to involve search concerning options' characteristics (cues). Therefore, we excluded two studies that presented participants with a number of

Table 1
*Studies Identified in the Literature Search*

| Study | Research interest | Options |
|---|---|---|
| Cole & Balasubramanian (Exp. 2; 1993) | Age differences in consumer search for nutritional information | Cereals |
| Johnson (1990) | Age differences in information search | Cars |
| Johnson (1993) | Age differences in information search as a function of think-aloud and self-report instructions | Apartments |
| Johnson (1997) | Age differences in information search as a function of use of a memory aid | Apartments |
| Johnson & Drungle (2000) | Age differences in information search as a function of type of medication | Medication |
| Löckenhoff & Carstensen (2007) | Age differences in information search and recall as a function of information valence (positive, negative, neutral) and goal (emotion regulation vs. information gathering) | Health plans and physicians |
| Löckenhoff & Carstensen (2008) | Age differences in information search as a function of information valence (positive, negative, neutral) and target (self vs. other) | Health plans and physicians |
| Mata et al. (2007) | Age differences in adaptive strategy selection as a function of individual differences in cognitive abilities | Diamonds |
| Mata et al. (2009) | Age differences in adaptive strategy selection learning | Stocks |
| Mather et al. (Exp. 4b; 2005) | Age differences in cue-wise vs. option-wise search for information as a function of individual differences in executive function | Cars |
| Riggle & Johnson (1996) | Age differences in information search in the political domain | Political candidates |
| Stephens & Johnson (2000) | Age differences in information search as a function of type of medication | Medication |

Table 2
*Comparisons Included in Meta-Analysis: Task Characteristics, Participants' Characteristics, and Information Search*

| Study | Health domain | Information | | Mean age | | *n* | | Information search (*SD*) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Options | Cues | Older | Younger | Older | Younger | Older | Younger |
| Cole & Balasubramanian (Exp. 2; 1993)[a] | No | 5 | 9 | 75 | 36 | 40 | 40 | .22[b] | .41[b] |
| | No | 5 | 9 | 75 | 36 | 40 | 40 | .11[b] | .46[b] |
| Johnson (1990) | No | 6 | 9 | 65.7 | 18.7 | 28 | 36 | .24[b] | .53[b] |
| Johnson (Exp. 1; 1993)[a] | No | 5 | 12 | 67.8 | 22.8 | 32 | 24 | .20 (.21) | .34 (.22) |
| | No | 5 | 12 | 67.8 | 22.8 | 32 | 28 | .26 (.15) | .40 (.23) |
| Johnson (Exp. 2; 1993)[a] | No | 8 | 8 | 70.5 | 21.2 | 17 | 19 | .42 (.21) | .60 (.24) |
| | No | 8 | 8 | 70.5 | 21.2 | 21 | 18 | .42 (.26) | .54 (.20) |
| Johnson (1997)[a] | No | 8 | 8 | 69.6 | 21.2 | 20 | 20 | .73 (.25) | .71 (.24) |
| | No | 8 | 8 | 69.6 | 21.2 | 18 | 22 | .57 (.37) | .65 (.27) |
| | No | 8 | 8 | 69.6 | 21.2 | 12 | 8 | .71 (.34) | .77 (.27) |
| Johnson & Drungle (2000) | Yes | 7 | 7 | 66.6 | 23.6 | 36 | 36 | .58 (.24) | .54 (.18) |
| Löckenhoff & Carstensen (2007)[a] | Yes | 4 | 5 | 79.8 | 27.3 | 20 | 20 | .80 (.20) | .79 (.22) |
| | Yes | 4 | 5 | 79.8 | 27.3 | 20 | 20 | .85 (.17) | .86 (.17) |
| | Yes | 4 | 5 | 79.8 | 27.3 | 20 | 20 | .80 (.25) | .78 (.18) |
| Löckenhoff & Carstensen (2008)[a] | Yes | 4 | 5 | 78.1 | 19.9 | 24 | 24 | .80 (.22) | .85 (.18) |
| | Yes | 4 | 5 | 78.1 | 19.9 | 20 | 20 | .80 (.25) | .81 (.22) |
| | Yes | 4 | 5 | 78.1 | 19.9 | 27 | 27 | .83 (.19) | .78 (.16) |
| Mata et al. (2007) | No | 2 | 8 | 70.9 | 24.8 | 41 | 41 | .69 (.25) | .81 (.13) |
| | No | 2 | 8 | 70.3 | 24.0 | 42 | 39 | .50 (.25) | .69 (.19) |
| Mata et al. (2009) | No | 3 | 6 | 69.1 | 23.6 | 25 | 25 | .80 (.25) | .79 (.20) |
| | No | 3 | 6 | 68.8 | 24.5 | 25 | 25 | .87 (.19) | .85 (.14) |
| Mather et al. (Exp. 4b; 2005) | No | 6 | 9 | 72.6 | 21.3 | 48 | 44 | .67 (.49) | .65 (.34) |
| Riggle & Johnson (1996) | No | 6 | 8 | 72.2 | 24.0 | 20 | 20 | .53 (.32) | .70 (.27) |
| Stephens & Johnson (2000) | Yes | 7 | 7 | 76.9 | 23.8 | 30 | 30 | .16 (.09) | .32 (.28) |

