Chapter 2

Cognitive Aging and Strategy Selection

According to the concept of bounded rationality, originally developed by Herbert Simon (1956), people can successfully solve the problems they face despite their limited resources, such as time and cognitive capacity, by using satisficing strategies or heuristics. Gigerenzer et al. (1999) and Gigerenzer and Selten (2001) have recently promoted a related notion, arguing that people have at their disposal an adaptive toolkit filled with simple tools suited for many of the inferences they make. This approach has successfully identified environmental structures and proposed simple mechanisms that take advantage of these structures to make accurate decisions (Gigerenzer et al., 1999). Additionally, the study of the adaptive toolbox aims at describing people's use of decision strategies, including the description of "individual differences in the use of heuristics, and the change in the adaptive toolbox over the life course" (Gigerenzer, 2004, p. 83). However, the approach has so far produced little work focusing on individual differences in strategy use and it has not addressed lifespan changes in decision behavior. In an effort to fill this research gap, this chapter contributes to the study of the relation between cognitive aging and strategy selection.

Recently, it has been suggested that paying attention to the fit between person and task characteristics can be a way to understand decision making behavior in general (Bröder, 2003) and, in particular, age-related changes (Finucane et al., 2005). Building on these approaches, the work reported here adopted an ideographic approach to understanding the relation between cognitive aging and strategy use in inference tasks. The general research strategy adopted was the following. First, I investigated the relation between cognitive capacity and strategy use in younger populations. Second, I evaluated the role of individual differences due to aging in strategy use. Consequently, this chapter will first report two studies concerning strategy use in young adults. Subsequently, a third study investigating this issue in an older sample is presented and a comparison between younger and older adults is given.

Before presenting an overview of the empirical work, I present a brief summary of previous research on heterogeneity in strategy selection, and the main hypotheses under investigation concerning the role of cognitive capacity and age-related changes in determining the selection of decision strategies.

Heterogeneity in Strategy Selection

The toolbox of decision strategies is thought to be adaptive in the sense that it deploys a suitable tool for a particular situation. How does the adaptive toolbox achieve this feat? Two prominent models of strategy selection propose that, to select a particular strategy, decision makers establish a balance between their personal resources and the expected benefits of using a particular strategy. Beach and Mitchell's (1978) contingency model of strategy selection and Payne et al.'s (1993) effort-accuracy framework hold that each strategy can be evaluated in two dimensions, costs and benefits. The costs are assumed to be related to the cognitive effort necessary to apply a strategy while the benefits are related to its accuracy. According to these views, the decision maker anticipates, although not necessarily consciously, the effort and accuracy of different strategies and uses these criteria to select an appropriate strategy for a problem. Empirical evidence for these models lies in people's apparent skill in adapting their strategy use as a function of different task demands. For instance, it has been shown that people rely on simpler, noncompensatory decision strategies when they have to choose from a large number of alternatives (e.g., Ford et al., 1989; Payne, 1976; Payne et al., 1988), they are under time pressure (Payne, 1976; Payne et al., 1988; Rieskamp & Hoffrage, 1999; see Svenson & Maule, 1993, for a review) and they incur high costs when searching for information (Bröder, 2000; Newell et al., 2003; Newell & Shanks, 2003). Furthermore, in accordance with the adaptive toolbox approach's focus on environmental structure, it has been shown that people adapt their strategies according to the statistical properties of environments when appropriate feedback is given (Bröder, 2003; Rieskamp & Otto, submitted). Thus, overall, people seem to behave adaptively by selecting strategies according to task characteristics, including environment structure, at least when feedback is provided.

In comparison, the role of individual resources or characteristics has received little attention in the literature on the use of decision strategies. However, there are considerable individual differences in strategy selection, so that different individuals facing the same inference problem select different strategies (e.g., Newell & Shanks, 2003; Bröder 2000, 2003). Bröder (2000) tested people in an artificial stock market game and showed that even though the majority of participants used the best-performing strategy a substantial proportion of individuals failed to do so. The wide spread heterogeneity in strategy selection behavior has led some to propose that the adaptive toolbox should consider more closely the role of individual characteristics, such as individual differences in cognitive capacity (Bröder, 2003; Gigerenzer, 2004; Newell, 2005). However, to my knowledge, only two studies have investigated the relation between individual differences in cognitive capacity and strategy selection. Klayman (1985) analyzed the role of working memory capacity on the information search patterns of twelve-year-olds in different-sized matrices of information. Klayman’s results showed that an increase in the number of alternatives led to increased use of simpler strategies mostly in a group of children with lower working memory capacity. In a study evaluating the role of environmental structure on adaptive strategy use, Bröder (2003) assessed the importance of individual differences in reasoning ability and working memory capacity. He found that participants with higher reasoning abilities were more likely to use a noncompensatory strategy, TTB, in an environment in which this strategy earned them the highest payoff, while working memory capacity did not mediate strategy use. In short, the results of Klayman and Bröder are at odds concerning the relation between working memory and strategy use. Moreover, both consider only some components of cognitive capacity thus providing a limited view of the relation between basic cognitive abilities and strategy selection.

Summing up, the pervasive interindividual differences in strategy use have led some to claim that the adaptive toolbox approach is in critical need of a theory of heterogeneity in strategy selection (Newell, 2005). Aiming to contribute to the scarce literature on the relation between individual characteristics and strategy selection the work in this chapter attempts to show that the issue of individual differences in strategy selection is a tractable one and that some heterogeneity in strategy use can be explained by individual differences in cognitive capacity.

Individual Differences in Cognitive Capacity and Strategy Selection

The literature reviewed above and in Chapter 1 suggests that the costs associated with strategy use are a function not only of task characteristics but in addition depend on the resources of the decision maker. Accordingly, strategy use should depend at least to some extent on individual differences in cognitive capacity. However, cognitive capacity is not a unified concept. Working memory and short-term memory (Badelley, 1996), speed of processing (Salthouse, 1996), inhibition-related functions (Zacks & Hasher, 1997), and intelligence, in both its knowledge and reasoning components, (Cattell, 1971; Horn, 1982) have all been proposed as components of cognitive capacity (e.g., Baltes, Staudinger, & Lindenberger, 1999). What is known about how these different components relate to decision behavior?

Working memory capacity, generally conceptualized as the system that allows processing of information during temporary storage of information in short-term memory (Neath, Brown, Poirier, & Fortin, 1999; Miyake & Shah, 1999), should supply the scaffolding for all the encoding, maintenance, and processing such as integrating or comparing pieces of information in an inference task. Speed of processing can be directly translated as the rate at which these operations can take place (Salthouse, 1996). Inhibition-related functions, such as the ability to neglect previously processed information (Friedman & Miyake, 2004), are crucial if a decision maker is to focus on the most important decision cues for a problem. Two other relevant constructs, crystallized and fluid intelligence, are not directly translated into information processing terms. Nonetheless, individual differences in intelligence are related to those in other cognitive measures, such as working memory (Conway et al., 2003), and have been shown to be related to higher-order cognition (Stanovich & West, 2000) and adaptive strategy use (Bröder, 2003).

In this approach, I assume that limitations in any of the basic components of cognitive mechanics (i.e. working memory and short-term memory, speed of processing, inhibition-related functions) may determine which strategies can be applied by setting an upper limit on the cognitive effort expendable. For instance, the use of information-intensive strategies should be off-limits to individuals with severe limitations in the amount of information they can memorize. In this sense, limitations in information processing capacity pose limits to adaptive strategy use by constraining the range of possible strategies that can be employed in a particular situation. One possibility is that limitations in cognitive capacity may also play a role at more basic levels of the decision process, namely, in terms of information search. For example, it follows from the assumption that individuals with fewer cognitive resources use simpler strategies that they should more often comply with stopping rules (i.e. rules determining when search for information should stop) predicted by simpler strategies and, thus, that they search for less information overall.

Concerning the role of intelligence, one important issue is to what extent this construct is related to strategy use versus learning of environmental structure. Bröder (2003) saw intelligence as playing a major role in extracting "the relevant features of the environment" (p. 621) from feedback. This is in accordance with Schunn and Reder's (1991) proposal that individual differences in intelligence are related to differential ability to adaptively select between strategies in response to feedback from the environment. However, it remains an open question whether individual differences in intelligence are also relevant in inference tasks in which people do not have to learn environmental structure over time. The studies reported below provide a more detailed picture of the relation between a set of major psychological constructs and strategy use in a task precluding learning of environmental structure through feedback.

Age-Related Changes in Cognitive Capacity and Strategy Selection

Aging is usually associated with losses in the cognitive domain, with mild to severe declines in intellectual functioning, such as in memory performance (e.g., Baltes & Kliegl, 1992). Underlying this decrease in performance is decline in basic components of cognitive functioning, such as working memory, speed of processing, and inhibition-related functions (Baltes et al., 1999). On the other hand, increased age is associated with increases in knowledge and experience. The present chapter looks at both of these phenomena in an attempt to understand possible links between aging and strategy selection.

As reviewed in Chapter 1, research on preferential choice suggests that older adults spend more time viewing information and look up less information overall compared to younger adults (e.g., Johnson, 1990). Assuming that limitations in information processing underlie these effects, one would expect that the same pattern should be observed in inference problems.

Additionally, the work reported here goes a step further than previous research on aging and decision making by identifying the strategies used by younger and older adults and analyzing their use as a function of environmental structure. Furthermore, the studies map the relation between strategy use and basic components of cognitive functioning, such as working memory, speed of processing, and inhibition-related functions. Thus, this project offers the groundwork for future modeling efforts, such as computational modeling of strategy selection, by providing suggestive evidence concerning which components must be considered in such models.

Concerning predictions about age differences in strategy selection, these arise from the premise that limitations in basic cognitive components, such as working memory, speed, and inhibition-related functions, may determine which strategies can be applied at a given moment. Under this assumption, one would expect older adults should generally rely more on simpler strategies, that is, strategies that require fewer computations, compared to their younger counterparts. In other words, information-intensive strategies should be out of reach to older adults more often than younger adults. This prediction can be found in the decision making literature (cf., Gigerenzer, 2003; Sanfey & Hastie, 1999), but has not yet been empirically tested. Purportedly, the rationale underlying this hypothesis is that older adults will have to rely on simpler strategies because they 1) cannot cope with storing and recalling large amounts of information, 2) cannot use more complex strategies within reasonable time constraints, and 3) are more susceptible to interference from different sources of information, such as different cues. Using measures that tap into the cognitive components directly associated with storing and recalling information, speed of information processing, and the ability to resist interference, will provide an appropriate test of these hypotheses.

Concerning strategy adaptivity, that is, the ability to select the right strategy for a particular environment, two opposing predictions can be made. On the one hand, to the extent that selecting a strategy appropriately is dependent on experience, older adults should be better at strategy selection older adults. On the other hand, research on strategy use in other domains, such as arithmetic computation (Lemaire et al., 2004), has shown that older adults are overall less adaptive in their strategy use. Moreover, and if indeed cognitive capacity limitations limit the range of strategies that older adults have at their disposal, older adults may have to rely on simpler strategies regardless of task characteristics such as the structure of the decision environment. Consequently, older adults would be less adaptive in their strategy selection. In conclusion, it is not clear to what extent older adults will show limitations in strategy adaptivity — Study 3 will provide an answer to this question in the decision making domain, particularly, concerning decisions between alternatives.

Overview of the Studies

Three studies investigated adaptivity in strategy selection. Studies 1 (N = 22) and 2 (N = 80) did so concerning samples of younger adults, while Study 3 (N = 83) did the same concerning an older population. All three studies involved presenting participants with one of two environmental structures in which either the use of compensatory or noncompensatory strategies was favored. Additionally, the role of cognitive capacity in strategy selection was investigated using correlational methods.

The participants' goal in all three studies was to decide, based on a set of cues, which of two diamonds was more expensive. Participants had at each step the option between acquiring one piece of information about one of the two diamonds (e.g., size, overall proportions), up to a total of 8 cue values per diamond, or making a decision about which diamond is more expensive. A paradigm was employed similar to that used in an experiment reported by Bröder (experiment 3; 2000), in which participants had to search for cues in the order of their validities. There were no monetary costs associated with information search so that I could attribute most costs associated with information processing to cognitive effort.

Nevertheless, it was impossible to attribute all costs to cognitive effort as, for example, time spent in the experiment was also associated with information search. Prior to the decision task, participants were provided a summary of the environmental structure in the form of cue validities, which represent the predictive value of the cues. Also, no feedback was provided during the task. These two actions freed participants from having to learn the structure of the environment for themselves over time. After the decision task, an assessment of cognitive capacity was conducted.

In all studies three strategies varying in the cognitive demands imposed to decision makers were considered: TTB, Take Two, and Franklin's rule (FR). TTB makes a decision based on one piece of discriminating information. Take Two can be considered a hybrid between compensatory strategies and TTB: it stops search when it finds two discriminating cues favoring the same alternative. FR is an information-intensive, compensatory strategy; it creates a weighted value for each cue by multiplying the cue value by the respective cue validity and summing over all weighted cue values to arrive at an overall evaluation of an alternative.

Appendix B reports an estimate of the effort required to use each of these strategies. To quantify the cognitive effort associated with the use of the different decision strategies, TTB, Take Two, and FR, I computed the number of operations (EIP) each decision rule involves. The results of these estimates can be summarized as follows; TTB was the least effortful decision rule, followed by Take Two, and finally the most cognitively demanding strategy, FR.

Study 1: Individual Differences in Cognitive Capacity and Strategy Selection in a Sample of Younger Adults

Study 1 was a pilot study that served the main purpose of testing the experimental decision task, the environments used, and the individual difference measures. Nevertheless, Study 1 also tested the hypothesis, central to the adaptive toolbox approach, that people can adaptively select strategies as a function of environmental structure. Additionally, Study 1 preliminarily investigated the relation between individual differences in cognitive capacity and strategy use. Thus, more specifically, Study 1 had two theoretical goals. First, it tested the assumption that individuals behave adaptively by selecting the appropriate strategy for a given environment in the absence of direct performance feedback. For this reason participants were told that they would be performing decisions in either a compensatory environment (i.e., one in which cues have equal validities; and a compensatory strategy should achieve the highest payoff) or a noncompensatory environment (i.e., one in which cues have different validities and are rank-ordered accordingly; and in which a noncompensatory strategy should achieve the highest payoff)[1]. The predictions concerning participant's behavior in these two environments follow from a cost-benefit analysis (Beach & Mitchell, 1978, Payne et al., 1993). First, differential outcomes in terms of strategy use for the two environments were expected. In the compensatory environment the benefits associated with searching all the information were particularly evident in face of the uniform distribution of cue validities. In fact, the more rewarding strategy was the information-intensive Franklin's rule (FR). Thus, it was expected that a majority of participants would make use of such a strategy in this environment as best they could.

In contrast, in the noncompensatory environment, a number of cues had very low validities. Therefore, subjects would do better if they searched for less information, in particular, considering the potential costs of searching for large amounts of information. For example, the probability of forgetting early acquired cue values and interference with later acquired ones increase with the amount of information searched. Thus, in comparison to the compensatory condition, participants in the noncompensatory environment should rely more on less information-intensive strategies, such us the simple but accurate TTB.

Second, Study 1 tested the idea that individual differences in cognitive capacity can explain heterogeneity in strategy use. The main prediction concerned an interaction effect between cognitive mechanics (e.g., working memory, speed, inhibition-related functions) and environment. The rationale for this prediction is that if participants are proficient at selecting what would be the most appropriate strategy to use in a given environment, one possible reason for not adopting a particular strategy is lack of resources to do so. This should be particularly the case for information-intensive, cognitively demanding strategies. Consequently, in the compensatory environment, those participants with fewer cognitive resources were expected to fallback on simpler decision strategies, such as TTB and Take Two.

In contrast, a majority of participants should want and be able to use simpler strategies in the noncompensatory environment not due to lack of resources but because of the expected benefits of using simpler strategies in this condition. As consequence, no relation between

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[1] Please note that Gigerenzer et al. (1999) have also used the terms compensatory and noncompensatory to describe the structure of beta weights originating from a multiple regression analysis of environment structure. The meaning here however follows the terminology used by Bröder (2003) and refers to the structure of cue validities.

individual differences in basic components of cognitive mechanics and strategy use was expected.

