Running head: Recognition as a cue

Recognition is used as one cue among others in judgment and decision making

Tobias Richter and Pamela Späth

University of Cologne, Germany

accepted for publication in *Journal of Experimental Psychology: Learning, Memory, and Cognition*

Mailing address:

Tobias Richter

University of Cologne

Department of Psychology, General Psychology

Herbert-Lewin-Straße 2

D-50931 Köln, Germany

E-mail: tobias.richter@uni-koeln.de

Abstract

Three experiments with paired comparisons were conducted to test the non-compensatory character of the recognition heuristic (Goldstein & Gigerenzer, 2002) in judgment and decision making. Recognition and knowledge about the recognized alternative were manipulated. In Experiment 1, participants were presented pairs of animal names with the task to select the animal with the larger population. In Experiment 2 participants chose the safer one out of two airlines, and three knowledge cues were varied simultaneously. Recognition effects were partly compensated by task-relevant knowledge. The compensatory effects were additive. Decisions were slower when recognition and knowledge were incongruent. In Experiment 3, compensatory effects of knowledge and recognition were found for the city-size task which had originally been used to demonstrate the non-compensatory character of the recognition heuristic. These results suggest that recognition information is not used in an all-or-none fashion but is integrated with other types of knowledge in judgment and decision making.

Key words: decision making, ecological rationality, fast and frugal heuristics, judgment, recognition

Recognition is used as one cue among others in judgment and decision making

Recently, Goldstein and Gigerenzer (1999, 2002) have proposed a theory of judgment which implicates that a lack of knowledge, or more specifically lack of recognition, may be beneficial when it comes to inferences concerning quantitative properties of entities. They assume that people use a non-compensatory recognition heuristic to identify those entities (e.g., cities) which score highest on a quantitative dimension (e.g., population sizes). For paired comparisons, the theory predicts that the recognition heuristic is applied whenever one of the entities is known whereas the other one is completely unknown. Despite the generality of this claim, empirical support for the recognition heuristic still rests on a small body of research within a limited range of judgment problems. In particular, there is no experimental evidence that people indeed use recognition in a non-compensatory manner, i.e. without consulting their knowledge about the known alternative. In this paper, three experiments are presented which allow direct tests of the validity of this proposition in judgment and decision making.

Recognition Heuristic and Ecological Rationality

The recognition heuristic has been introduced by Goldstein and Gigerenzer (1999, 2002) as the prototype of a set of fast and frugal heuristics. According to Gigerenzer and coworkers (Gigerenzer, Todd & The ABC Research Group, 1999), the use of these heuristics in real-life judgments and decisions is guided by simple stopping rules which pick out the simplest strategy applicable to a given problem. The recognition heuristic applies to tasks where a subset of entities is to be selected which score highest on a quantitative criterion. The criterion values are unknown to the person who makes the decision. All empirical investigations conducted so far concentrate on the simplest case of paired comparisons where the task is to pick out the one alternative with the higher criterion value, for example, the larger one out of two cities (Gigerenzer & Hoffrage, 1995). For such tasks, the recognition heuristic states that whenever one alternative is recognized and the other is not, the recognized alternative is to be selected.

The recognition heuristic differs in several ways from classical judgment and decision strategies based on formal algorithms (e.g., linear regression, Brehmer, 1994; Dawe's rule, Dawes & Corrigan, 1974; or Bayesian models) which aim at maximizing coherence of knowledge relevant to the problem at hand and to the judgments and decisions themselves (coherence criterion of rationality, Hammond, 2000). Instead of integrating as much information as possible to gain precise predictions of the criterion values, the recognition heuristic relies on recognition as the sole predictor. For this reason, the recognition heuristic is a non-compensatory decision rule: Any time it is applied, the decision process is terminated and further knowledge about the recognized alternative will not be considered. What is more, the application of the recognition heuristic is restricted to situations where knowledge is rather limited, i.e. not all entities of a population are recognized. Goldstein and Gigerenzer (1999, 2002) claim that despite its striking simplicity, the recognition heuristic is rational in the sense of *ecological rationality*: Recognition is supposed to correspond to the distributions of many adaptively relevant features of the environment (correspondence criterion of rationality). As a consequence, the recognition heuristic should make fast and frugal inferences about environmental features possible if two conditions are met. First, there must be variance in recognition (some objects are recognized and others are not) and second, a correlation has to exist between recognition and the criterion whose values are to be inferred (*recognition validity*). If this correlation is higher than the correlation between relevant cues and the to-be-inferred criterion (*knowledge validity*), a counterintuitive less-is-more effect occurs: Individuals with less knowledge (recognition for only a subset of entities) perform better in criterion-related judgments than individuals with more knowledge (recognition of all entities plus relevant knowledge).