[a] Mean age reported for the full sample. [b] *SD*s not reported in the original paper.

pieces of information referring to the situation (i.e., status of the decision maker) rather than the options (Meyer, Russo, & Talbot, 1995; Meyer et al., 2007).

4. Three studies (Löckenhoff & Carstensen, 2007, 2008; Mather, Knight, & McCaffrey, 2005) were appropriate for inclusion but did not report the information required to compute between-age-group effect sizes on the proportion of information searched. We therefore contacted the authors to obtain the necessary information.

5. An unpublished study by Rui Mata that met the four previous criteria was included (Mata, von Helversen, & Rieskamp, 2009).

## Results

The 12 studies identified by the literature search were all designed to investigate age differences in decision making (see Table 1) and asked participants to make decisions in one of two broad domains: the consumer or financial domain (cereals, cars, apartments) and the health domain (physicians, health plans, medication). The studies are heterogeneous in the amount of information provided to participants, with the number of options (two to eight) and cues (five to 12) made available to participants varying considerably (see Table 2). All studies granted participants unlimited time to make each decision and did not impose monetary costs on the search. About half of the studies supplied cue values as text to participants (e.g., "very good," "good," "poor"), but one provided only numeric information (Riggle & Johnson, 1996), whereas others provided both text and numeric information (e.g., "small rooms," "$200 per month"; Cole & Balasubramanian, 1993; Johnson, 1993, 1997; Johnson & Drungle, 2000; Stephens & Johnson, 2000).

All effect size calculations were conducted using Microsoft Excel. We first calculated an effect size (Cohen's *d*) for each age group comparison in each study by subtracting the younger group's mean proportion of information search from that of the older group and dividing this score by the pooled standard deviation. Calculation of Cohen's *d* requires information regarding the mean performance of each group and the corresponding standard deviations (Cohen, 1992). When this information was not available (Cole & Balasubramanian, 1993; Johnson, 1990), we calculated *d* from *t* statistics. We were interested in obtaining truly independent age-comparative effect sizes, and so we considered only between-subjects experimental manipulations. Consequently, for studies in which the same participants completed two (or more) conditions, we averaged the results for these within-subjects conditions (Johnson & Drungle, 2000; Riggle & Johnson, 1996).

The calculated effect sizes were coded so that positive scores indicate greater information search by older age groups and negative scores indicate greater information search by younger age groups. To correct for biased estimation of the effect size with small samples, we then calculated an unbiased estimate, *g* (Hedges & Olkin, 1985). Because we intended to compare the differences in effect sizes for all the studies, we had to determine whether these effects were homogeneous and could therefore be assumed to estimate the same population mean. For this purpose, we performed a homogeneity analysis test ($Q = 113$, $df = 23$, $p < .001$).

The result led us to reject the null hypothesis of homogeneity and infer that the distribution of effect sizes is heterogeneous. As a consequence, we assumed that the variability between effect sizes was due to both sampling error and variability in the population of effects, leading us to fit a random effects model to our data. We thus proceeded to calculate a random effects variance component and compute a weighted mean effect size as well as the associated confidence interval. Figure 1 presents weighted mean effect size and each study's effect size ($g$) as well as the respective 95% confidence intervals (CIs) concerning age differences in proportion of information searched. In interpreting these findings, we have adopted the conventional values of .20 and .50 for small and medium effect sizes for comparing independent groups (Cohen, 1992). A significance level of .05 can be inferred when zero is not contained within the 95% CI.