In sum, Study 1 tested the following predictions 1) participants adapt their information and strategy use to the structure of environments, using more information intensive strategies in the compensatory environment and the less cognitively demanding strategies in the noncompensatory environment 2) individual differences in cognitive mechanics (i.e., working memory, speed, inhibition-related functions) are related to the use of more information-intensive strategies in an environment rewarding the use of such strategies.

Method

Participants

22 adults (10 men and 12 women) with an average age of 23 years (*SD* = 2.62; years of education, *M* = 13.45, *SD* = 1.63) participated in the study, which took about 1 hr. Most participants were students in various departments of the Free University of Berlin (90%). Payment was contingent on each participant's performance: for each correct choice they received 10 euro cents; on average, a total of about 3 euro was paid plus a basic participation payment of 8 euro, making a total average of 11 euro per participant. However, due to a programming error participants were slightly underpaid (up to 50 euro cents).

Design

The independent variable in this study was the payoff structure of the decision environment presented to the participants (compensatory vs. noncompensatory; between subjects design). Participants were told that all cues in the compensatory environment had a validity of .71, while in noncompensatory environment the first cue had the highest validity; the second cue had the second highest validity, and so on. In this latter condition the cue validities were the following: .81; .71; .69; .66; .63; .60; .57; .54 (see Figure 2.1).

The average discrimination rate, that is, the proportion of times a cue discriminates between the two objects, was .70 for all cues (*SD* = .05). I chose the medium size discrimination rate, first, because this provided a large number of discriminating cues which increased memory demands. Second, this medium valued prevented the possibility that after observing a cue value on one alternative one could infer the cue value of the other alternative without acquiring this information: As discrimination rate of a cue approaches unity the incentive to look up the value for a second alternative decreases given you have seen the value on the first alternative.

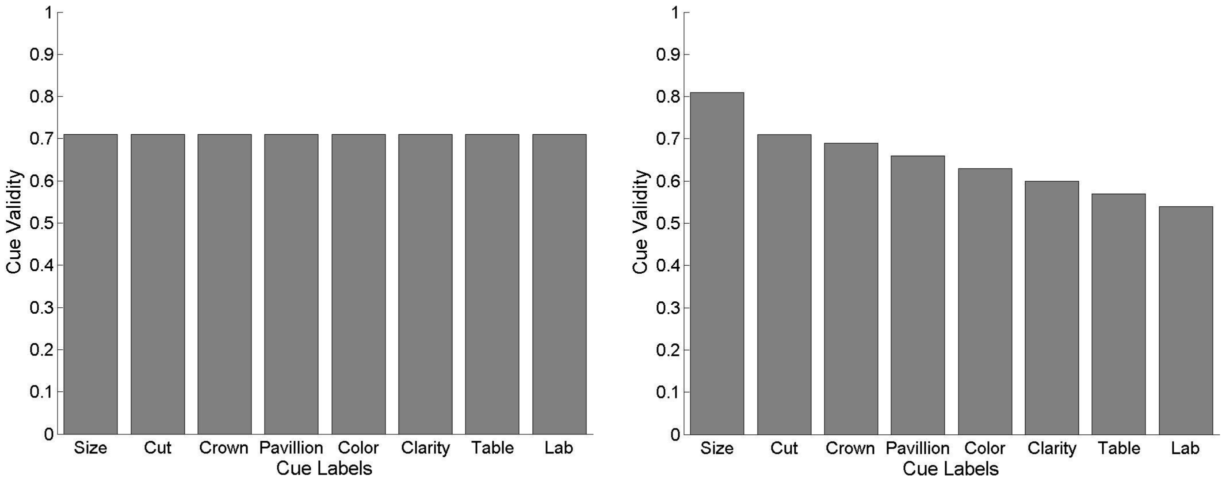

Figure 2.1: Cue dispersion in compensatory (left) and noncompensatory environment (right) communicated to participants.

Measures

Four different intellectual abilities were assessed: working memory (Operation Span; Engle, Laughlin, Tuhoslki, & Conway, 1999); short-term memory (Forward Span; Wechsler, 1981); an inhibition-related function, resistance to proactive interference (Brown-Peterson; Kane & Engle, 2000); and speed of processing (digit symbol substitution, Wechsler, 1981).

Operation span. The stimuli of Hamm (unpublished) were used for this task. Participants saw individual operation-word strings (e.g., IS (8/4)-1=1? bear). They had to solve the math problems, each of which was followed by a lowercase word, which was to be read aloud. On hearing the word “bear” the experimenter would press a key that would cause the presentation of the next string. After a set of these operation-word strings, participants recalled the words. The dependent measure was the cumulative number of words recalled from perfectly recalled trials. The version used included all items with 5 words (see Engle et al. 1999); thus, the possible score ranged from 0 to 48.

Forward span. This task corresponds to the WAIS-R Digit Span subscale (Wechsler, 1981). Sequences of digits with increasing number of elements (3-9 digits) were presented. The participants were instructed to recall the digits in the correct sequence at the end of the presentation. After a correct response the number of digits presented was increased by one. When the participants made a mistake, an alternative sequence of the same length was shown. If the participant failed again, the test was finished. The maximum number of correct recalled digits was used as the dependent variable.

Digit symbol substitution. Participants had to follow a scheme relating a set of symbols to digits by writing as many symbols as possible within 90s below rows of digits. The regular paper-and-pencil format was used (Wechsler, 1981).

Brown-Peterson task. Participants viewed three lists of items from the category professions followed by one list of the category animals. Between lists participants had to recall the items. Additionally, before the recall they had to perform a distracting task consisting of counting aloud from, for instance D-32 (e.g., D-32, E-33, F-34) for 16 seconds. The dependent variable was the difference between number of correct items recalled in the first list and the second one (see Kane & Engle, 2000). This variable was then transformed so that lower values would indicate less resistance to proactive interference.

Procedure

The participants first performed the inference task. The task consisted of deciding, based on a set of cues, which of two diamonds was more expensive. Initially participants were familiarized with the task, the concept of cue validity was explained, and the validity hierarchy of the binary cues as well as their direction was introduced. Participants then performed 50 decisions based on information search in a computerized display. Participants had at each step the choice between acquiring one piece of information about one of the two diamonds, up to a total of 8 cue values per diamond, or making a decision about which diamond was more expensive. Each cue value was presented briefly (2 seconds) and only once. All participants had assess to the following cues in this order: size, overall proportions of the diamond, crown proportions, pavilion proportions, size of table, color, clarity, and certification laboratory. All cues had binary values (e.g., big vs. small diamond, colored vs. uncolored diamond). Participants had to touch appropriate buttons on a touchscreen to ask for information and make a decision (see Figure 2.2).

The order of information acquisition was partially constrained, with participants having to follow a predetermined cue order (from the most valid to the least valid cue). However, participants had the possibility of choosing which alternative they wanted to find out more about at a particular time, and they were able to alternate between objects. After performing the decision task participants' working memory, short-term memory, resistance to proactive interference, and speed of processing were assessed.

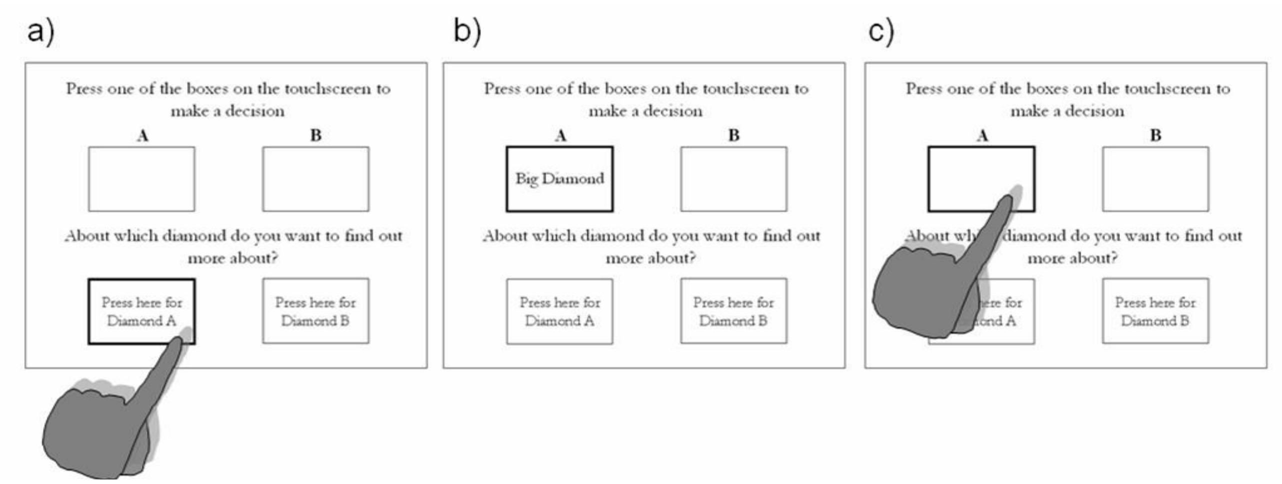

Figure 2.2: Experimental Display. In a) the participant presses a button to see information concerning diamond A; b) the participant observes the cue value for 2 seconds; c) the participant chooses diamond A by pressing the appropriate button.

Results

The results section is structured in the following way: First, I give an overview of participant's performance in the decision task. Second, I argue for a strategy classification method which takes into account participants' decisions as well as their information search behavior. Third, I provide a description of the relation between cognitive capacity measures and associate these with participants' information search behavior. Finally, the relation between cognitive capacity and strategy use is assessed.

Overview of Performance in the Decision Task: Strategy Fit

To gain an overview of decision behavior in both environments Table 2.1 presents the mean overall fit of the strategies, TTB, Take Two, and FR, in the compensatory and noncompensatory environments, where fit is defined as the proportion of participants' choices predicted by the strategies. Table 2.1 shows that, in the compensatory condition, the fits of FR and Take Two both exceed the fit of TTB. In the noncompensatory condition, both the fits of Take Two and TTB exceed that of FR. This switch in ranking of fits provides suggestive evidence for an effect of environment on strategy use. Moreover, the difference between strategies' fits in the two conditions represent large to very large effects (see Table 2.1). This suggests that there was an effect of environment in strategy use, with participants relying more on simpler strategies in the simpler noncompensatory environment.

Table 2.1: Mean Fit (and SD) of TTB, Take Two, and FR's Choices to Participants' Decisions

	COMP		NONCOMP		*t* test		Effect Size
Measure	*M*	*SD*	*M*	*SD*	*t*(20)	*p*	*d*
TTB	.64	.07	.73	.09	2.61	.017	1.17
TAKE TWO	.72	.08	.75	.08	1.03	.315	.46
FR	.71	.07	.63	.09	2.23	.038	1.00

COMP = Compensatory Environment; NONCOMP = Noncompensatory Environment

Overview of Performance in the Decision Task: Information Search

As a second analysis I examined participants' information search behavior, which was characterized by six variables commonly used to summarize the information search behavior of participants (e.g., Bröder, 2003; Rieskamp & Hoffrage, 1999; Payne et al., 1993).

Number of acquisitions (ACQ). ACQ concerns the depth of search and is defined as the total number of cue values looked up.

TTB's stopping rule (STOP TTB). STOP TTB examines whether the search is consistent with the search predicted by TTB and is defined as the proportion of decisions for which only one discriminating cue is looked up as predicted by TTB.

Take Two's stopping rule (STOP TAKE2). STOP TAKE2 examines whether the search is consistent with the search predicted by the Take Two strategy and is defined as the proportion of decisions for which only two discriminating cues favoring the same alternative are looked up.

Franklin's Rule's stopping rule (STOP FR). STOP FR, examines whether the search is consistent with the search predicted by FR and is defined as the proportion of decisions for which all cue values are examined.

Payne's index (PAYNES INDEX). Payne's (1976) index reflects the general pattern of information search. This variable aggregates two types of search transitions. Starting from a particular piece of information on an object, another piece for the same object can be viewed (alternative-wise transition) or another piece for the same cue can be looked up (cue-wise transition). The index is determined by the number of alternative-wise transitions minus the number of cue-wise transitions, divided by the sum of these two types of transitions, yielding values from -1 to 1. Positive values indicate a more alternative-wise search, and negative values indicate a more cue-wise search.

Time per decision (TIME PER DECISION). Finally, TIME PER DECISION refers to the average time taken per decision trial excluding the two seconds presentation time for each cue value.

The values for the six variables in the two conditions are summarized in Table 2.2. I assessed whether there was an effect of payoff structure on the processing variables. Because the measures are not independent, a multivariate analysis of variance (MANOVA) was conducted, with environment (compensatory vs. noncompensatory) as independent variable and the six search measures described above as the dependent variables.

The main effect of environment was evident, $F(6, 15) = 3.58$, $p = .02$, partial $\eta^2 = .59$. However, univariate follow-up tests revealed that only STOP FR differed between conditions. As can be observed in Table 2.2, overall, FR's stopping rule was more often followed in the compensatory than in the noncompensatory condition.

In sum, the two environments show some differences between conditions in what respects search measures averaged across participants: Participants showed more information-intensive searches in the compensatory compared to the noncompensatory environment, which supports the idea that decision makers change their behavior as a function of environment characteristics. In the next sections participants are categorized as a function of their search and decision outcomes and the effect of environment on strategy use is investigated.

Strategy Classification

Classification procedures that use both participants' decisions and their information search to classify them as users of particular strategies — o*utcome and search* classification procedures — are often called for but seldom used (Einhorn, Kleinmuntz, & Kleinmuntz, 1979; Einhorn & Hogarth, 1981; Pitz & Sachs, 1984). Most decision making research has used *outcome only classification* procedures that classify participants solely on the outcome of their inference process, that is, their final decisions (e.g., Harte & Koele, 2001; Bröder, 2003). However, using both the final choices and information search of the decision makers should increase the validity of the classification.

Table 2.2: Means and Standard Deviations for the Process Tracing Variables Dependent on Structure of the Environment and Strategy Classification

	ACQ		STOP TTB		STOP TAKETWO		STOP FR		PAYNES INDEX		TIME PER DECISION	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Compensatory Environment												
TTB ($n = 1$)	2.16	—	.26	—	.04	—	.00	—	.96	—	6.41	—
FR ($n = 10$)	13.57	2.54	.02	.03	.02	.03	.59	.34	-.39	.75	10.04	3.89
ALL ($n = 11$)	12.54	4.2	.04	.08	.02	.03	.53	.37	-.27	.82	9.72	3.85
Noncompensatory Environment												
TTB ($n = 2$)	6.78	1.25	.27	.13	.12	.06	.07	.07	-.70	.05	6.50	1.59
TAKE TWO ($n = 3$)	7.82	2.06	.03	.04	.16	.08	.07	.08	-.07	.85	6.72	1.78
FR ($n = 5$)	13.07	.87	.00	.01	.03	.02	.32	.24	-.69	.16	15.45	5.51
ALL ($n = 11$)	10.36	3.10	.06	.11	.08	.08	.19	.20	-.46	.51	11.02	5.70

Appendix C reports the use of model recovery techniques to assess how much is gained by adopting an outcome and search classification over an outcome only procedure. Model recovery techniques involve generating data on the basis of a known process or distribution and using some method of interest to identify the underlying structure of the data. This general strategy was adopted here to determine how successful the two classification methods are at uncovering the strategies used by simulated participants. The results from this simulation suggest that an outcome and search classification method is overall a more accurate method when application errors are present, such as errors in reading and comparing information, or making a decision (see Appendix C for details). Nevertheless, to allow comparisons with related studies, Appendix D provides an overview of participants' behavior when classified solely on the basis of their decisions.

Given the superiority of the outcome and search procedure, this method was used to classify each participant as using a particular inference strategy. The outcome and search classification procedure involved counting for each participant the number of inferences for which the information search *and* the final choice corresponded to the predicted search and choice by the different strategies. The strategy that predicted most inferences correctly for a participant was assigned to the participant. Recall that TTB's stopping rule consists of stopping search after seeing the first discriminating cue. Take Two involves stopping search after seeing two discriminating cues favoring the same alternative. Finally, for FR, all cue values had to be searched on both objects.