Evidence Suggesting that Recognition is Used in Judgments and Decisions

Borges, Goldstein, Ortmann and Gigerenzer (1999) have demonstrated less-is-more effects for (hypothetical) stock market investment decisions. German and American stock market experts and amateurs were given the task to decide which companies they want to include in a portfolio. The amateurs, who tended to select companies they had heard of (those with a high recognition rate), made more successful investment decisions than the experts, who recognized most of the companies and were able to base their investment decisions on knowledge about the companies (but see Boyd, 2001, for contrary results in a changed stock market climate). In line with these results, Goldstein and Gigerenzer (2002) investigated less-is-more effects for the decision problem to select the larger one out of two cities taken from the population of all 83 German cities with more than 100,000 inhabitants. They illustrated the theoretical feasibility of less-is-more effects for this domain by a computer simulation, which compared the performance of the recognition heuristic and the take-the-best heuristic, another fast and frugal heuristic that takes only the cue with the highest validity into account (Gigerenzer & Goldstein, 1996). In this computer simulation, the number of available cues led to a strikingly better performance only when recognition rates exceeded 70%, and accordingly, variance in recognition declined. Besides illustrating the theoretical feasibility of the recognition heuristic, these results underscore that the use of recognition may be normatively warranted in the city-size task with German cities. The validity of the recognition heuristic as a descriptive model for this task was first demonstrated in a study with students from the University of Chicago, a population for which variance in recognition of German cities may be expected. The participants of this study demonstrated 90% choices in accordance with the recognition heuristic for pairs where only one city was recognized. A second study with participants from the same population investigated the non-compensatory nature of the recognition heuristic. Participants were taught the names of four cities that had a premier league soccer team and four that had not, and they were told (truthfully) that the soccer team cue had high knowledge validity. Even in pairs where the soccer team cue conflicted with recognition (one city was unrecognized and the other one had no soccer team), 92% of the participants selected the recognized city. In a third study, Goldstein and Gigerenzer (2002) demonstrated that students from the University of Chicago did perform about equally well in two different city-size tasks, one with US cities and one with German cities, despite their presumably better knowledge about US cities. In a fourth study in the series, this time with Germans who worked on a city-size task with US cities, accuracy of the choices in the city size task was impaired when a higher recognition rate was created by repeated testing.

Is Recognition Used in a Non-compensatory Manner?

Apart from these studies, most of them concerned with the city-size task, there is no positive evidence for the proposition that people actually use the recognition heuristic rather than some more thorough decision rule. Moreover, despite its theoretical importance, support for the proposed non-compensatory nature of the recognition heuristic comes from one study alone (Goldstein & Gigerenzer, 2002, study 3) where a single kind of knowledge cue (soccer team information) was employed. The supportive evidence from this study is weak for three methodological reasons. First, recognition as the main explanatory variable was not manipulated experimentally, which makes it hard to draw conclusions concerning its assumed causal role in inferences concerning city sizes. Second, Goldstein and Gigerenzer (2002, study 3) reported the proportion of choices consistent with the recognition heuristic merely for the critical city pairs where recognition information and knowledge about the recognized city conflicted with one another. Although the reported proportion is amazingly high, this result per se cannot be interpreted as evidence for a non-compensatory use of recognition. To qualify as evidence, it would have to be shown that the proportion of choices of the recognized alternative in pairs with conflicting cue information equals the proportions in pairs with no or consistent cue information, and comparisons of these proportions would have to be based on an experimental design with sufficient power to detect potential differences. The third objection pertains to the ecological validity of the knowledge cue manipulation. Since soccer is a much less popular sport in the USA than it is in Europe, it may be doubted that the American students participating in Goldstein and Gigerenzer's (2002) study perceived the soccer team cue as a valid cue for inferring city sizes. Despite being told in the abstract that the knowledge validity of the soccer team cue was high, participants might have given less weight to it in their judgments than they would have given to a subjectively valid cue.