Two main results are worthy of notice. First, older adults showed on average a tendency to search for less information, compared with young adults. However, the mean weighted effect size was rather small, –.30. Older adults searched on average for 56% of the available information, 95% CI [46%, 66%], compared with 65% for the younger adults, CI [58%, 72%]. Furthermore, the effects sizes were considerably heterogeneous across studies: Some studies found pronounced differences between younger and older adults, whereas others reported no differences or even more information search with increased age. In sum, although reviews of aging and decision making are warranted in associating aging with reduced information seeking, our results show that age differences are small and vary considerably across studies.

The small number of studies originating from a small set of laboratories suggests that there may be other systematic differences between the studies that should be considered. We first tested whether effect sizes of those comparisons by Johnson and colleagues (Johnson, 1990, 1993, 1997; Johnson & Drungle, 2000; Riggle & Johnson, 1996; Stephens & Johnson, 2000), which represent 10 out of the 24 comparisons, differed from the remaining studies; we found they did not when a dichotomous variable representing lab membership (Johnson vs. other) was correlated with effect size ($r$ = .34, $p$ = .11). In addition, we considered whether the Löckenhoff and Carstensen (2007, 2008) comparisons (six out of 24) differed from the remaining studies; they did so significantly ($r$ = .48, $p$ = .02). As can be seen in Figure 1, Löckenhoff and Carstensen found that older adults searched about the same amount of information as their younger counterparts. One possible reason for this is that Löckenhoff and Carstensen focused on comparisons in the health domain. To test this possibility, we proceeded to contrast the eight age comparisons (out of 24) that relied on the health domain (Johnson & Drungle, 2000; Löckenhoff & Carstensen, 2007, 2008; Stephens & Johnson, 2000) with the remaining studies and found a significant difference in effect sizes, $\beta$ = .45, $p$ = .03. We also computed weighted effect sizes for the two sets of studies and found the age differences to be smaller for the health domain comparisons ($g$ = –0.08, 95% CI [−0.58, −0.24]) compared with the others ($g$ = –0.42, CI [−0.58, −0.24]).

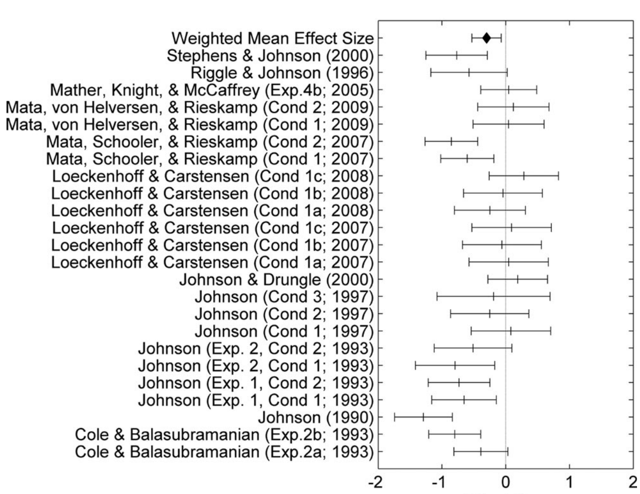


*Figure 1.* Tree plot with effect sizes in each study.

Other participant or task characteristics could also have determined the size of age differences in search, such as the age of participants or the number of cues and options made available to decision makers. The difference between mean age of the younger and older sample was marginally related to effect size ($r$ = .37, $p$ = .08); number of options showed no relation ($r$ = –.11, $p$ = .62), whereas number of cues showed a strong relation to effect size ($r$ = –.61, $p$ = .002). We further regressed the difference in age between groups, number of cues in each task, and a dichotomous variable representing domain (health vs. other) on the effect size for each study. The results suggest that the heterogeneity in effect sizes may be due to the number of cues. The number of cues was negatively related to the effect size ($\beta$ = –.57, $p$ = .04) but we found no significant relation for age ($\beta$ = .04, $p$ = .85) or domain (health vs. other; $\beta$ = .02, $p$ = .94). These results suggest that age differences in information search may differ as a function of task characteristics; namely, age differences may be larger in those environments in which many pieces of information concerning each option need to be integrated to arrive at a decision.