In the compensatory condition, 1 participant (9.1 %) was classified as using the TTB strategy, and 10 participants (91.9 %) were classified as using FR. No participant was classified as being a Take Two user. In the noncompensatory condition, 1 participant (18.2 %) was classified as using TTB, 3 participants (27.3 %) were classified as using Take Two, and 5 participants (45.5 %) were classified as using FR. One participant remained unclassified (9.1 %; because the fit of two strategies, TTB and FR, was equal). A chi-square test comparing strategy use in the two conditions, in which the frequency of simpler strategies, TTB and Take Two, was compared to that of FR, revealed an effect of environment on strategy use, $\chi^2(1, N = 21) = 4.30$, $p = .04$, $w = .45$.

Table 2.3 shows the proportion of inferences where the strategies predict the choices and information search correctly, differentiated for the classified participants. Considering participants' best fits based on the outcome and search classification it becomes evident that these were relatively low, ranging from .14 to .41, compared to those obtained based when considering strategies fits to decisions alone (from .63 to .75; see Table 2.1).

Table 2.3: Mean Fit of TTB, Take Two, and FR according to an Outcome and Search Classification Method

	TTB		Take Two		FR	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*
			Compensatory Environment			
TTB (*n* = 1)	.24	—	.02	—	.00	—
FR (*n* = 10)	.02	.03	.02	.03	.41	.26
			Noncompensatory Environment			
TTB (*n* = 2)	.27	.13	.12	.06	.03	.04
TAKE TWO (*n* = 3)	.02	.02	.14	.08	.05	.06
FR (*n* = 5)	.00	.01	.03	.02	.18	.16

However, this result is not surprising when considering the strict search criterion used which did not consider errors. Moreover, the results of the classification appear valid: the fit of different strategies differs substantially: Participants classified as TTB users share a considerably larger fit with TTB's predictions compared to that of other strategies.

Cognitive Capacity Measures

As can be seen in Table 2.4, the intercorrelations among cognitive capacity measures are mostly positive, which replicates the positive manifold often reported in the literature (e.g., Ackerman, Beier, & Boyle, 2002). Moreover, and despite the small sample size, most values are in line with those of previous studies (Engle et al., 1999; Friedman & Miyake, 2004; Park et al., 1996).

To check whether the participants in the two experimental condition differed with respect to their cognitive capacity, I conducted a multivariate analysis of variance (MANOVA), with environment (compensatory vs. noncompensatory) as independent variable and the four cognitive capacity measures as the dependent variables. As expected, given participants were randomly assigned to the two conditions, the main effect of environment was not significant, $F(4, 17) = 1.97$, $p = .145$. Table 2.5 shows the average scores on each cognitive measure in each condition as well as differentiated according to strategy classification.

Table 2.4: Correlations Among Cognitive Capacity Measures (N = 22)

	STM	SPEED	RPI
WM	.47 (.03)	.13 (.57)	.49 (.02)
STM	—	.34 (.12)	.54 (.01)
SPEED	—	—	.02 (.94)

Numbers in brackets represent *p* values.

Table 2.5: Means and Standard Deviations of Cognitive Variables Dependent on Environment and Strategy Classification

	WM		STM		SPEED		RPI	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
				Compensatory Environment				
TTB (*n* = 1)	33.00	—	6.00	—	64.00	—	- 2.00	—
FR (*n* = 10)	34.20	4.02	6.50	1.08	60.50	5.23	- 0.80	1.68
ALL (*n* = 11)	34.09	3.83	6.45	1.04	60.82	5.01	- 0.91	1.64
				Noncompensatory Environment				
TTB (*n* = 2)	27.00	9.90	5.50	.71	68.50	7.78	- 1.50	.71
TAKE TWO (*n* = 3)	32.33	2.52	7.00	1.73	65.67	16.8	- 1.67	2.08
FR (*n* = 5)	29.80	2.86	5.60	1.14	57.60	4.16	- 2.40	1.52
ALL (*n* = 11)	29.90	5.19	6.00	1.27	62.82	9.81	- 2.27	1.68

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference

Cognitive Capacity and Information Search

The predictions concerning the role of individual differences on information search were the following, in the compensatory condition, individuals with lower scores on the cognitive capacity measures were expected to 1) search for less information, 2) follow stopping rules of simpler strategies more often, and 3) take less time to make a decision. In contrast, in the noncompensatory environment, individual differences in basic cognitive mechanics should play a lesser role.

To investigate these issues I computed the correlations between the four measures of cognitive capacity and the six search measures. Table 2.6 shows the correlations between these in both the compensatory and the noncompensatory environment.

Table 2.6: Correlation between Search Variables and Cognitive Capacity Measures

Capacity	WM	STM	SPEED	RPI
	Compensatory Environment			
ACQ	.42 (.20)	.23 (.48)	.24 (.48)	.24 (.48)
STOP TTB	-.25 (.45)	-.12 (.72)	-.06 (.87)	-.09 (.79)
STOP TAKE2	-.76 (.01)	-.49 (.13)	-.31 (.36)	-.32 (.33)
STOP FR	.49 (.13)	.18 (.60)	.58 (.06)	.30 (.37)
PAYNES INDEX	-.82 (.01)	-.35 (.29)	-.21 (.54)	-.31 (.35)
TIME PER DECISION	.01 (.98)	-.27 (.42)	.16 (.64)	-.25 (.46)
	Noncompensatory Environment			
ACQ	.07 (.84)	-.19 (.58)	-.23 (.49)	-.36 (.28)
STOP TTB	-.45 (.16)	-.24 (.48)	.14 (.68)	.20 (.56)
STOP TAKE2	.24 (.48)	.55 (.08)	.52 (.10)	.30 (.37)
STOP FR	.08 (.81)	-.32 (.34)	-.22 (.52)	.11 (.75)
PAYNES INDEX	-.20 (.55)	.02 (.96)	-.20 (.55)	.04 (.92)
TIME PER DECISION	-.01 (.99)	-.36 (.27)	-.16 (.65)	-.40 (.22)

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference. Numbers in brackets represent *p* values.

Because the small sample size and consequent low power of this analysis prevents making general claims regarding the relation between capacity and information search, I discuss only the general pattern of findings. From the inspection of Table 2.6, it is evident that while cognitive capacity was positively related to the amount of information searched (ACQ) in the compensatory environment it was negatively or not related to information search in the noncompensatory condition. Additionally, in the compensatory environment the measures of cognitive capacity overall correlated negatively with the stopping rules of simpler strategies, TTB and Take Two, and positively with FR's stopping rule, suggesting that higher scores in measures of capacity were associated with more extensive search in this environment. In comparison, the pattern concerning strategies' stopping rules in the noncompensatory environment is mixed, which provides support for the idea that individual differences in cognitive capacity play a larger role in the use of simpler strategies in the compensatory compared to the noncompensatory environment. Regarding the pattern of information search (PAYNES INDEX), it appears that higher scores in cognitive capacity measures were associated with a more cue-wise search.

Cognitive Capacity and Strategy Use

The prediction concerning strategy use and individual differences in cognitive capacity was that those individuals with lower scores in cognitive capacity measures would have to default to simpler strategies even in an environment in which information-intensive strategies would be more rewarding. In contrast, given most participants would prefer simpler strategies in a noncompensatory environment, an effect of cognitive capacity should not emerge in this condition. To investigate these issues I conducted a MANOVA with strategy as independent variable and the four cognitive measures as the dependent variables. According to the hypothesis that cognitive limitations should determine strategy use in the compensatory but not in the noncompensatory environment, an effect of strategy was predicted in the former but not the latter condition.

The main effect of strategy was not significant neither in the compensatory, $F(4, 6) = .18$, $p = .942$, partial $\eta^2 = .11$, nor the noncompensatory environment, $F(8, 10) = .78$, $p = .63$, partial $\eta^2 = .38$. Note that this contrasts with the expectation that individual differences in cognitive capacity would be a particularly important determinant of strategy use in a compensatory environment. The failure to find the expected effect may be due to the small sample size used which did not provide enough variability in strategy distribution.

Discussion

Study 1 set out to investigate whether young adults are able to adapt their strategy use as a function of environmental structure in the absence of direct performance feedback. For this purpose participants made decisions in either a compensatory or a noncompensatory environment. The results showed that the use of an information-intensive strategy, FR, was higher in a compensatory compared to a noncompensatory environment, while the opposite was true for simple strategies, TTB and Take Two. This difference in strategy distributions between the two conditions support the idea that individuals are adaptive in their strategy selection behavior, being to some extent sensitive to the distribution of cue validities when opting for particular strategies.

Additionally, Study 1 preliminarily investigated the relation between individual differences in cognitive capacity and strategy use. Some suggestive patterns emerged from the relation between cognitive capacity measures and information search behavior: In the compensatory environment, *cognitive mechanics* (i.e., working memory, speed, resistance to proactive interference) *were positively related to more extensive information search behavior*. However, contrary to expectations, *Study 1 did not show any relation between cognitive capacity and strategy selection*. Please note that Study 1 was a pilot study, and thus represented only a first pass attempt at investigating the issues of interest which suffered from statistical power limitations. Study 2 dealt with this problem by making use of a larger sample and adopting appropriate analytical methods.

Study 2: Individual Differences in Cognitive Capacity and Strategy Selection in a Sample of Younger Adults

Study 2 investigated largely the same issues as Study 1 using a larger sample and therefore profiting from increased statistical power. First, Study 2 tested the assumption that individuals behave adaptively by selecting the appropriate strategy for a given environment in the absence of direct performance feedback. Participants performed decisions in either a compensatory environment (i.e., one in which cues have equal validities; and a compensatory strategy achieved the highest payoff) or a noncompensatory environment (i.e., one in which cues have different validities and are rank-ordered accordingly; and in which a noncompensatory strategy achieved the highest payoff). Once again the predictions concerning participant's behavior in these two environments follow from a cost-benefit analysis (Beach & Mitchell, 1978, Payne et al., 1993), which suggests differential outcomes in terms of strategy use for the two environments. In the compensatory environment the benefits associated with searching all the information were particularly evident in face of the uniform distribution of cue validities. In fact, the more rewarding strategy was the information-intensive Franklin's Rule (FR). Thus, a majority of participants should make use of such a strategy in this environment. In contrast, in the noncompensatory environment, a number of cues had very low validities. This should lead to a subjective low expected benefit of searching all available information. Thus, in comparison with the compensatory condition, participants in the noncompensatory environment should rely more on less information-intensive strategies, such as TTB and Take Two.

Second, Study 2 investigated whether individual differences in cognitive capacity explain some heterogeneity in strategy use. An interaction effect between cognitive capacities, such as working memory, and environment was predicted. The rationale for this is that given participants behave adaptively by choosing the most appropriate strategy for a given environment, a major reason for not adopting a particular strategy should be lack of resources to do so. This should be particularly the case for information-intensive strategies such as FR. Therefore, it was expected that those participants with fewer cognitive resources would have to fallback on simpler decision strategies in the compensatory environment. In contrast, no relation between basic cognitive components and strategy use was predicted in the noncompensatory environment as a majority of participants should want and be able to use simpler strategies in this condition not due to lack of resources but because of the expected benefits of using simpler strategies.

Additionally, Study 2 went beyond Study 1 by investigating whether intelligence, in either of its components, knowledge and reasoning, is associated with strategy use. Please recall that Bröder (2003) suggested that intelligence is associated with the use of simple strategies in the appropriate environment. However, Bröder based his conclusions on data resulting from a study which involved learning of strategy performance on the basis of feedback. In Study 2, I investigated the role of intelligence in conditions which precluded learning strategy performance through feedback over time.

The general experimental setup followed closely that of Study 1. Participants first performed the decision task. Afterwards, a comprehensive assessment of cognitive capacity was conducted, measuring 1) working memory, 2) short-term memory, 3) speed, 4) an inhibition-related function, resistance to proactive interference, and in addition to Study 1, 5) two components of intelligence, knowledge (Gc), and reasoning (Gf).

In short, Study 2 tested the following predictions 1) participants adapt their information and strategy use to the structure of environments, using more information intensive strategies in the compensatory environment and the less cognitively demanding strategies in the noncompensatory environment, 2) individual differences in cognitive mechanics (i.e., working memory, speed, inhibition-related functions) are related to information-intensive searches and the use of information-intensive strategies in an environment rewarding the use of such strategies, 3) individual differences in intelligence are related to the use of simpler strategies in the appropriate noncompensatory environment.

Method

Participants

A total of 83 adults participated in the study. Most were students in various departments of the Free University of Berlin (85%). Participants received a fixed payment of 20 euros for taking part in the experiment. In addition, they received an extra bonus payment dependent on their performance such that they received an extra payment of 10 cents for each correct choice they made. In sum, participants received on average 23.5 euros for taking part in the experiment, which was conducted in individual session that took approximately 2.5 hours each. I had to exclude three participants from analysis: one participant stuttered, making it difficult to test him in tasks demanding oral responses; one participant's keyboard malfunctioned; and one tried to tamper with the experimental program while performing the decision task. Thus, the final sample comprised 80 participants (41 female, 39 male, *M* age = 24.40 years, *SD* = 3.30; years of education, *M* = 16.21, *SD* = 2.62).

Design

In the experiment I had two between-subjects conditions which differed in terms of the cue structure of the environments. In one condition, the compensatory environment, all cues had the same validity of .71, whereas in the noncompensatory environment the cues' validities varied substantially, so that the cues had the following validities: .81, .71, .69, .66, .63, .60, .57, and .54. The discrimination rate, that is, how often a cue made a prediction, was kept constant with .70 for all cues and across both conditions.

In the compensatory environment, the mean expected payoff of a strict TTB strategy was 3.6 euros, that of Take Two was 3.9 euro, and FR was 4.2 euro. In the noncompensatory environment, TTB provided the highest payoff, 4.0 euro, followed by take Two with 3.9 euro, and FR, 3.5 euro. Thus, although FR was the most rewarding strategy in the compensatory condition, TTB and Take Two were better in the noncompensatory environment.

Each participant observed a set of 50 pair-comparisons randomly generated with the constraints of having the previously specified cue validities and discrimination rate. In addition, the item sets were constructed such that for a minimum of 15 items the two strategies TTB and FR made different predictions, for another minimum of 15 items TTB and Take Two made different predictions, and for another minimum of 10 items Take Two and FR made different predictions. Because I regarded the first inference the participants made as a practice trial and I only analyzed the remaining 49 choices, the actual proportion of discriminating items varied slightly across participants.

Measures

Six different intellectual abilities were assessed using a total of ten tests: working memory (Operation Span; Hamm, unpublished); short-term memory (Forward Span; Wechsler, 1981); resistance to proactive interference (Brown-Peterson; Kane & Engle, 2000); knowledge or Gc (Spot-a-word; Vocabulary; Lindenberger, Mayr, & Kliegl, 1993), reasoning or Gf (Figural Analogies, Letter Series, Practical Problems; Lindenberger, Mayr, & Kliegl, 1993), and speed (Identical Pictures, Digit Symbol Substitution; Lindenberger, Mayr, & Kliegl, 1993). An additional task assessed participants' motor speed (Box Tap Task). In what follows I present a description of the tasks used in Study 2, except working memory, short-term memory, digit-symbol substitution, and resistance to proactive interference, which were already described in Study 1 (see p. 42).

Spot-a-word. Twenty items containing one word and 4 pronounceable nonwords were presented successively on the screen. The task of the participant was to touch the word on the screen. Three practice items were provided. The total number of words correctly identified was the dependent measure.

Vocabulary. Sixteen words were presented one by one on the screen. Participants' answers were coded, each word receiving a score of 0 (wrong), 1 (partially correct), or 2 (correct) (Lindenberger, Mayr, & Kliegl, 1993).

Practical problems. Twelve items depicting everyday problems such as the hours of a bus schedule were used. For each item problems were presented in the upper part of the screen while five response alternatives were shown in the lower part. Participants gave their answers by touching the screen. The test phase was terminated if participants made three consecutive false responses, if they reached the time limit of 10 min, or if they answered the last item. The total number of problems correctly solved was the dependent measure (Lindenberger, Mayr, & Kliegl, 1993).

Letter series. Sixteen items containing 5 letters followed by a question mark (e.g., c e g i k ?) were displayed in the upper half of the screen while five responses were presented in the lower half. Items followed simple rules like +1, -1, +2. Participants gave their answers by touching the screen. The score was based on the total number of correct answers (Lindenberger, Mayr, & Kliegl, 1993).

Figural analogies. Items in this test followed the format "A is to B as C is to ?". Problems were presented in the upper part of the screen while possible answers were presented in the lower part. Participants gave their answers by touching the screen (Lindenberger, Mayr, & Kliegl, 1993).

Identical pictures. In this task 32 items were presented. For each item, a target figure was presented in the upper part of the screen and five possible responses were shown in the lower part. Participants had to touch the correct figure, which matched the target figure, in the lower part as fast as possible. Testing ended after 80 seconds. The dependent variable being the total number of correct answers (Lindenberger, Mayr, & Kliegl, 1993).

Box Tap. Participants tapped on computerized boxes in a limited time period (90 seconds). Average time between taps was used as dependent measure.

Procedure

The setting was the same as that for Study 1. Thus, participants were first familiarized with the inference task, the concept of cue validity was explained, and the validity hierarchy of the binary cues as well as their direction was introduced. Participants then performed 50 decisions based on information search in the same computerized display as in Study 1. The cues available to the participants were the also the same as in Study 1 and all cues had binary values (e.g., big vs. small diamond, colored vs. uncolored diamond). However, in contrast to the pilot study, the ranking of cue labels was randomized between participants. After performing the decision task participants' working memory, short-term memory, speed of processing, resistance to proactive interference, knowledge (Gc), and reasoning (Gf) were assessed.

Results

In this section, I first present an overview of participant's performance in the decision task, how participants were classified as users of particular strategies, and the descriptives concerning the cognitive capacity measures. Lastly, I analyze the relation between individual differences in cognitive capacity at both the level of information search and strategy use.

Overview of Performance in the Decision Task: Strategy Fit

Table 2.7 presents the mean fit of TTB, Take Two, and FR in the compensatory and noncompensatory environments, defined as the proportion of participants' choices predicted by the strategies. Table 2.7 shows that, in the compensatory condition, the fit of FR exceeds that of Take Two, while that of Take Two exceeds the fit of TTB. This pattern of results reverses completely in the noncompensatory condition, providing suggestive evidence for an effect of environment on strategy use. Moreover, the difference between strategies' fits in the two conditions represent large to very large effects (see Table 2.7). This suggests that there was an effect of environment in strategy use; participants relied more on information-intensive strategies in the compensatory environment and on simpler strategies in the noncompensatory one.

Table 2.7: Mean Fit (and SD) of TTB, Take Two, and FR's Choices to Participants' Decisions

	COMP		NONCOMP		*t* test		*Effect Size*
Measure	*M*	*SD*	*M*	*SD*	*t*(20)	*p*	*d*
TTB	.67	.05	.78	.11	5.54	<.001	1.25
TAKE TWO	.75	.05	.77	.05	1.92	.059	.43
FR	.85	.07	.72	.10	6.76	<.001	1.53

COMP = Compensatory Environment; NONCOMP = Noncompensatory Environment

Overview of Performance in the Decision Task: Information Search

Concerning participants' information search, the same six variables used in Study 1 were considered, more specifically, 1) total number of cue values looked up (ACQ), 2) proportion of trials in which TTB's topping rule is followed (STOP TTB), 3) proportion of trials in which Take Two's stopping rule is followed (STOP TAKE2), 4) proportion of trials in which FR's stopping rule is followed (STOP FR), 5) the pattern of information search (PAYNES INDEX), and 6) the average time taken per decision (TIME PER DECISION). Table 2.8 presents the values of these variables as a function of environment.

I assessed whether there was an effect of environment structure on the processing variables. Because the measures are not independent, a multivariate analysis of variance (MANOVA) was conducted, with environment (compensatory vs. noncompensatory) as independent variable and the six search measures described above as the dependent variables. A medium effect of environment was evident, $F(6, 73) = 6.08$, $p < .001$, partial $\eta^2 = .34$. As

Table 2.8 shows, the average number of cue values searched was higher in the compensatory environment condition (*M* = 13.06, *SD* = 2.39) compared with that in the noncompensatory condition (*M* = 11.05, *SD* = 3.45). In addition, the information search was more attribute-wise with an average value of -.12 (*SD* = .74) for PAYNES INDEX compared with an average of PAYNES INDEX of -.61 (*SD* = .33) in the noncompensatory condition. In contrast, univariate follow-up tests revealed that adherence to TTB and FR' stopping rules did not differ between conditions.

Overall, the differences in information search between conditions are compatible with the adaptivity assumption, that is, the idea that people adjust their decision behavior according to the characteristics of the decision environment. This is remarkable given that the participants received no feedback during the task and the conditions only differed in the different cue validities provided to the participants.

Strategy Classification

The following step in the analysis consisted of classifying each participant according to which strategy fit their behavior best. Similarly to Study 1, both participants' decisions and their information search were used to classify them as users of particular strategies, thus, an outcome and search classification was used. Once again, to allow comparisons with related studies, an overview of participants' behavior when classified solely on the basis of their decisions is given in the appendix (see Appendix D).

In the compensatory condition, 1 participant (2.4 %) was classified as using the TTB strategy, 5 participants (12.2 %) were classified as using Take Two, and 35 participants (85.4 %) were classified as using FR. In the noncompensatory condition, 1 participant (2.6 %) was classified as using TTB, 13 participants (33.3 %) were classified as using Take Two, 24 participants (61.5 %) were classified as using FR, and 1 participant remained unclassified (the fits of two strategies, TTB and Take Two, were equal; 2.6 %). A chi-square test revealed a small effect of environment on strategy use, $\chi^2(2, N = 79) = 5.50$, $p = .06$, $w = .26$.

Table 2.9 shows the proportion of inferences where the strategies predict the choices and information search correctly, differentiated for the classified participants. From inspecting the table one can see that mirroring the results of Study 1 some fits are low (e.g., Take Two's fit, .24). Again, however, the classification seems to be valid: participants classified as Take Two users share a considerably larger fit with Take Two's predictions (.24) compared to the other strategies' predictions (.04 and .08).

Table 2.8: Means and Standard Deviations for the Process Tracing Variables Dependent on Structure of the Environment and Strategy Classification

	ACQ		STOP TTB		STOP TAKETWO		STOP FR		PAYNES INDEX		TIME PER DECISION	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Compensatory Environment												
TTB (*n* = 1)	6.04	—	.58	—	.04	—	.08	—	-.66	—	7.30	—
TAKE TWO (*n* = 5)	9.47	.97	.04	.04	.24	.10	.12	.07	-.71	.13	8.48	1.56
FR (*n* = 35)	13.77	1.65	.01	.03	.01	.03	.50	.24	-.02	.76	11.51	4.83
ALL (*n* = 41)	13.06	2.39	.03	.09	.04	.09	.44	.26	-.12	.74	11.04	4.63
Noncompensatory Environment												
TTB (*n* = 1)	3.28	—	.92	—	.02	—	.02	—	-.39	—	4.79	—
TAKE TWO (*n* = 13)	7.71	1.59	.04	.04	.27	.12	.08	.07	-.60	.17	7.69	2.50
FR (*n* = 24)	13.45	1.35	.00	.01	.02	.04	.52	.19	-.63	.40	13.99	4.64
ALL (*n* = 39)	11.05	3.45	.05	.15	.11	.14	.34	.27	-.61	.33	11.39	5.16

Table 2.9: Mean Fit of TTB, Take Two, and FR according to an Outcome and Search Classification Method

	TTB		Take Two		FR	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*
			Compensatory Environment			
TTB (*n* = 1)	.54	—	.04	—	.04	—
TAKE TWO (*n* = 5)	.04	.04	.24	.10	.08	.05
FR (*n* = 35)	.01	.03	.01	.02	.40	.22
			Noncompensatory Environment			
TTB (*n* = 1)	.92	—	.02	—	.02	—
TAKE TWO (*n* = 13)	.04	.04	.25	.11	.03	.03
FR (*n* = 24)	.00	.01	.02	.04	.35	.19

Cognitive Capacity and Motor Skill Measures

A confirmatory factor analysis was performed with the BASE measures to ensure the expected psychometric properties emerged (cf. Lindenberger et al., 1993). This procedure confirmed the expected psychometric relation between variables and, thus, unit-weighted composites were used to arrive at single measures of knowledge (Gc), reasoning (Gf), and speed. After this first confirmatory step, the correlations between the different capacity variables and factors and the motor skill measure were assessed and compared to previous studies. As can be seen in Table 2.10, the intercorrelations among cognitive capacity measures are all positive, which replicates the positive manifold reported in the literature (e.g., Ackerman et al., 2002). Moreover, most values are in line with those of previous studies (Engle et al., 1999; Friedman & Miyake, 2004; Park et al., 1996). It is also worth mentioning that the highest correlation was that between working memory capacity and the reasoning factor, which matches the common finding that these two constructs share large amounts of variance (Conway et al., 2003).

To check whether the participants in the two experimental condition differed with respect to their cognitive capacity and motor skill, I conducted a multivariate analysis of variance (MANOVA), with environment (compensatory vs. noncompensatory) as independent variable and the six cognitive capacity measures plus the motor measure as the dependent variables. As expected, given participants were randomly assigned to the two conditions, the main effect of condition was not significant, $F(7, 72) = .73$, $p = .646$. Table 2.11 shows the average values for the different variables describing participants' cognitive capacity, differentiated according to environment and strategy classification.

Table 2.10: Correlations Among Cognitive Capacity Variables and Factors and Motor Skill Measure

	STM	SPEED	RPI	KNOW	REASON	MOTOR
WM	.16 (.17)	.18 (.12)	.18 (.11)	.21 (.06)	.49 (.00)	.27 (.01)
STM	—	.11 (.32)	.04 (.72)	.09 (.41)	.02 (.87)	.02 (.85)
SPEED	—	—	.05 (.65)	.09 (.41)	.16 (.15)	.13 (.24)
RPI	—	—	—	.22 (.06)	.21 (.06)	.02 (.85)
KNOW	—	—	—	—	.18 (.10)	-.16 (.16)
REASON	—	—	—	—	—	.17 (.14)

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. Numbers in brackets represent *p* values.

Cognitive Capacity and Information Search

Recall that the predictions concerning the role of individual differences on information search in the compensatory condition included that individuals with lower scores on the measures of cognitive mechanics would 1) search for less information, 2) follow stopping rules of simpler strategies more often, and 3) take more time to arrive at a decision.

As in Study 1, I computed the correlation between cognitive capacity measures and the information search variables. Table 2.12 shows the correlations as a function of the two environments. Although it was predicted that in the compensatory condition the different measures of cognitive mechanics, in particular, working memory, speed, and resistance to proactive interference, would all show a positive relation to the number of acquired cue values, it was mainly working memory that showed medium sized correlations with search variables.

Table 2.11: Means and Standard Deviations for the Cognitive Capacity Measures Dependent on Structure of the Environment and Strategy Classification

	WM		STM		SPEED		RPI		KNOW		REASON	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Compensatory Environment												
TTB (*n* = 1)	26.00	—	9.00	—	85.00	—	0	—	53.00	—	31.00	—
TAKE TWO (*n* = 5)	30.80	6.50	5.80	.84	95.60	4.67	-1.40	.89	43.00	8.80	43.20	7.95
FR (*n* = 35)	35.66	5.60	6.49	1.15	98.91	10.37	-1.74	1.48	46.11	7.61	47.40	7.02
ALL (*n* = 41)	34.83	5.96	6.46	1.19	98.17	9.96	-1.66	1.43	45.90	7.70	46.49	7.50
Noncompensatory Environment												
TTB (*n* = 1)	42.00	—	7.00	—	89.00	—	-2.00	—	58.00	—	46.00	—
TAKE TWO (*n* = 13)	33.46	3.64	6.77	.83	100.4	9.19	-1.23	1.48	45.77	3.92	46.77	7.45
FR (*n* = 24)	35.00	5.18	6.88	1.15	95.25	12.92	-1.62	1.63	43.00	8.37	47.54	7.32
ALL (*n* = 39)	34.64	4.73	6.85	1.01	96.77	11.65	-1.46	1.55	44.56	7.48	47.38	7.14

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning.

Table 2.12: Correlations between Cognitive Capacity Measures and Search Variables

	WM	STM	Speed	RPI	KNOW	REASON
			Compensatory Environment			
ACQ	.35 (.03)	.01 (.95)	.21 (.19)	-.05 (.75)	-.10 (.53)	.20 (.20)
STOP TTB	-.32 (.04)	.29 (.07)	-.21 (.20)	.14 (.37)	.18 (.28)	-.33 (.03)
STOP TAKE TWO	-.15 (.34)	-.21 (.19)	-.09 (.59)	.10 (.52)	-.12 (.45)	-.09 (.58)
STOP FR	.30 (.06)	.10 (.52)	.22 (.16)	.04 (.79)	.01 (.94)	.14 (.37)
PAYNES INDEX	.33 (.04)	.03 (.84)	.44 (.01)	.06 (.70)	.07 (.67)	.13 (.41)
TIMER PER DECISION	.42 (.01)	-.18 (.27)	.23 (.14)	.20 (.21)	.20 (.21)	.19 (.24)
			Noncompensatory Environment			
ACQ	-.04 (.81)	.13 (.44)	-.14 (.40)	.20 (.22)	-.40 (.01)	-.05 (.76)
STOP TTB	.21 (.20)	.01 (.98)	-.08 (.65)	-.04 (.80)	.38 (.02)	.01 (.94)
STOP TAKE TWO	-.01 (.94)	-.14 (.41)	.18 (.27)	-.30 (.07)	.14 (.41)	.06 (.72)
STOP FR	-.07 (.67)	.08 (.64)	-.22 (.18)	.08 (.63)	-.31 (.06)	.04 (.81)
PAYNES INDEX	.26 (.11)	.10 (.55)	.14 (.40)	-.07 (.68)	-.06 (.73)	-.11 (.50)
TIMER PER DECISION	-.01 (.97)	.19 (.25)	-.29 (.07)	.14 (.38)	-.15 (.38)	.07 (.66)

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. Numbers in brackets represent *p* values.

Higher scores in working memory capacity were positively associated with 1) search for more information (ACQ), 2) more often following FR's stopping rule, 3) performing a more alternative-wise search, and 4) taking longer to make a decision. Furthermore, lower scores in this measure were related to less adoption of TTB's stopping rule. A similar relation was observed between the reasoning factor and this simple strategy's stopping rule. In contrast, measures of speed and resistance to proactive interference were weakly associated with information search, with the exception of a positive relation between speed and performing a more alternative-wise search.

Regarding the noncompensatory environment, the only relations identified between cognitive capacity measures and search concerned the knowledge factor. Knowledge showed negative correlations with ACQ and STOP FR, and a positive relation with STOP TTB. This suggests that higher levels of knowledge were linked to less information-intensive search for information. Please note that this was not the case in the compensatory environment.

In sum, the general pattern of findings matches roughly those of Study 1 in that capacity was associated with strategy use at the level of information search mostly in a compensatory environment. Moreover, it was also generally the case in Study 1 that working memory capacity was more highly correlated with search variables than other measures of capacity (see Table 2.6). Taken together, these results suggest that *individual differences in working memory capacity were a determinant of information search in a compensatory environment*. The rationale for this is that in an environment in which information-intensive search is favored, one reason to default to simpler search patterns is lack of resources to engage in more cognitively demanding processing. However, in an environment in which information-intensive search is not favored, limitations in cognitive capacity are less of an issue. In addition, in the noncompensatory environment, accumulated experience (i.e., knowledge) seems to be related to the use of simpler strategies, which supports Bröder's (2003) claim that *intelligence is a predictor of the use of simpler strategies in the appropriate noncompensatory environments*.