## Discussion

Our meta-analysis suggests that there are small but significant age-related differences in predecisional information search. But what factors are responsible for older adults' limited information search compared to younger adults? Some candidate explanations, although plausible, have so far received little empirical support. First, it has been suggested that older adults have different goals at heart compared to younger adults when making decisions. Specifically, researchers have argued that older adults are more concerned with emotion regulation and less with information gathering, which may lead to differences in information search and satisfaction (e.g., Hanoch et al., 2007; Mather, 2006). In line with this view, older adults show positivity biases in decision tasks; they spend more time (Mather et al., 2005), search more (Löckenhoff & Carstensen, 2007, 2008), or enumerate more positive relative to negative information (Kim, Healey, Goldstein, Hasher, & Wiprzycka, 2008), compared with younger adults. However, studies considering these factors have not found age differences in the total amount of information searched (e.g., Löckenhoff & Carstensen, 2007, 2008; Mather et al., 2005).

Second, older adults may have increased expertise with specific product types or brands and thus may not require much information to make their decisions. However, older adults sometimes (Cole & Balasubramanian, 1993; Lambert-Pandraud et al., 2005) but not always have been found to be more loyal to brands (Burnett, 2002). Furthermore, expertise alone does not explain the decrease of information search, because expertise is sometimes not correlated with information search (Cole & Balasubramanian, 1993); it may even be positively correlated with increased search in those domains in which product comparison is crucial (Lambert-Pandraud et al., 2005). The results of the meta-analysis also undermine the idea that expertise is a crucial factor leading to less search in older groups. Older adults are likely more knowledgeable about health care and medication, yet there is an indication that older adults searched for the same amount of information as younger adults in the health domain.

The suggestion that age differences in search may largely disappear in the health domain hints at another important dimension that may moderate the size of age differences in predecisional search: the relevance of the domain in which decisions are made. The health domain is likely more relevant to older compared to younger adults and may have motivated the older group considerably more, thus leading to a reduction of age differences compared to other domains. Note that the domain factor (health vs. other) did not emerge from our multiple regression analysis that considered the contribution to age differences in search of different participant and task characteristics simultaneously. Therefore, we regard the average findings with caution. More generally, these results exemplify a methodological limitation of our meta-analytic approach, which considers studies that were not specifically designed to study the factors of interest (e.g., number of cues, domain) and as such did not vary these factors systematically.

Finally, another explanation for reduced information search with increased age is that older adults lack the cognitive resources to process all available information. Researchers have suggested that older adults may attempt to reduce the cognitive requirements of decision making in an attempt to reduce cognitive effort (Gigerenzer, 2003; Sanfey & Hastie, 1999). Examining fewer pieces of information is a main way to reduce effort (Shah & Oppenheimer, 2008), and aging has been associated with reliance on simpler strategies in other domains, such as arithmetic skill (Lemaire, Arnaud, & Lecacheur, 2004) and memory (Dunlosky & Hertzog, 1998). Accordingly, older adults have more difficulty applying decision rules (Bruine de Bruin, Parker, & Fischhoff, 2007) and rely more often on simpler strategies (Mata, Schooler, & Rieskamp, 2007; Pachur, Mata, & Schooler, in press). Also, Mata et al. (2007) found that individual differences in fluid abilities completely mediated age-related differences in amount of information search in their decision task. The results of the meta-analysis match these findings, in that they suggest that age differences in information search are more likely to arise when many cues are available—that is, when considerable cognitive resources are likely to be needed to integrate large amounts of information. Although a large number of options should lead to similar cognitive demands, we did not find a relation between information search and the number of options available. One possibility is that the little variability in number of options in the studies considered did not allow us to identify such an effect. Nevertheless, future studies should investigate whether there is a differential effect of number of options and cues on information search by systematically varying both.

Summing up, age-related cognitive decline could underlie the small but significant age-related differences identified in our meta-analysis of predecisional information search. We now turn to the potential impact of these search differences on decision quality.

## Age Differences in Decision Quality: A Simulation Study

Older adults' limited information search could prove harmful if neglecting information led to substantially worse, unsatisfactory choices. The amount of information needed to make good decisions is an issue of significant debate in statistics, computer science, and psychology (Dawes, 1979; Einhorn & Hogarth, 1975; Gigerenzer, Todd, & the ABC Research Group, 1999; Pitt, Myung, & Zhang, 2002). The concept of ecological rationality, which holds that particular environment structures are best fit by specific strategies, suggests that simple strategies that neglect information may do well in some environments (Gigerenzer et al., 1999; Hanoch et al., 2007). For example, Dawes (1979) has shown that improper linear models that ignore cue weights can be robust methods for predicting the future state of events. Likewise, Dieckmann and Rieskamp (2007) have identified statistical properties underlying the success of simple noncompensatory decision strategies—namely, attribute redundancy and dispersion. When the characteristics of options (cues) are highly positively correlated, they can be said to be redundant, in which case a simple decision strategy that neglects information can do well. Also, the success of a simple strategy may be further enhanced if the attribute considered by the simple strategy is significantly more predictive of the criterion relative to the neglected attributes, which is the case in environments with high dispersion of attributes' predictive power. Fasolo, McClelland, and Todd (2007) have conducted simulations showing that consumers may neglect most characteristics of a product and still make good enough choices in simulated environments with high attribute redundancy. Fasolo et al. (2007) also considered a real-world product in their simulations (digital cameras) but did not provide an analysis of how simple strategies fare in other real-world environments. In other words, we do not know the extent to which neglecting information leads to decreased quality in consumer choice in real-world environments.

Our simulation aimed to estimate the impact of older adults' decreased information search on decision quality, where quality was determined by a third party (expert judges or consumers) rather than on the basis of a normative criterion such as whether the reasoning process follows the rules of logic or probability. Nevertheless, the underlying process or information integration must also be considered (Finucane, Mertz, Slovic, & Schmidt, 2005). The idea that people have different strategies at their disposal to integrate information is common in the decision-making literature (Gigerenzer et al., 1999; Mata et al., 2007; Shah & Oppenheimer, 2008). In our simulation we considered four strategies that represent different points of a cognitive effort continuum: a weighted additive rule (WADD), tallying (TALLY), take-the-best (TTB), and elimination by aspects (EBA). WADD represents an information-greedy and cognitively effortful strategy that considers all available information and weights each piece of information according to its ability to predict the criterion. Consequently, WADD represents the prototypical compensatory strategy that allows one good cue to compensate for a bad one. In turn, EBA, TALLY, and TTB represent effort-reduction attempts (Shah

& Oppenheimer, 2008) that ignore options, cues, and cue weights, respectively. Overall, these strategies have been shown to capture well the decision making of younger adults (for reviews, see Payne et al., 1993; Shah & Oppenheimer, 2008). Moreover, both earlier work on aging and decision making that inferred strategy use from patterns of search (e.g., Johnson, 1990,1993, 1997) and recent computational work that explicitly models strategy use suggest that such strategies can account for older adults' decisions (Mata et al., 2007, 2009). By considering different strategies that vary in their cognitive effort requirements, we hoped to gain an understanding of the impact of search on quality across different levels of effort.

In sum, aging may be associated with decline in information search. However, the perspective of ecological rationality suggests that the impact on decision quality depends on the statistical structure of the decision environment (Gigerenzer et al., 1999). In what follows, we evaluate the potential consequences of effort reduction attempts for overall decision quality using computer simulations. Our simulations were based on real-world data and informed by the findings of the meta-analysis on predecisional information search described above. Specifically, we used the estimates of mean information search by younger and older adults obtained in our meta-analysis to estimate decision quality in 140 consumer product types, such as refrigerators, shoes, and credit cards.

## Method

**Data.** We considered 140 product types (e.g., refrigerators, shoes, credit cards) from a range of consumer categories (e.g., appliances, health, finance; available at http://ConsumerReports.org).[1] All product types had at least three but no more than 70 products, and each product had a rating (i.e., consumer satisfaction or expert rating) and was described on at least three attributes (test results).

**Strategies.** We simulated four strategies: WADD, EBA, TALLY, and TTB. WADD represented fully compensatory decision making; it considered all available pieces of information and weighted each according to its predictive value (i.e., validity). EBA is a heuristic strategy that ignores options. EBA selected the most important cue and eliminated options that had lower cue values than the highest value for that cue. The process then continued (the second most important cue would be selected and so on) until all alternatives but one were eliminated. TTB is a noncompensatory strategy that makes a decision after finding one piece of discriminating evidence favoring one alternative. To model TTB, we assigned weights to cues in a noncompensatory fashion such that the combined weights of less valid cues did not exceed the weight of the most valid cue. The TALLY strategy, like WADD, always considered all available information but weighted each test result equally. All strategies guessed if no information was available, if options had equal estimated values, or if (in the case of EBA) more than one option remained after all cues were considered. All strategies considered missing cue values as zeros; therefore, missing values did not contribute to determining the value of options. For each product type (e.g., refrigerators), we operationalized the predictive value of each test result (e.g., energy efficiency) as the respective beta weight obtained using linear regression with the product rating as a criterion and the test results as independent variables. For the TTB strategy, beta weights were substituted by noncompensatory weights (from the most to the least valid cue: 1, ½, ¼, etc.). A noncompensatory weighting structure models the principle that the best cue cannot be outweighted by any combination of less important cues. For TALLY all cue weights were set to 1.