Cognitive Capacity and Strategy Use

To investigate whether the selection of a particular strategy can be predicted by the different cognitive measures, I performed a series of multinomial logistic regressions. In this section, I first present the general procedure concerning this analysis, and for demonstration purposes, outline a specific numerical example concerning the effect of working memory. Then, I summarize the results concerning the different cognitive capacity measures. Finally, I discuss the extent to which the different cognitive capacity measures shared explained variance in strategy use.

Logic of the analysis. The analysis for each cognitive capacity factor consisted of the following steps: First, a multinomial logistic regression model was estimated by using the strategy selected by the participants (excluding unclassified participants) as the dependent variable and the environment as a predictor. The dependent variable consisted of the outcome and search classification results. Next, a second regression model was estimated by again using the strategy selected by a participant as the dependent variable, the environment as the first predictor and the cognitive capacity measurement as a second predictor. To test whether the cognitive capacity predictor substantially increased the fit of the logistic regression, the first "restricted" logistic regression including only the environment predictor was compared to the "complete" logistic regression with both predictors by a log-likelihood ratio test (Cohen, Cohen, West, & Aiken, 2003). The fit of each multinomial logistic regression model is defined by -2 times the log likelihood of the model, and the ratio of the two likelihoods are χ^2 distributed, with two degrees of freedom for the additional predictor in the complete model (given a 3 category outcome variable; see also Tabachnick & Fidell, 2001, p. 569). This difference is frequently noted as *G*, for goodness of fit or model prediction (cf. Cohen et al., 2003, p. 504). Third, the interaction between the environment condition and the capacity measure was added in the form of the multiplication of both predictors. The improvement in prediction was then tested against the model containing environment and capacity as predictors. This procedure allows one to test, first, the relation between a measure of cognitive capacity and strategy use independently of environment and, second, whether there is an interaction effect between capacity and environment. Recall that an interaction was predicted by which individual differences in cognitive mechanics should play a role in a condition that called for more cognitively demanding strategies, that is, in the compensatory environment, but not in the noncompensatory condition. Additionally, we wanted to assess whether, as Bröder (2003) suggested, intelligence is related to the use of noncompensatory strategies in appropriate environments, in this case, the noncompensatory environment.

A numerical example. To facilitate the reading of Table 2.13, I first present a detailed numerical example concerning the effect of working memory on strategy selection. First, I estimated the effect of environment on strategy use, G $(2, N = 79) = 5.60$, $p = .059$ (Step 1). Step 2 in Table 2.13 shows the *G* of the model when both environment and cognitive capacity are inserted as predictors and the respective *G* when both factors plus the interaction term are inserted. In addition, it shows the difference between *G* of the models when environment was used as a predictor and when environment plus each cognitive capacity measure was included. Thus, when both environment and working memory were included, G $(4, N = 79) = 9.62$, $p = .047$. Hence, the combined effect of environment and working memory did not lead to a significant increment in prediction compared to environment alone, ΔG $(4\text{-}2 = 2, N = 79) = 9.62 - 5.60 = 4.02$, $p = .136$. This indicates that working memory did not have an effect on strategy use which is independent of the effect of environment. In Step 3, environment, working memory, and their interaction were considered, G $(6, N = 79) = 16.24$, $p = .013$. The difference between this model and one assessing the combined effect of environment and working memory led to a significant increment in prediction, ΔG (6-4 = 2, N = 79) = 16.24 - 9.62 = 6.62, p = .036, suggesting that working memory had a differential role in the two environments. Please note that this provides initial support for the hypothesis that the effect of cognitive capacity, such as working memory, should be particularly evident in the compensatory condition.

Table 2.13: Goodness of Fit of a Series of Multinomial Logistic Regression Models with Strategy Classification as the Dependent Variable

		G	*P*	Δ*G*	*P*
Step 1: Environment by itself		5.60	.059		
Step 2: Environment + Capacity	WM	9.62	.047	4.02	.136
	STM	9.61	.048	4.01	.137
	SPEED	8.27	.082	2.67	.268
	RPI	6.89	.142	1.29	.533
	KNOW	12.20	.016	6.60	.038
	REASON	8.99	.061	3.39	.187
Step 3: Environment + Capacity + Environment*Capacity	WM	16.24	.013	6.62	.036
	STM	13.23	.039	3.62	.163
	SPEED	10.55	.103	2.28	.319
	RPI	8.47	.206	1.58	.454
	KNOW	18.08	.006	5.88	.053
	REASON	11.17	.083	2.18	.336

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. In Step 2, Δ*G* represents the difference between *G* of the model with environment and cognitive capacity as predictors and that of the model with only environment as predictor. In Step 3, Δ*G* represents the difference between *G* of the model with environment, each capacity, and their interaction as predictors and that of the model involving only environment and each cognitive capacity.

Individual Cognitive Capacity Predictors. The results concerning each cognitive capacity measure can be observed in Table 2.13. Besides working memory capacity, knowledge appears to have been the only other cognitive factor associated with strategy selection. As can be seen in Table 2.13, adding knowledge as a predictor significantly improved the model fit compared to when only environment was considered. Furthermore, the interaction of knowledge and environment also emerged as a significant predictor, suggesting that this component of intelligence was particularly relevant in one of the experimental conditions. This is in accordance with Bröder's (2003) suggestion that intelligence is predictive of adaptive use of strategies. I further examined these effects by splitting the conditions and testing the individual effects of the different cognitive capacity measures. The results of this procedure are presented in Table 2.14, which shows the relation between cognitive capacity and strategy classification in the two conditions. An analysis of this table indicates that working memory and short-term memory components were predictive of strategy use in the compensatory environment. Furthermore, the effect of reasoning was close to reaching conventional levels of statistical significance. In the noncompensatory environment, knowledge appeared as the single significant predictor.

Table 2.14: Effect of Cognitive Capacity Measures on Strategy Use as a Function of Environment

	Compensatory Environment			Noncompensatory Environment		
Predictors	*G*	*DF*	*P*	*G*	*DF*	*P*
WM	6.85	2	.033	3.76	2	.152
STM	7.48	2	.024	0.12	2	.943
SPEED	2.70	2	.260	2.22	2	.329
RPI	2.16	2	.339	0.68	2	.714
KNOW	1.85	2	.396	10.60	2	.005
REASON	5.41	2	.067	0.13	2	.937

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning.

To better understand these effects I examined the cognitive capacity scores presented in Table 2.11. Concerning the compensatory environment, the pattern for working memory and reasoning is the same, with participants classified as FR users showing higher scores in these measures compared to Take Two users, and Take Two users showing on average higher scores than the TTB participant. Concerning short-term memory, FR users had higher scores on this measure compared to Take Two users. However, the TTB participant had the highest possible score on the short-term memory measure. Regarding the noncompensatory environment, the TTB user had a higher score on the knowledge factor compared with the averages for Take Two and FR users. In addition, Take Two users had on average higher scores in knowledge compared to FR participants.

In short, the results suggest that in the compensatory environment individuals with higher scores in working memory, short-term memory, and reasoning measures preferred or were able to use information intensive strategies such as FR, while those with lower scores relied on simpler decision rules such as Take Two or even TTB. Thus, *cognitive mechanics were predictive of the use of more complex strategies in the compensatory environment*. In the noncompensatory environment higher scores in knowledge were associated with the use of simpler strategies, suggesting that *intelligence was a determinant of the use of simpler strategies in the appropriate noncompensatory environment.*

Combined Effect of Working and Short-term Memory. Given the theoretical status of the relation between the different cognitive constructs (e.g., Conway et al., 2003; Süß, Oberauer, Wittman, Wilhelm, & Schulze, 2002) and their role in strategy use (cf., Bröder, 2003; Klayman, 1985) I also investigated to what extent they share explained variance in strategy use in the compensatory environment. It is possible that the various measures are predictive of strategy selection behavior because of their particularities, each relating to specific components of strategy use. To investigate the predictive value of the different measures I considered the combined effect of capacity constructs. working memory and short-term memory, and tested whether there was an increase in predictive power when the two variables are included as predictors compared to when only one is considered. Again improvement in prediction was tested by calculating the difference between the log likelihoods of the two models, which is referred here as G. When working memory was considered alone G (2, N = 41) = 6.85, p = .033, when short-term memory was added G (4, N = 41) = 14.02, p = .007. Consequently, the difference between these is significant, ΔG (4-2 = 2; N = 41) = 14.02 - 6.85 = 7.17, p = .028. These results suggest that working memory and short-term memory measures contributed independently to predicting strategy use. One possibility is that individual differences in short-term memory relate more to quantity of information stored, while those in working memory are more strongly associated with the processing components responsible for information integration. Further studies aiming at distinguishing the contribution of these two components should be conducted.

Summing up, the results arising from the multinomial logistic regression analyses concerning the relation between cognitive capacity and strategy use indicate that, in this experiment, *individual differences in working memory and short-term memory capacity were a predictive factor of strategy use in a compensatory environment*, with those individuals with more limitations in working and short-term memory capacities relying on less information intensive strategies such as Take Two. Additionally, *knowledge, was found to be associated with the use of simpler strategies in the appropriate noncompensatory environment*.

Outcome Only and Outcome and Search Classification Procedures Provide Similar Results

The results based on the outcome and search classification method suggest that, under specific circumstances, individual differences in working memory and short-term memory may play a role in strategy selection. In particular, individual differences in these cognitive components may be a determinant of strategy use in cognitively demanding situations in which large amounts of information need to be searched and integrated to arrive at a correct decision. This is apparently at odds with previous work by Bröder (2003) who failed to find an effect of working memory with a similar decision task. However, the study differed from Bröder's in the choice of classification procedure. To address the possibility that classification procedure was the determinant factor behind these differences I conducted the analyses involving strategy classification and cognitive capacity using the same classification method as Bröder (2003), which relied only on the choices of the participants.

The results concerning the outcome only classification are presented in Appendix E. Overall, the results suggest that the strategy distributions based on an outcome only classification differ a little from the preferred outcome and search classification method. Nevertheless, the results concerning the relation between cognitive capacity and strategy use do not differ extensively when the results of the two different classification procedures are considered. In sum, the *differences between Study 2 and Bröder's (2003) results should be mostly attributed not to the classification method used but to the differences in experimental design*.

Discussion

Overall, results show that a large portion of participants behaved adaptively by choosing appropriate strategies for a given environment. In the compensatory condition more than 80% of our participants used FR, while in the noncompensatory at least 40% used simpler strategies (75% according to the outcome only classification; cf. Appendix D).

Additionally, as predicted, the results suggest that strategy use was related to cognitive capacity, in particular working memory and short-term memory, and that this relation depended on the environment: Individual differences in working memory and short-term memory were predictive of use of more cognitively demanding strategies in the compensatory but not in the noncompensatory environment. Additionally, the effect of intelligence emerged in the form of a relation between knowledge and strategy use in the noncompensatory environment, supporting Bröder's (2003) hypothesis stating a role of intelligence in adaptive use of frugal strategies in the appropriate noncompensatory environments.

The remainder of the discussion is organized as follows: First, I relate the results with the idea that people are adaptive decision makers tuned to the characteristics of the decision environment. Second, I discuss how the findings relate to previous work on the relation between cognitive capacity and decision strategies and argue that heterogeneity in strategy selection can partly be attributed to individual differences in cognitive capacity.

Adaptivity in Strategy Use

A considerable portion of decision making research has investigated the conditions under which people use particular decision strategies. Researchers have mostly focused on the impact of task characteristics in determining strategy use, such as number of alternatives and attributes (Ford et al., 1989), the dispersion of the wining probabilities in gambles (Payne et al. 1989), or time pressure (Rieskamp & Hoffrage, 1999). In addition, more recently researchers have shown that people can adapt their strategy use as a function of environment structure when extensive performance feedback is provided (Bröder, 2003; Rieskamp & Otto, submitted). Overall, this work suggests that people behave adaptively, that is, they are able to use the strategy that is most appropriate given a set of task demands. Hence, the idea that people are adaptive decision makers has a good standing in the literature (Payne et al. 1993; Beach & Mitchell, 1978).

The results of Study 2 add to the existing body of research in that they show that adaptivity can be observed even in the absence of extensive performance feedback. In this study participants were only told the value of information prior to starting the experiment and received no feedback throughout, thus making it impossible for them to learn the payoff strategies provided over time, which rules out explanations of strategy adaptivity based on reinforcement learning in the short term. Consequently, one must conclude that, either explicitly or implicitly, participants knew something of the expected benefits of choosing one strategy over another based only on the summary of environment structure provided by the experimenter.

Individual Differences in Cognitive Capacity Explain (Some) Heterogeneity in Strategy Selection in a Sample of Younger Adults

Decision scientists have yet to explain heterogeneity in strategy use (see Bröder, 2003; Newell, 2005). To deal with this concern, Study 2 dealt with individual differences in decision behavior and how these relate to individual differences in cognitive capacity. The rationale behind the approach was that, because different strategies involve different levels of cognitive costs, measurable in the numbers of computations required in information gathering and integration, cognitive capacity should be a determinant of strategy use. Furthermore, the perspective adopted was that the costs of information search and integration are relative: cognitive costs depend both on task characteristics and the individual's cognitive resources. As a result, it was reasoned that in conditions of high cognitive demand those people with fewer cognitive resources might have to rely on simpler, less computationally demanding decision strategies.

A recent study by Bröder (2003) also investigated these issues. More specifically, he manipulated the payoff structure of environments to produce two experimental conditions, one favoring the use of compensatory and one the use of noncompensatory decision strategies. Additionally, he measured participant's intelligence and also, in a second experiment, working memory. Bröder reported intelligence was a predictor of the use of simple strategies only in a noncompensatory environment and found no effects of individual differences in working memory capacity in strategy use. Bröder's results seem to be at odds with the findings from this study concerning working memory and short-term memory capacity. Nonetheless, it is likely that Bröder's results owe to the specific characteristics of the paradigm used: there was a monetary cost associated with information search which may explain why participants searched for few pieces of information. As a consequence, participant's "capacity limit was presumably not reached" (Bröder, 2003, p. 620), which could explain why no effect of individual differences in working memory on strategy use was found. In contrast, in Study 2 plenty of information available to participants at no monetary cost (16 vs. 12 pieces of information in Bröder's, 2003, experiment 2). As a consequence, some participants who could not use information intensive strategies, like FR, had to rely on simpler ones such as Take Two and TTB. Concerning the effect of intelligence, Study 2 precluded learning effects by providing all participants with the environmental structure beforehand and giving them no performance feedback throughout the task. Because intelligence was predictive of strategy use in these conditions one should conclude that strategy selection per se rather than learning may have been responsible for Bröder's (2003) results.

Summing up, Study 2 showed that 1) *young adults are able to adapt their strategy use as a function of environment structure*. Additionally, it was shown that 2) *individual differences in cognitive capacity are a determinant of strategy use*. In particular, the results of Study 2 support the hypothesis that limitations in basic components of cognitive mechanics, namely, working memory and short-term memory, pose a constraint in terms of the strategies that can be employed. Consequently, those individuals with fewer resources had to rely on simpler, less cognitively demanding strategies. In addition, individual differences in intelligence were predictive of the adaptive use of strategies, with more intelligent individuals relying on simpler strategies in the appropriate noncompensatory environment. In Study 3, I investigated older adult's adaptivity in decision making and how their cognitive capacities determine the selection of decision strategies.

Study 3: Individual Differences in Cognitive Capacity and Strategy Selection in a Sample of Older Adults

Older adults' adaptivity in strategy use has been questioned in the arithmetic computation domain (Lemaire et al., 2004). However, some research in cognitive aging suggests that older adults' experience can to some extent compensate for their decline in basic cognitive abilities (Krampe & Ericsson, 1996), which could be reflected in maintained adaptivity. To resolve the tension between these two positions, Study 3 investigated whether older adults behave adaptively in that they select appropriate decision strategies for a given environment.

Previous research suggests that older adults look up less information and take longer to make a decision than younger adults (e.g., Johnson, 1990, 1993). Additionally, it has been suggested that older adults may rely more on simpler strategies (Gigerenzer, 2003; Sanfey & Hastie, 1999). Although some evidence supports this claim (e.g., Chen & Sun, 2003; Johnson, 1990) some studies failed to find age differences in strategy use (e.g., Johnson, 1993; Riggle & Johnson, 1996). Whether older adults can only rely on simpler decision rules has an implication concerning how adaptive their strategy selection behavior can be. If older adults are only able to make use of simpler, less cognitively demanding strategies, they will have to use these regardless of environment structure. Consequently, their decision behavior would be overall less adaptive. Alternatively, if older adults can make use of a range of strategies they would be able to adapt to particular environments. To the extent that the ability to adapt is dependent on experience, it is possible that older adults' greater decision making experience would help them better tailor their decision strategies to fit the environment structure compared to younger adults.

One additional aim of Study 3 was to investigate whether individual differences in cognitive capacity predict which decision strategies are deployed in an older group and to determine the extent to which this pattern matches that found for younger adults. Remember that Study 2 showed that, in an environment in which information-intensive strategies provided the highest payoff, those individuals with lower scores in working and short-term memory capacity showed a tendency to use simpler, less cognitively demanding decision rules. It is a robust finding in the developmental literature that correlations between cognitive measures increase with age (Baltes, Cornelius, Spiro, Nesselroade, & Willis, 1980) and it has been suggested that basic components of cognitive mechanics gain predictive value in older compared to younger samples (e.g., Li, Lindenberger, Hommel, Aschersleben, Prinz, & Baltes, 2004; Lindenberger et al., 1993). Consequently, one would expect that with increased age the different components of cognitive mechanics should be better predictors of decision making performance. This leads to the prediction that in an older sample, not only working memory and short-term memory, but also speed and inhibition-related functions should emerge as predictive factors of the use of demanding strategies in a compensatory environment.

As in the previous studies, participants' had to decide, based on a set of cues, which of two diamonds was more expensive. After the decision task, cognitive capacity was assessed, including (1) working memory, (2) short-term memory, (3) speed, (4) an inhibition-related function, resistance to proactive interference, and (5) two components of intelligence, knowledge (Gc), and reasoning (Gf).

Summing up, Study 3 tested the following predictions 1) older adults adapt their information and strategy use to the structure of environments, using more information intensive strategies in the compensatory environment and the less cognitively demanding strategies in the noncompensatory environment, 2) individual differences in cognitive mechanics (i.e., working memory, speed, inhibition-related functions) are related to more information-intensive searches and the use of more cognitively demanding strategies in an environment rewarding the use of such strategies, 3) individual differences in intelligence are related to the use of simpler strategies in the appropriate noncompensatory environment.

Method

Participants

A total of 86 adults, all healthy community dwellers, participated in the study. Participants received a fixed payment of 30 euros for taking part in the experiment and received an extra bonus payment dependent on their performance, such that for each correct choice they made they received an extra payment of 10 cents. In sum, participants received on average 33.5 euros for taking part in the experiment, which was conducted in individual sessions that took approximately 3.5 hours each. I had to exclude three participants from analysis because of technical problems with the experimental program implementing the decision task. Thus, the final sample comprised 83 participants (49 female, 34 male; age, M = 70.57, SD = 4.93, Min = 64, Max = 90; years of education, M = 14.32, SD = 3.95).

Design

The experiment consisted of two between-subjects conditions obtained by varying the payoff-structure of environments. The structures of the two environments were the same as those in Study 2. Thus, in the compensatory environment, all cues had the same validity of .71, whereas in the noncompensatory environment the cues' validities varied substantially: .81; .71, .69, .66, .63, .60, .57, and .54. Also, the discrimination rate, was kept constant (.70) for all cues and across both conditions.

In the compensatory environment, the mean expected payoff of a strict TTB strategy was 3.6 euros, that of Take Two was 3.9 euro, and FR was 4.2 euro. In the noncompensatory environment, TTB provided the highest payoff, 4.0 euro, followed by take Two with 3.8 euro, and FR, 3.7 euro. Thus, although FR was the most rewarding strategy in the compensatory condition, TTB and Take Two were somewhat better in the noncompensatory environment.

Each participant observed a set of 50 pair-comparisons randomly generated with the constraints of having the previously specified cue validities and discrimination rate. In addition, the item sets were constructed such that for a minimum of 15 items the two strategies TTB and FR made different predictions, for another minimum of 15 items TTB and Take Two made different predictions, and for another minimum of 10 items Take Two and FR made different predictions.

Measures

The same measures as in Study 2 were used to assess six different intellectual abilities (see Study 2 for details): working memory (Operation Span; Hamm, unpublished); short-term memory (Forward Span; Wechsler, 1981); inhibition (Brown-Peterson; Kane & Engle, 2000); knowledge or Gc (Spot-a-word; Vocabulary; Lindenberger, Mayr, & Kliegl, 1993), reasoning or Gf (Figural Analogies, Letter Series, Practical Problems; Lindenberger, Mayr, & Kliegl, 1993), speed (Identical Pictures, Digit Symbol Substitution; Lindenberger, Mayr, & Kliegl, 1993); and motor skill (Box Tap).

Procedure

The same procedure as in Study 2 was adopted in this experiment. Thus, participants were first familiarized with the inference task and the decision environment. However, in this experiment participants had the chance to perform 5 practice trials before performing the 50 decisions. After the decision task, participants' cognitive capacities were assessed.

Results

The results section is structured in the following way, first, I provide an overview of performance in the decision task, classify participants according to their strategy use, and present the descriptive information concerning the cognitive capacity assessment. Subsequently, I analyze the relation between cognitive capacity and strategy use as well as information search.

Overview of Performance in the Decision Task: Strategy Fit

Table 2.15 presents the mean fit of TTB, Take Two, and FR in the compensatory and noncompensatory environments, defined as the proportion of participants' choices predicted by the strategies. Table 2.15 mirrors the findings of Study 2 (see Table 2.9), providing support for the idea that environment structure influenced participants' decision behavior. In the compensatory condition, the fit of FR exceeds that of Take Two, which in turn exceeds the fit of TTB. The reverse pattern was observed in the noncompensatory condition. The effect sizes concerning the difference between TTB and FR's fit in the two conditions represent medium effects.

Table 2.15: Mean Fit (and SD) of TTB, Take Two, and FR's Choices to Participants' Decisions

	COMP		NONCOMP		*t* test		*Effect Size*
Measure	*M*	*SD*	*M*	*SD*	*t*(20)	*p*	*d*
TTB	.67	.11	.74	.13	2.48	.015	.55
TAKE TWO	.71	.09	.70	.10	.56	.575	.12
FR	.74	.11	.68	.11	2.75	.007	.61

COMP = Compensatory Environment; NONCOMP = Noncompensatory Environment

Overview of Performance in the Decision Task: Information Search

Concerning participants' information search, the same six variables used in the previous studies were considered, namely, 1) the total number of cue values looked up (ACQ), 2) the proportion of trials in which TTB's stopping rule was followed (STOP TTB), 3) the proportion of trials in which Take Two's stopping rule was followed (STOP TAKE2), 4) the proportion of trials in which FR's stopping rule was followed (STOP FR), 5) the pattern of information search (PAYNES INDEX), and 6) the average time taken per decision

(TIME PER DECISION). Table 2.16 presents the corresponding values as a function of experimental condition.

As in the previous studies, I assessed whether there was an effect of payoff structure on the processing variables. A multivariate analysis of variance (MANOVA) was conducted, with environment (compensatory vs. noncompensatory) as independent variable and the six search measures as the dependent variables. The main effect of environment was small, $F(6, 76) = 3.12$, $p = .009$, partial $\eta^2 = .20$.

Univariate follow-up tests revealed that these results held for all variables except adherence to Take Two's stopping rule, $F(1, 81) = 3.46$, $p = .07$, the pattern of search, $F(1, 81) = 2.95$, $p = .09$, and the time taken per decision, $F(1, 81) = .89$, $p = .35$. As can be seen in Table 2.16, older adults looked up more information and more often followed FR's stopping rule in the compensatory than in the noncompensatory condition. In turn, they more often followed TTB's stopping rule and performed a more cue-wise search in the latter condition.

In sum, results indicate that there was overall an effect of environment, with *older adults performing more information-intensive searches in the compensatory compared to the noncompensatory environment*.

Strategy Classification

As in Studies 1 and 2, both participants' decisions and their information search were used to classify them as users of particular strategies, thus, an outcome and search classification was used. The results of an outcome-only classification are given in the appendix (see Appendix D).

Table 2.17 shows the proportion of inferences in which the strategies predict the choices and information search correctly. The results seem to validate the classification: the fits of different strategies differ substantially for each group in accordance with their classification. For example, participants classified as TTB users share a considerably larger fit with TTB's predictions compared to that of other strategies.

In the compensatory condition, the outcome and search classification identified 3 participants (7.3 %) as using TTB, 10 participants (24.4 %) as Take Two users, 27 participants (65.9 %) as using FR, and 1 participant was left unclassified (equal fits of all three strategies; 2.4 %). In the noncompensatory condition, 14 participants (33.3 %) were classified as using TTB, 10 participants (23.8 %) were classified as using Take Two, 17 participants (40.5 %) were classified as using FR, and 1 participant remained unclassified (equal fits of Take Two and FR; 2.4 %). A chi-square test revealed an impact of environment on strategy use, $\chi^2(2, N = 81) = 9.38$, $p = .01$, $w = .34$.

Table 2.16: Means and Standard Deviations for the Process Tracing Variables Dependent on Structure of the Environment and Strategy Classification

Strategy	ACQ		STOP TTB		STOP TAKE WO		STOP FR		PAYNES INDEX		TIME PER DECISION	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Compensatory Environment												
TTB ($n = 3$)	2.53	.79	.47	.18	.06	.04	.00	.00	-.14	.31	9.29	4.21
TAKE TWO ($n = 10$)	6.97	.89	.05	.05	.15	.07	.01	.01	.07	.79	17.84	7.78
FR ($n = 27$)	13.69	1.85	.01	.01	.02	.02	.57	.30	-.28	.74	20.64	6.03
ALL ($n = 41$)	11.08	4.13	.05	.13	.05	.07	.38	.36	-.15	.75	18.98	6.91
Noncompensatory Environment												
TTB ($n = 14$)	3.64	2.09	.38	.25	.06	.05	.01	.02	-.09	.43	11.93	8.23
TAKE TWO ($n = 10$)	6.48	1.69	.08	.06	.22	.11	.03	.04	-.27	.62	14.36	5.42
FR ($n = 17$)	12.83	1.77	.03	.05	.04	.04	.46	.24	-.69	.33	23.50	9.61
ALL ($n = 42$)	8.20	4.48	.16	.21	.09	.10	.20	.27	-.40	.51	17.25	9.60

Table 2.17: Mean Fit of TTB, Take Two, and FR according to an Outcome and Search Classification Method

Strategy	TTB		Take Two		FR	
	M	*SD*	*M*	*SD*	*M*	*SD*
			Compensatory Environment			
TTB (*n* = 3)	.46	.18	.03	.01	.00	.00
TAKE TWO (*n* = 10)	.05	.05	.12	.06	.01	.01
FR (*n* = 27)	.00	.01	.01	.02	.41	.27
			Noncompensatory Environment			
TTB (*n* = 14)	.34	.22	.04	.04	.01	.02
TAKE TWO (*n* = 10)	.07	.04	.17	.07	.02	.03
FR (*n* = 17)	.03	.04	.03	.04	.34	.21

Cognitive Capacity and Motor Skill Measures

I used confirmatory factor-analytic techniques (cf. McArdle & Nesselroade, 1994) to check the structural differentiation of the Berlin Aging Study (BASE) measures into the expected three latent ability factors (cf. Lindenberger et al., 1993). Because the predicted structure could be demonstrated for this sample, unit-weighted composites were used to arrive at single factors concerning knowledge (Gc), reasoning (Gf), and speed.

After this confirmatory procedure, the correlations between the different capacity variables and factors and the motor skill measure were assessed and compared to previous studies. Table 2.18 presents the intercorrelations among cognitive capacity measures. Note that relations between cognitive capacity measures showed the expected positive manifold (e.g., Ackerman et al., 2002). The relation between motor speed and cognitive capacity is overall positive which matches the common finding that higher values in cognitive capacity measures are positively related to motor speed (e.g., Salthouse, 1996). Correlations between knowledge, reasoning, and speed were low (.21 to .47) compared to those reported by Lindenberger et al. (1993; .82 to .87). Note, however, that Lindenberger et al.'s results concerned the performance of a slightly older sample in a more extensive battery of cognitive tests, and considering a slightly larger age range, which may explain some discrepancy between the studies.

Table 2.18: Correlations Among Cognitive Capacity Variables and Factors and Motor Skill Measure

	STM	SPEED	RPI	KNOW	REASON	MOTOR
WM	.22 (.04)	.31 (.01)	.21 (.06)	.36 (.01)	.32 (.01)	.24 (.03)
STM	—	.00 (.95)	.20 (.08)	.16 (.16)	.01 (.92)	.02 (.87)
SPEED	—	—	.25 (.02)	.21 (.07)	.47 (.01)	.29 (.01)
RPI	—	—	—	.14 (.22)	.24 (.03)	.27 (.01)
KNOW	—	—	—	—	.32 (.01)	.25 (.03)
REASON	—	—	—	—	—	.29 (.01)

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. Numbers in brackets represent *p* values.

Comparing the intercorrelations obtained in this study with those from Study 2, one observes that, overall, the pattern of associations is stronger in the older sample. For example, compared to Study 2, the working memory capacity measure is more strongly associated with all other cognitive variables, except reasoning. This is also the case for the speed measure. This fits well with the dedifferentiation hypothesis (Baltes et al., 1980; Li et al., 1996; Reuter-Lorenz, 2002), which holds that relations between cognitive abilities become stronger with increased age. Furthermore, in general, the motor speed measure correlates more highly with other cognitive factors, which is compatible with the idea that the coupling between cognitive and motor performance increases with age (Baltes & Lindenberger, 1997).

To check whether the participants in the two experimental conditions differed with respect to their cognitive capacity and motor skills, I conducted a multivariate analysis of variance (MANOVA), with environment (compensatory vs. noncompensatory) as independent variable and the six cognitive capacity measures plus the motor measure as the dependent variables. As expected, given participants were randomly assigned to the two conditions, the main effect of environment was not significant, $F(7, 74) = 0.92$, $p = .493$.

Table 2.19 shows the average values for the different variables describing participants' cognitive capacity, differentiated as a function of experimental condition and the outcome and search classification results.

Table 2.19: Means and Standard Deviations for the Cognitive Capacity Measures Dependent on Structure of the Environment and Strategy Classification

	WM		STM		SPEED		RPI		KNOW		REASON	
Strategy	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
					Compensatory Environment							
TTB ($n = 3$)	26.67	7.51	5.33	1.16	55.67	18.56	-1.67	.58	46.67	8.51	27.00	7.21
TAKE TWO ($n = 10$)	28.60	5.50	5.80	1.03	64.70	16.53	-2.10	1.79	51.10	6.37	30.80	7.21
FR ($n = 27$)	30.26	4.89	5.96	1.19	68.73	9.89	-1.11	1.53	51.78	5.38	35.70	9.10
ALL ($n = 41$)	29.46	5.18	5.88	1.12	66.95	12.62	-1.37	1.58	50.93	6.08	34.02	8.82
					Noncompensatory Environment							
TTB ($n = 14$)	27.43	5.13	5.50	1.09	60.43	10.85	-1.57	2.30	42.14	13.83	26.00	10.59
TAKE TWO ($n = 10$)	29.80	4.96	5.70	1.16	63.90	16.58	-1.80	1.55	50.90	4.53	32.80	8.01
FR ($n = 17$)	29.24	4.70	5.71	0.92	67.53	11.70	-1.06	1.30	48.53	7.19	37.76	8.58
ALL ($n = 42$)	28.52	5.06	5.67	1.03	64.14	12.68	-1.43	1.73	47.00	9.91	32.31	10.32

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning.

Cognitive Capacity and Information Search

Concerning the role of individual differences on information search, it was predicted that individuals with lower scores on the cognitive capacity measures should, particularly in the compensatory environment, 1) search for less information, 2) follow stopping rules of simpler strategies more often, and 3) take more time per decision to arrive at a decision.