**Simulation.** We wanted to estimate decision quality under different assumptions—namely, varying the decision strategy used: WADD, EBA, TTB, or TALLY—and do so separately for each product type (e.g., refrigerators, shoes, credit cards). For each strategy and product type we used the following procedure. First, information search was varied by supplying the strategy with a proportion of the total information pertaining to a product type. Specifically, we varied the amount of information supplied to each strategy systematically (in 1% increments) from 0% (in which case the strategy had to guess) to 100%. Second, for each run of the strategy we computed the proportion value lost (PVL; Barron, 1987), a relative measure of loss commonly used to report decreasing decision quality through limited search (Barron, 1987; Fasolo et al., 2007). PVL is computed as the difference between the highest product rating for that product type and the rating of the option chosen by the strategy on that run divided by the highest product rating. We conducted 100 runs of the strategy at each level of information search. Thus, for each product type (e.g., refrigerators) and level of information search (e.g., 60%), each strategy made 100 decisions; we averaged the PVL across the 100 decisions to obtain the PVL for that strategy, given the level of information search and product type. We then averaged PVL results across product types at each level of information search to obtain a global estimate of decision quality in the consumer products domain as a function of information search.

## Results

The plots in Figure 2 represent the mean PVL and associated confidence intervals across the 140 environments, given the WADD, TALLY, EBA, and TTB strategies. We were interested in estimating the decision quality expected of younger and older adults, given the information search values estimated from the meta-analysis of predecision information described above; therefore, we also plotted the age-appropriate interval of proportion of information searched for the two age groups.

As can be seen in Figure 2, PVL is highest when strategies receive no information and thus have to guess to make a decision. This result suggests that consumers can lose up to 20% of product value by choosing randomly between consumer products. As strategies receive more information, PVL diminishes, because strategies are more often able to choose the better options. We found differences between strategies with results suggesting that TALLY, TTB, and EBA fared on average slightly worse than WADD. The mean PVL using TALLY is about 2% higher compared with TTB and EBA, and 5% higher compared to the more effortful WADD. TTB and EBA showed similar performances, but EBA was slightly closer to the best performing WADD strategy. In other words, neglecting cue weights (TALLY) led to slightly more

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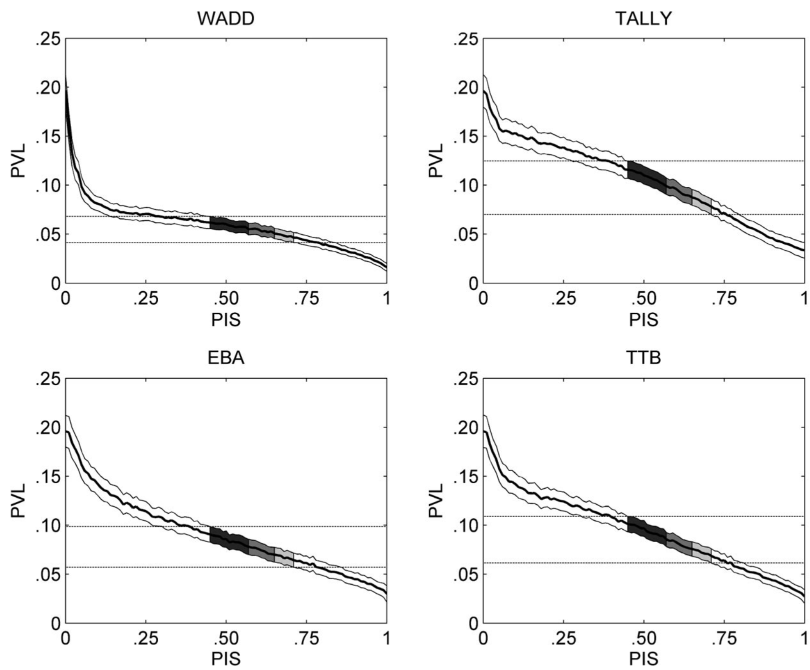


*Figure 2.* Proportion value lost (PVL) by the weighted additive rule (WADD), tallying (TALLY), take-the-best (TTB), and elimination by aspects (EBA), strategies as a function of the average proportion information searched (PIS). Grey areas represent the PVL areas corresponding to the average information searched by older adults (dark grey), younger adults (light grey), and their overlap (intermediate shade of grey) as estimated from our meta-analysis.

pronounced losses in decision quality, compared with neglecting both cues and options.