To understand the relation between cognitive capacity and information search, I computed correlations between cognitive capacity measures and the information search variables. Table 2.20 shows the correlations as a function of the two environments.

As can be observed in table 2.20, in the compensatory environment, higher scores in working memory capacity were positively associated with number of cue values looked up (ACQ), and proportion of trials compatible with following FR's stopping rule. However, unlike Study 2, the working memory measure was not significantly associated with following TTB or Take Two's stopping rules or any other search variable. In addition, a positive relation was observed between reasoning and number of acquisitions. In contrast, measures of speed and resistance to proactive interference were weakly, non-significantly associated with information search.

Regarding the noncompensatory environment, the reasoning factor showed significant correlations with all search variables expect STOP TAKE TWO: While reasoning correlated positively with ACQ, STOP FR and TIME PER DECISION, it was negatively associated with STOP TTB, and PAYNES INDEX. This indicates that higher scores in reasoning were related to searching for more information, including looking up all cues on both objects and a low adoption of TTB's stopping rule, but doing so in a more cue-wise fashion.

As to other cognitive measures, the speed factor was positively associated with number of acquisitions and negatively associated with STOP TTB. Concerning knowledge, this factor was positively associated with TIME PER DECISION, furthermore, it was weakly negatively associated with TTB's stopping rule (STOP TTB) and PAYNES INDEX, and positively with ACQ. Note that this contrasts with the results of Study 2, in which knowledge was predictive of *less* information-intensive search behavior in a noncompensatory environment.

Table 2.20: Correlations Between Cognitive Capacity and Motor Skill Measures and Search Variables

	WM	STM	Speed	RPI	KNOW	REASON
			Compensatory Environment			
ACQ	.33 (.04)	.06 (.73)	.26 (.11)	-.13 (.42)	.20 (.21)	.32 (.05)
STOP TTB	-.12 (.46)	-.11 (.51)	-.25 (.12)	-.01 (.95)	-.18 (.27)	-.26 (.11)
STOP TAKE TWO	-.20 (.20)	.04 (.81)	-.14 (.39)	.16 (.32)	-.06 (.71)	-.14 (.38)
STOP FR	.33 (.04)	.03 (.87)	.11 (.50)	-.16 (.33)	.08 (.60)	.27 (.09)
PAYNES INDEX	-.01 (.94)	.14 (.37)	.22 (.18)	-.01 (.93)	-.07 (.67)	.25 (.11)
TIMER PER DECISION	-.12 (.44)	.25 (.12)	-.13 (.43)	-.28 (.07)	-.14 (.40)	.14 (.37)
			Noncompensatory Environment			
ACQ	.06 (.73)	.01 (.94)	.30 (.058)	-.04 (.82)	.21 (.18)	.57 (.01)
STOP TTB	-.12 (.44)	-.05 (.77)	-.32 (.04)	-.11 (.49)	-.23 (.16)	-.47 (.01)
STOP TAKE TWO	-.05 (.73)	-.04 (.83)	-.23 (.15)	.01 (.96)	.25 (.11)	-.08 (.63)
STOP FR	.02 (.91)	-.01 (.96)	.17 (.28)	-.11 (.50)	.09 (.59)	.43 (.01)
PAYNES INDEX	.06 (.69)	.07 (.67)	-.05 (.74)	-.09 (.56)	-.24 (.14)	-.39 (.01)
TIMER PER DECISION	.16 (.32)	-.04 (.80)	.08 (.59)	-.01 (.97)	.31 (.05)	.41 (.02)

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. Numbers in brackets represent *p* values.

In sum, the overall pattern of findings is at odds with those of Studies 1 and 2. In the latter, cognitive mechanics were associated with strategy use at the level of information search mostly in a compensatory environment and only knowledge was somewhat predictive of less information intensive search in the noncompensatory environment. However, in Study 3, *cognitive mechanics seemed to play a lesser role in the compensatory environment*, while *relations were found between two intelligence factors, reasoning and knowledge, and information search in both environments.*

Cognitive Capacity and Strategy Use

To investigate the relation between the different cognitive measures and strategy selection, I applied the same logic as in Study 2. Thus, the analysis consisted of the following steps: First, a multinomial logistic regression model was estimated by using the strategy selected by the participants as the dependent variable and the environment as a predictor (Step 1). In a second step, a series of multinomial logistic regression models were estimated by again using the strategy selected by a participant as the dependent variable, the environment as the first predictor and each cognitive capacity measure as a second predictor. Subsequently, the improvement in prediction of each of these models was tested against the model containing only environment as a predictor. Finally, in a third step, the interaction between environment and the capacity measure was added in the form of the multiplication of both predictors and the improvement in prediction was tested against the model containing environment and capacity as predictors. This procedure allowed one to test, first, the relation between a measure of cognitive capacity and strategy use independently of environment and, second, whether there was an interaction effect between capacity and environment.

I first estimated the effect of environment on strategy use, G (2, N = 81) = 10.00, p = .007 (see Step 1 in Table 2.21). Step 2 in Table 2.21 shows 1) the G of the model when both environment and cognitive capacity are inserted as predictors, and 2) the difference between G of the model when environment was used as a predictor and when environment plus cognitive capacity measures were included. In short, Step 2 identified two effects of interest concerning knowledge, and reasoning. Additionally, the effect of speed approached but did not reach the conventional .05 significance level.

To understand the direction of these effects I considered the means in Table 2.19. In both environments, participants classified as FR users had higher scores in reasoning and speed compared to Take Two users. The same pattern was evident in the compensatory environment when knowledge was considered. However, in the noncompensatory environment, FR users had slightly lower scores in knowledge than Take Two users. In turn, Take Two users had on average higher scores in all three measures compared to TTB participants, regardless of environment. In sum, it seems that higher scores in reasoning, speed, and knowledge were in general associated with the use of more information-intensive strategies such as FR and Take Two compared to TTB, suggesting that those older adults with enough cognitive resources tended to employ these more cognitively demanding strategies.

Table 2.21: Goodness of Fit of a Series of Multinomial Logistic Regression Models with Strategy Classification as the Dependent Variable

		G	*P*	Δ*G*	*P*
Step 1: Environment by itself		10.00	.007		
Step 2: Environment + Capacity	WM	12.86	.012	2.86	.239
	STM	11.07	.026	1.07	.585
	SPEED	14.98	.005	4.98	.083
	RPI	14.28	.006	4.28	.118
	KNOW	16.56	.002	6.56	.038
	REASON	25.86	<.001	15.86	.001
Step 3: Environment + Capacity + Environment*Capacity	WM	13.61	.034	0.75	.689
	STM	11.30	.080	0.23	.893
	SPEED	15.53	.017	0.55	.758
	RPI	14.58	.024	0.30	.861
	KNOW	17.45	.008	0.89	.642
	REASON	25.87	<.001	0.01	.996

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. In Step 2, Δ*G* represents the difference between *G* of the model with environment and cognitive capacity as predictors and that of the model with only environment as predictor. In Step 3, Δ*G* represents the difference between *G* of the model with environment, each capacity, and their interaction as predictors and that of the model involving only environment and each cognitive capacity.

Turning our attention to Step 3 in Table 2.21, which concerns the difference between a model using environment, cognitive capacity, and their interaction, and a model that does not contain this last term, one observes no effects of interest. Please recall that an interaction effect was predicted between capacity and environment, in which cognitive mechanics should play a major role in a compensatory compared to a noncompensatory environment. These results indicate that for older adults the effects of individual differences in cognitive capacity, namely, knowledge and reasoning, were evident regardless of environment.

As can be observed in Table 2.19, FR and Take Two users had higher scores in the reasoning and knowledge measures compared to TTB users. These results suggest that those older adults with lower scores in reasoning and knowledge were those who tended to use the less cognitively demanding TTB strategy.

Summing up, *individual differences in cognitive capacity were associated with strategy use*: Higher performance in tasks measuring knowledge and reasoning abilities was associated with the use of more information-intensive strategies, FR and Take Two, compared to TTB, regardless of environment.

Discussion

Adaptivity in Strategy Use

Study 3 investigated how the structure of environments and decision-maker characteristics determine the use of decision strategies in an older population. In short, the results showed that older adults adopt different strategies as a function of environment structure: Older adults tended to use more information-intensive strategies in a compensatory environment (circa 60% of FR users) and more fugal strategies in the noncompensatory environment (circa 60% of TTB and Take Two users). Also, analyses of older adult's information search showed that older adults' look up on average more pieces of information in a compensatory compared to a noncompensatory environment. As a whole, these results support the idea that *older adults are adaptive decision makers, adjusting their information search and deploying different strategies as a function of environment structure*.

Individual Differences in Cognitive Capacity Explain (Some) Heterogeneity in Strategy Selection in a Sample of Older Adults

Concerning the role of individual characteristics on information search, working memory capacity was predictive of information search in the compensatory environment for the older adults. In addition, relations were found between reasoning and some search variables indicating a more information-intensive search. Thus, individual differences in cognitive capacity were linked to heterogeneity in information search behavior.

Regarding strategy use, higher performance in tasks measuring speed of processing, knowledge, and reasoning abilities was associated with the use of more information-intensive strategies. In addition, results suggest that this was independent of environment. These results differ from those concerning younger adults for which higher scores in working memory capacity were also predictive of the use of more information-intensive strategies. Note, however, that the effect of working memory was found concerning information search of older adults. Hence, Studies 2 and 3 agree in that heterogeneity in strategy use is associated with individual differences in cognitive capacity. Nonetheless, the pattern of results concerning older adults indicates that individual differences in cognitive capacity play a role regardless of environment, perhaps indicating that individual differences in cognitive capacity are particularly relevant in determining which decision strategies are available in older age.

To end on a cautionary note, one limitation of Study 3 was its reliance on a convenience sample of older adults, which calls for precautious generalization to the population at large. In particular, because the older adults assessed were highly educated and all healthy individuals, any sampling bias is likely to be toward overestimating ability levels.

Age Comparisons of Information Search and Strategy Selection

The analyses conducted so far investigated the role of environment in information search and strategy use *within* age groups. However, to investigate differences between young and older adults' decision behavior it is necessary to ask to what extent the groups differ in terms of information search and strategy use. The next sections do this by collapsing data resulting from Studies 2 and 3. Study 1 was not considered because it did not include the full spectrum of measures that I wanted to consider in the analyses.

One caveat must be addressed regarding the general procedure of comparing young and older adults' performances in a cross-sectional design. Although some have argued that "in the field of cognitive aging cross-sectional findings appear to provide good estimates of average changes with age" (Baltes, Mayer, Helmchen, & Steinhagen-Thiessen, 1999, p. 21), cross-sectional age groups differ not only in their chronological age but in their life contexts, therefore, cohort differences are a potential source of error which is not easily overcome without resorting to longitudinal designs. Thus, one should exert caution in the interpretation of the results.

Age Differences in Information Search: Older Adults Show Less Information-intensive Searches Compared to Younger Adults

Previous experimental findings suggest that older adults look up less information and take longer to make a decision compared to younger adults (e.g., Johnson, 1990, 1993). To check whether the age-groups differed with respect to their search behavior in each of the environments, I conducted a multivariate analysis of variance (MANOVA), with age-group (young adults vs. older adults) and environment (compensatory vs. noncompensatory) as independent variables and the six information search measures as the dependent variables. The main effect of age represented a medium sized effect, $F(6, 154) = 22.61$, $p = .001$, partial $\eta^2 = .47$. Univariate follow-up tests revealed that these results held for all variables except STOP TAKE TWO and PAYNES INDEX. Older adults tended to search for less information, more often following TTB's stopping rule, and less often searching for all available information compared to younger adults.

The main effect of environment was small, $F(6, 154) = 7.56$, $p = .001$, partial $\eta^2 = .23$, but univariate tests confirmed this pattern held for all search variables, with more information-intensive searched being performed in the compensatory than in the noncompensatory environment. The interaction between age group and environment, however, represented a negligible effect $F(6, 154) = 2.21$, $p = .211$, partial $\eta^2 = .05$. This suggests that an effect of environment was equally evident in the younger and older groups.

Overall, these results suggest that 1) both *younger and older adults were adaptive* showing less information-intensive search in the appropriate noncompensatory environment, 2) *older adults showed less information-intensive searches* compared to younger adults and that 3) *age differences were equally evident in the two environments*.

Age Differences in Strategy Use: Older Adults Tend to Use Simpler Strategies Compared to Younger Adults

Table 2.22 presents a summary of strategy classification in Studies 2 and 3. To quantify any differences in terms of distribution of strategies, I computed a series of χ^2 tests. First, considering age differences in strategy use collapsed across environments, the effect of age represents a medium effect, $\chi^2(2, N = 160) = 14.11$, $p = .001$, $w = .30$. However, the same effect is small when considering strategy use in the compensatory environment alone, $\chi^2(2, N = 81) = 3.69$, $p = .158$, $w = .21$. Conversely, in the noncompensatory environment, the effect of age is medium sized, $\chi^2(2, N = 79) = 12.76$, $p = .002$, $w = .40$. This shows that the effect of age was somewhat stronger in the noncompensatory than in the compensatory environment.

Table 2.22: Summary of Strategy Distributions in Studies 2 and 3

	Study 2 (*N* = 80)				Study 3 (*N* = 83)			
	COMP		NONCOMP		COMP		NONCOMP	
	No.	%	No.	%	No.	%	No.	%
TTB	1	2.4	1	2.6	3	7.3	14	33.3
Take Two	5	12.2	13	33.3	10	24.4	10	23.8
FR	35	85.4	24	61.5	27	65.9	17	40.5
Unclassified	—	—	1	2.6	1	2.4	1	2.4
Total	41	100	39	100	41	100	42	100

COMP = Compensatory Environment; NONCOMP = Noncompensatory Environment

One possibility raised a priori was that older adults would have to default to simple strategies regardless of the environment. According to this possibility, age differences should be particularly evident in a compensatory environment in which older adults would more likely have to fall back on simple inference rules compared to younger adults. In comparison, in the noncompensatory environment, age differences should be smaller because both younger and older would rely on simpler strategies not due to lacks of resources but due to the simple rules' fit to this environment. The results are not compatible with the idea that older adults are limited to the use of simpler strategies as it was shown that they adapted their strategy use as a function of environment structure.

An alternative hypothesis was that older adults would be able to use information-intensive strategies to a similar extent as younger adults. However, it was argued that older adults' greater decision making experience could allow them to better identify the fit between strategies and environment structure. This ability could possibly lead them to choose the information-intensive strategies in the compensatory environment to a similar extent as younger adults, while more often choosing the appropriate simpler strategies in the noncompensatory environment compared to their younger counterparts. The fact that age differences were found in the noncompensatory but not in the compensatory environment supports this hypothesis. Further support for this premise would come from establishing a link between individual differences in experience (i.e., knowledge) and adaptive strategy selection. Before investigating to what extent individual differences in knowledge and other cognitive factors are predictive of strategy use, I consider whether older adults' increased reliance on simpler strategies proves less successful than younger adults' behavior.

Despite Being Adaptive Older Adults Are Generally Worse Off Compared to Younger Adults

In both studies, the information-intensive FR provided the highest payoff in the compensatory environment, while the simpler TTB and Take Two strategies provided higher payoffs in the noncompensatory condition. Consequently, one would expect older adults' reliance on simpler strategies to make them worse off compared to younger adults in a compensatory environment, but better off in a noncompensatory one. To assess this supposition I compared the payoffs obtained by younger and older adults in the two environments.

The payoffs differed slightly between studies, therefore, in an effort to normalize payoffs I first computed the difference between the payoff obtained by each participant and the one predicted by the most accurate strategy in an environment separately for the two studies. One can think of this difference measure as representing loss of accuracy due to, for example, using a strategy other than the most accurate one, or making application errors when applying the most accurate strategy. For example, FR achieved an accuracy of .83 in the compensatory environment, thus, if a participant achieved .80 accuracy, its value on this loss measure would be -.03. The closer the value is to zero the more it approximates the performance of the best performing strategy in an environment. Importantly, this value allows direct comparisons between studies.