Concerning estimated age differences in PVL, the estimates of information search for younger and older adults obtained from our meta-analysis suggest that PVL is consistently smaller for younger compared with older adults, regardless of the strategy used. However, differences between younger and older adults seem small in magnitude: The largest difference between younger and older adults' PVL, given information search CIs, is about 2% for the WADD strategy and about 5% for the TTB, EBA, and TALLY strategies. Consequently, the difference between younger and older adults' PVL is, at most, of the same magnitude as differences between strategies and considerably smaller than choosing randomly.

## General Discussion

We aimed to quantify the potential impact of aging on decision quality in the consumer products domain. For this purpose, we first used meta-analytic techniques to quantify age differences in the amount of predecisional information search. We then simulated the decision making of younger and older adults by implementing decision strategies as computer algorithms and having these decide between a number of real-world consumer products. Specifically, we used the estimated confidence intervals corresponding to younger and older adult's predecisional information search to inform our simulation of choices concerning 140 different product types, such as refrigerators, shoes, and credit cards. Overall, our results suggest that the aging decision maker tends to consider fewer pieces of information when making decisions but that considering less information may lead to only small losses in decision quality.

### Age Differences in Information Search

The results of the meta-analysis suggest there is a small effect of age on the amount of predecisional information search ($g = -0.30$). Our findings thus match self-report studies showing that older adults consider fewer pieces of information before making a decision (Berg et al., 1999; Meyer et al., 1995, 2007; Streufert et al., 1990).

Our meta-analysis focused on a small and homogeneous set of studies regarding the methodology employed; specifically, all 12 studies gave participants a defined number of cues regarding each option and allowed participants to stop search any time before deciding for one of the options. Real-world decision problems are often less well-defined. For example, when deciding between health treatments, a patient may not have equal amounts of information about each possible course of action, the nature of information may be different (financial cost vs. duration), and the patient may have the option of not making a decision or delaying it (cf. Meyer et al., 2007). Future work should investigate whether age differences found in our meta-analysis generalize to these situations. Existing studies suggest age differences in information search could be at least as pronounced in more real-world tasks. Meyer et al. (1995) found significant age differences when younger and older participants were asked to underline which pieces of information from a list they would consider prior to making a decision about cancer treatments ($d = -0.60$). Also, Meyer et al. (2007) found older adults searched significantly fewer resources than younger adults ($d = 0.80$).

How do these effect sizes compare to other age differences found in the literature? Thornton and Dumke (2005) reported a medium effect size in everyday problem-solving competence favoring younger adults ($g = 0.48$). Overall, these effect sizes pale in comparison to large age effects found in memory tasks ($gs > 0.80$; Old & Naveh-Benjamin, 2008; Verhaeghen, Marcoen, & Goossens, 1992), suggesting that the decision tasks considered did not overwhelmingly tax older adults. This also suggests that more pronounced age differences may be expected when information must be retrieved from memory: Decision makers are likely to rely on simpler strategies when making decisions from memory (Bröder & Schiffer, 2003), and older adults' poorer memory may predispose them to searching for less information and rely on simpler strategies in these circumstances (Touron & Hertzog, 2004).

On a positive note, the small effect size found for age differences in predecisional information search suggests that this domain is amenable to intervention. For example, age effects on everyday problem solving and information search are well within the range of those found for the effects of physical activity training on overall cognitive performance ($g = 0.48$; Colcombe & Kramer, 2003). Consequently, to the extent that cognitive deficits are responsible for age differences in information search, these differences may be amenable to general intervention, such as aerobic training.

## Aging and Decision Quality

Our analysis suggests that large differences in decision quality are unlikely to arise due to differences in information search. Our results thus match those of Meyer et al. (1995), which showed information search was unrelated to the quality of the rationale underlying choice of health treatment. Unfortunately, other factors may contribute to decreases in decision quality with increased age. First, older adults are likely to rely on simpler strategies compared with younger adults. Research suggests that older adults show considerable differences in strategy selection, with older adults tending to rely on simpler strategies that reduce cognitive effort (e.g., Lemaire et al., 2004; Mata et al., 2007, 2009). For example, Mata et al. (2009) asked younger and older adults to make decisions about which of three companies' stocks would be more profitable as a function of a number of characteristics of these companies, such as their revenue, shareholders' ratings, and international status. Mata et al. observed that older adults had an increased initial preference for simpler strategies like TTB and TALLY compared with younger adults. Moreover, older adults had more difficulty relying on the complex WADD strategy, even after a prolonged learning phase. Our simulation suggests that the effects of strategy selection can have at least as much of an impact on decision quality as the amount of information searched. Across the 140 product types considered, using simple strategies like TTB, EBA, and TALLY can lead to between 2% and 5% loss in quality compared with the cognitively demanding WADD.

Second, younger and older adults may consider different types of information. Older adults tend to focus more on positive relative to negative information compared with younger adults (Hanoch et al., 2007; Mather, 2006). To the extent that the predictive value (i.e., validity) of positive and negative characteristics differs for estimating the quality of a consumer product, the valence of information may contribute to age differences in decision quality.

Finally, older adults may make more mistakes when applying a strategy. Older adults seem to have more difficulty correctly applying strategies (Bruine de Bruin, Parker, & Fischhoff, 2007), particularly more complex ones (Lemaire et al., 2004), such as WADD (Mata et al., 2009). In sum, although age differences in the amount of predecisional information search may lead to only a small decrease in decision quality, there are a number of other factors that can contribute to age differences in choice quality and that should receive attention in future research.

## Limitations and Future Work

Our work advances the understanding of aging and decision making by showing that real-world environments may allow competent decision making by the elderly. Nevertheless, our work has limitations that should be addressed in future research. First, the results of our meta-analysis suggest that task characteristics, such as the amount of cues available, and perhaps the domain in which decisions are made may be determinants of age differences in information search. Our meta-analytic approach cannot provide a conclusive answer to these issues because the factors of interest were not varied systematically in the studies we considered. Nevertheless, the current set of results suggests that future research should consider both the cognitive demands and the domain of decision tasks. Hanoch, Rice, Cummings, and Wood (2009) have already provided some suggestive evidence that the amount of information available does indeed play a role in determining older adults' decision quality. Second, concerning our simulation work, the majority of product ratings and characteristics we used was based on experts' knowledge, which may not reflect the knowledge of the average consumer when making decisions about these products. Also, our simulations may not be representative of the variety of strategies potentially used by elderly consumers. For example, older adults may often make purchasing decisions on the basis of familiarity with a brand or a recommendation from a friend. However, our simulations consider only decisions based on options' characteristics.

Our work also provides some ideas for future research. Our simulation findings predict that differences in strategy selection contribute at least as much to decision quality as do differences in amount of information searched. Future empirical work could test these predictions by varying the number of cues available to participants and using a choice/no-choice method (Siegler & Lemaire, 1995), in which participants are either asked to produce their own strategies or asked to use specific strategies to make decisions. Using such a design would allow estimating the role of strategy selection and application, as well as task characteristics on decision quality.

Finally, our simulation results point out the importance of knowledge for decision quality. To the extent that older adults know the relative value of options' characteristics, they can rely on strategies like EBA and TTB that are less cognitively demanding but may provide satisfactory choices; otherwise, they may have to ignore cue importance or rely on incorrect cue rankings. Future population-based surveys or laboratory experiments could help further specify the knowledge available and strategies employed by aging consumers in specific consumer environments and thus improve our understanding of older adults' decision making in this domain. Knowing in which environments older adults have knowledge about relative cue importance and whether simple strategies do well would allow determining in which situations to provide support, as in the form of cue rankings, to help elderly consumers make successful decisions with little effort.

## Conclusion

A meta-analysis of empirical studies comparing younger and older adults' predecisional information search indicates aging is associated with a small but significant decrease in the amount of information searched prior to making a decision. Our simulation results suggest that the aging decision maker may often afford to neglect some information because this leads only to small losses in decision quality. In other words, less may be enough for the aging consumer.

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