In the compensatory environment, younger adults (M = -.01, SD = .06) showed fewer losses compared to older adults (M = -.09, SD = .09), t(80) = 5.26, p = .001. Hence, as expected, the performance of younger adults was better than that of older adults in the compensatory environment. However, in the noncompensatory environment, younger adults (M = -.04, SD = .06) also showed fewer losses in accuracy compared to older adults (M = -.09, SD = .11), t(79) = 2.36, p = .021. Note that this is the case despite the higher reliance on simpler strategies by older compared to older adults.

One possible cause underlying the general poorer performance of older adults is that they more often make application errors, such as errors in comparing information in short-term memory, compared to their younger counterparts. Thus, even though older adults may more often use simpler strategies, they may still have problems applying these correctly, and as a consequence show overall poorer performances. Chapter 3 will investigate this issue by testing whether older and younger adults differ in the application of decision strategies.

Age Differences in Strategy Selection Explained by Individual Differences in Speed and Reasoning

The younger and older adults assessed in Studies 2 and 3 differed in respect to their cognitive capacities. As can be seen in Table 2.23, younger adults showed on average higher scores in working memory, short-term memory, speed, and reasoning compared to older adults. However, older adults showed higher scores in the knowledge factor compared to the younger group. These results replicate the common finding that older adults show limitations in cognitive mechanics but maintained or increased abilities in cognitive pragmatics compared to younger adults (cf., Baltes & Mayer, 1999). Note that the size of the effects concerning working memory, speed, and reasoning are very large to huge (> 1.10).

To investigate whether differences in cognitive capacity could underlie the age differences in strategy use, I conducted a series of multinomial logistic regression analyses on data from the combined samples of Studies 2 and 3. The goals that guided this analysis were those of confirming an effect of environment on strategy use, and an effect of age beyond the effect of environment. In addition, I wanted to assess the predictive value of the different cognitive capacity measures and whether there was an advantage of including age as a predictor, in other words, I wanted to know whether age contributed to explaining strategy use beyond the effect of the different cognitive capacity measures.

Table 2.23: Individual Difference Measures: Performance Means (and SDs) and Tests of Significant Differences Between Younger and Older Adults

	Younger		Older		*t* test		*Effect Size*
Measure	*M*	*SD*	*M*	*SD*	*t*(161)	*p*	*(d)*
WM	34.74	5.36	28.99	5.11	7.01	<.001	1.11
STM	6.65	1.12	5.77	1.07	5.13	<.001	.81
Speed	97.49	10.77	65.51	12.65	17.30	<.001	2.74
RPI	1.56	1.48	1.40	1.65	.671	.50	.10
KNOW	45.25	7.57	48.94	8.43	2.94	.004	.46
REASON	46.92	7.30	33.16	9.59	10.29	<.001	1.62

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning.

Hence, I was interested in testing 1) the effect of environment; 2) whether age predicted strategy use beyond the effect of environment structure; 3) whether, excluding age, any variance could be explained by cognitive capacity variables beyond the effect of environment structure; 4) whether an interaction existed such that some measures of cognitive capacity played a more determinant role in a particular environment; and 5) whether age remained an important factor after each of these independent variables had been entered in a regression model (see Finucane et al., 2005, for a similar procedure). Results for the regressions are summarized in Table 2.24.

Using strategy classification as the dependent variable, it emerged that environment had an effect on strategy classification. This result is consistent with the outcome of Studies 1, 2 and 3, in which an effect of environment was found to have an impact on the distribution of strategies. Additionally, the difference between a model including both environment and age and one using only environment as predictor was significant. This suggests that age is a predictor of strategy use beyond the effect of environment. As can be seen in Table 2.24, overall, a larger proportion of older adults tended to use simpler strategies compared to younger adults.

When each cognitive measure and environment were considered and compared to a model concerning only environment, the difference in model fit was significant for working memory, speed, and reasoning. This implies that while individual differences in these three cognitive components were predictive of strategy selection, differences in short-term memory, knowledge, and resistance to proactive interference played no significant role. Subsequently, the interaction between capacity and environment was tested by comparing the *G* of the model with environment, each capacity, and their interaction as predictors and that of the model involving both environment and respective cognitive measure. This analysis revealed no interaction effects, suggesting that the role of individual differences in cognitive capacity was not more pronounced in a particular environment.

Table 2.24: Goodness of Fit of a Series of Multinomial Logistic Regression Models with Strategy Classification as the Dependent Variable

		G	*P*	Δ*G*	*P*
Step 1: Environment by itself		12.776	.002		
Step 2: Environment + Age		34.331	<.001	21.555	<.001
Step 3: Environment + Capacity	WM	26.998	<.001	14.222	<.001
	STM	17.587	<.001	4.811	.090
	SPEED	33.874	<.001	21.098	<.001
	RPI	13.317	.010	0.541	.759
	KNOW	14.872	.005	2.096	.349
	REASON	46.576	<.000	33.800	<.001
Step 4: Environment + Capacity + Environment*Capacity	WM	29.081	<.001	2.083	.353
	STM	20.011	.003	2.424	.298
	SPEED	36.541	<.001	2.668	.263
	RPI	13.975	.030	0.658	.719
	KNOW	15.715	.015	0.843	.656
	REASON	47.718	<.001	1.142	.565
Step 5: Environment + Capacity + Environment*Capacity + Age	WM	40.484	<.001	11.404	.003
	STM	36.294	<.001	16.282	<.001
	SPEED	39.406	<.001	2.864	.239
	RPI	35.842	<.001	21.867	<.001
	KNOW	38.641	<.001	22.926	<.001
	REASON	50.791	<.001	3.073	.215

WM = Working Memory; STM = Short-term memory; RPI = Resistance to Proactive Interference; KNOW = Knowledge; REASON = Reasoning. In Step 2, Δ*G* represents the difference between *G* of the model with environment and age as predictors and that of the model with only environment as predictor. In Step 3, Δ*G* represents the difference between *G* of the model with environment and each capacity as predictors and that of the model involving only environment. In Step 4, Δ*G* represents the difference between *G* of the model with environment, each capacity, and their interaction as predictors and that of the model involving both environment and respective cognitive measure. Finally, in Step 5, Δ*G* represents the difference between *G* of the model with environment, each capacity, their interaction, and age as predictors and that of the model involving the same predictors but age.

Note that no effect concerning knowledge emerged from this analysis. This is in opposition to the hypothesis that older adults' greater decision making experience was responsible for the greater ability to identify the fit between strategies and environment structure, in particular, to use simpler strategies in the appropriate noncompensatory environment. One possibility is that the tasks assessing knowledge were too general a measure to pick up more specific age differences in decision making expertise.

Finally, I was interested in determining whether individual differences in the cognitive capacity variables explained all age-related variance in strategy use. For this purpose age was added to the models. Adding age increased the model fit for a model including working memory and, not surprisingly given the low predictive value of these cognitive variables, those including short-term memory, resistance to proactive interference and knowledge. However, adding age as a predictor did not produce an increase in fit when speed and reasoning were considered. This result indicates that both these variables, speed and reasoning, accounted for a large amount of age-related differences in strategy selection. Overall, results concerning the outcome only classification procedure provide similar results concerning the effects of cognitive capacity (see Appendix G).

Discussion

Chapter 1 summarized research on age differences in preferential choice. In short, previous research in the domain of preferences has established that older adults look up less information and take longer to arrive at a decision than younger adults (e.g., Johnson, 1990, 1993), with age differences in these behaviors representing very large effects (albeit some variability was evident). The comparison of the two studies reported above generalized these results to paired-comparison inference problems. Overall, the two age-groups differed in their information search and these differences were evident in the two environments: *Older adults used showed less information-intensive searches compared to younger adults*. Moreover, the results add to the aging and decision making literature in what respect age differences in strategy use by showing that *older adults more often used simpler strategies compared to younger adults*.

It is worth mentioning one difference between previous studies and those reported here. All studies summarized in Chapter 1 (Johnson 1990, 1993; Johnson & Drungle, 2000; Riggle & Johnson, 1996; Stephens & Johnson, 2000) used decision problems in which at least 5 options were compared, providing participants with at least 36 cue values to be searched in a given decision trial. The studies reported here involved a total of 16 pieces of information available per trial. This difference is relevant to the extent it shows that age differences can be identified in conditions where fewer pieces of information are available than those studied before. Consequently, this suggests that age differences in strategy use may be enhanced when larger amounts of information are considered.

The results emerging from the age comparisons also suggest that the tendency of older adults to use simpler strategies was greater in the appropriate noncompensatory environment. This possibly indicated a higher adaptivity of older adults, that is, an increased ability in tailoring decision strategies to the structure of the environment, compared to the younger group. However, older adults showed poorer performance in the noncompensatory environment compared to younger adults, possibly due to the former making more application errors than the younger adults. Chapter 3 will provide additional information concerning this hypothesis by reporting results on age differences in strategy application.

Previous research has identified that age differences in comprehension of decision problems are related to short-term memory and speed of processing deficits (e.g., Finucane et al., 2002, 2005). In the present work a comprehensive assessment of the relation between major cognitive constructs and decision behavior was also conducted. A major finding arising from it was that working memory, speed of processing and reasoning abilities can account for some age-related variance in decision behavior. In fact, individual differences in speed of processing and reasoning seem to individually account for most age-related variance in strategy use. These results add to those found by Salthouse (1996) who reported that speed is a good predictor of age differences in performance in problem-solving and reasoning tasks.

General Discussion

Overview of Studies 1, 2, and 3

All three studies varied the structure of decision environments, so that in one environment the cues had the same validity in predicting the criterion, whereas in the second environment the cues' validities differed substantially. This manipulation created two environments, one favoring the use of compensatory and the other the use of noncompensatory decision strategies. In each decision trial, participants had the possibility of searching eight pieces of information about each of two diamonds, making a total of 16 cue values. There were no monetary costs associated with information acquisition; the costs of information acquisition were mostly those associated with the cognitive maintenance and use of information. Prior to the decision task, a summary of the environmental structure in the form of cue validities was given to participants, who did not get feedback during the task. Unlike previous research which has neglected the mechanisms used to perform decisions, the studies used a comparative model fitting approach to classify participants as users of particular inference strategies. In addition, it was investigated how individual differences in different cognitive abilities were associated with the use of the different decision strategies identified. Thus, several intellectual abilities were assessed, which across studies included measures of working memory, short-term memory, speed, resistance to proactive interference, knowledge (Gc), and reasoning (Gf).

Younger and Older Adults as Adaptive Decision Makers

All three studies provided additional support for the adaptive toolbox approach by showing that people can adaptively select strategies as a function of environmental structure. Overall, participants tended to show search behavior signaling more information-intensive search in a compensatory compared to the noncompensatory environment: There was considerable variance in information search that could be explained by environment (partial $\eta^2 = .59$, partial $\eta^2 = .34$, partial $\eta^2 = .20$; Studies 1, 2, and 3, respectively). Similarly, concerning strategy use, there were small to medium effects of environment on strategy distributions in the different studies ($w = .45$, $w = .27$, $w = .34$; Studies 1, 2, and 3, respectively).

Individual Differences in Cognitive Capacity Determine Strategy Selection

Some researchers have argued that one major limitation of extant decision making theories is a failure to account for heterogeneity in strategy selection (e.g., Newell, 2005). Studies 1 and 2 contributed to our understanding of heterogeneity in strategy selection in samples of young adults. Results from these studies suggest that some variability in strategy selection can be accounted for by individual differences in basic cognitive components. Additionally, this issue was investigated in a sample of older adults in Study 3, whose results also support the idea that individual differences in cognitive capacity are related to the use of decision strategies. Although the results differ somewhat between age groups, higher scores in measures of cognitive mechanics were predictive of the use of more cognitively demanding strategies. However, while for younger adults this was the case only in the compensatory environment, in the older group higher scores in cognitive measures were associated with more information-intensive strategies regardless of environment. One possible explanation for this is that in older age limitations in basic cognitive functions become more manifest, having a larger impact on decision making behavior.

Older Adults Show Less Information-Intensive Searches and Use Simpler Strategies Compared to Younger Adults

Finally, the studies aimed at providing new evidence concerning age differences in information search and strategy use. Overall, it was found that older adults took longer to make a decision and viewed fewer pieces of information than younger adults. In addition, the work reported here went a step further and compared young and older adults' strategy use. In short, the distribution of strategies differed between young and older adults, with older adults using more often simpler, more frugal strategies compared to younger adults (w = .30, medium effect). However, this effect was stronger in a noncompensatory (w = .40, medium effect) than in a compensatory environment (w = .21, small effect). Please note that these results imply that older adults showed a *more* adequate strategy use in a noncompensatory environment compared to younger adults. In contrast, in the compensatory environment, where the use of information-intensive strategies was rewarded, the difference between younger and older groups was small. This is a remarkable finding as it indicates that older adults may not be generally worse off compared to younger groups in the selection component of strategy use. However, recall that older adults achieved lower performance compared to younger adults in *both* environments, suggesting that other issues are involved, namely, strategy application problems. Nevertheless, as a considerable number of natural environments may reward the use of simpler strategies (cf. Gigerenzer et al., 1999), older adults may turn out to be generally successful decision makers, given that they do not make too many application errors.

The results from the comparison of the two age groups suggest that the overall reliance of older adults on simpler strategies may be related to deficits in cognitive mechanics, possibly because older adults 1) cannot cope with storing and recalling large amounts of information, 2) cannot use more complex strategies within reasonable time constraints, and 3) are more susceptible to interference from different sources of information, such as different cues. Because individual differences in reasoning and speed accounted for all age-related differences in strategy use, one is led to conclude that limitations in the speed and ability to integrate information are responsible for the higher reliance on simpler strategies by older compared to younger adults.

Future Directions

Several avenues for future research can be foreseen. First, the studies reported above refered to a fairly artificial setting and domain: choosing between diamonds on a computerized display. However, the ecological validity of such a task is open to empirical scrutiny and future studies may profit from systematically assessing the impact of decision domain on strategy use and making use of more real-life situations. This may be theoretically relevant as it has been argued that older adults may profit from performing decisions in contexts in which they have greater expertise, such as in the domain of medication (e.g., Johnson & Drungle, 2000).

Second, research in more applied domains such as consumer choice has revealed that the number of alternatives and attributes exceeds by far those implemented in the studies reported here (Fasolo, Mcclelland, Todd, in press). In the future, using experimental designs that consider both small and large consideration sets would allow findings to bear more directly on real-world problems. Furthermore, this would allow studying effects of task complexity. Usually, reliance on simpler strategies increases with increased task demands (e.g., number of alternatives; Payne, 1976) and one would predict this to be particular evident in older compared to younger adults. Future empirical tests should aim to investigate this hypothesis.

Third, future work should pay more close attention to aspects of information search, such as the search rule employed, which determines the order in which cues are considered. This aspect may be particularly important when considering expertise effects. One possibility is that older adults are particularly good at ranking and selecting the cues on which to base their decisions in domains which are familiar to them. Given their increased knowledge this could even grant them an advantage in comparison with younger adults. However, older adults could potentially be worse off compared to a younger group in new domains, for example, in situations in which they must learn cue validities immediately prior to the decision task (cf., Bröder & Schiffer, 2003).

In short, application to real-world domains, the study of task complexity effects, and the role of expertise in conserving decision making abilities in old age are all aspects that have not been considered here but should be dealt with in future research on age differences in the decision making domain.

Conclusion

The goal of Chapter 2 was to provide a better understanding of the link between cognitive abilities and decision making behavior and, in particular, the relation between age-related changes in cognitive capacity and the selection of decision strategies. This aim led to the study of how person and task characteristics determine the use of frugal and information-intensive strategies. The results of the present studies suggest that there are at least two reasons why people rely on simple strategies. First, one may not have the necessary cognitive resources to use complex strategies in a cognitively demanding environment, and may have to fallback on simpler decision algorithms. Second, even though one has enough cognitive resources to use a complex strategy, one may know that a simple heuristic provides the most accurate solution in a particular environment. Consequently, one should not see cognitive limitations as the single main determinant in the use of simple decision rules. Only by adopting this perspective is it possible to view people of all ages as adaptive decision makers.