Apart from Goldstein and Gigerenzer (2002, study 3), all of the other studies conducted so far merely substantiate the general claim that recognition plays a role in judgment and decision making. Recent research even sheds doubt on a ubiquitously non-compensatory use of recognition. In an experiment by Newell and Shanks (2004), for example, participants made hypothetical investment decisions between two fictitious companies which were either repeated often in the course of the experiment (recognition) or mentioned only once (no recognition). In addition, the recognition validity, i.e. the correlation of recognition and a company's economic success, was varied. Participants were provided feedback about the success of their investment decisions. When recognition validity was low, participants chose the recognized alternative less often and bought additional information from a fictitious financial advisor. In a second experiment with the same hypothetical scenario, information about the recognized alternative which conflicted with recognition influenced the majority of decisions within 75% of the participants, whereas only 25% of the participants decided in a manner consistent with the recognition heuristic. In a similar vein, Oppenheimer (2003) has argued that the original city-size task used by Goldstein and Gigerenzer (2002) confounded recognition with the knowledge that the city was large (Americans might recognize Berlin, for example, but at the same time know that Berlin is a large city). In two questionnaire studies, he presented participants the names of neighborhood cities which were not known to be large or which were even known to be small. In both cases, participants preferred the unrecognized over the recognized city.

Taken together, these results argue against the assumption of a special, non-compensatory status of recognition in judgment and decision making. Instead, they seem to suggest that additional knowledge about the known alternative may be taken into account when people decide between a recognized and an unrecognized entity with respect to a criterion whose values are unknown. Both the original studies in favor of the recognition heuristic and the more discerning studies, however, carry methodological features which complicate general conclusions about the validity of the recognition heuristic. The studies reported by Goldstein and Gigerenzer (2002) and Oppenheimer (2003) suffer from the lack of a fully experimental design and comparison groups. Strictly speaking, causal interpretations regarding the role of recognition and a potential trade-off of recognition with knowledge about the known alternative are impossible for either of these studies. Newell and Shanks (2004), in contrast, report experimental results but use a quite artificial setting which might place the recognition heuristic at a disadvantage. As a manifestation of ecological rationality, the recognition heuristic is supposed to be grounded in structures of the environment. If recognized as well as unrecognized company names are only introduced in the experimental situation, the supposed correspondence of recognition to structures in the environment might not be taken into account in an adequate manner. Moreover, Gigerenzer and Todd (1999) have argued that tasks for which relevant information must be retrieved from memory are more suitable for investigating fast and frugal heuristics than tasks for which all the relevant information is provided by the experimenter. The recognition heuristic, in particular, might not work with artificially induced recognition because participants usually know that they recognize an object just because it has appeared in an earlier part of the experiment. As a consequence, participants have good reasons *not* to attribute recognition to the attribute in question, with the consequence that they might not to use it for inferences concerning this attribute. The possibility to make such an attribution could be a precondition for applying the recognition heuristic (just as it is for the availability heuristic, cp. Schwarz, Bless, Strack, Klumpp, Rittenauer-Schatka, & Simons, 1991).

Rationale of the Present Experiments

The overall equivocal findings leave Goldstein's and Gigerenzer's (2002) core assumption about the special status of recognition in judgment and decision making essentially undecided. Against this background, the present paper aims at a comprehensive and methodologically adequate test of the issue. We report results from three experiments which should allow meaningful experimental comparisons while taking the ecological grounding of the recognition heuristic into account. Care was taken to use judgment and decision tasks which were naturalistic with respect to the domains, entities, and features employed. Experiment 1 was concerned with judgments of the population sizes of animal species, a task comparable to the city-size task used by Goldstein and Gigerenzer (2002). In contrast to the original studies, however, recognition of animal names as well as knowledge about their population sizes were varied experimentally and independently of the actual population sizes. These methodological features enable a separation of the effects of recognition and knowledge, as well as a proper test of potential compensatory effects among the two types of information. Experiment 2 extended this perspective to a naturalistic decision problem with a medium recognition validity, namely to choose the safer one out of two airlines when a flight is to be booked. Instead of one global cue, we manipulated the values of three distinct cues for airline safety. By this means, we were able to test whether knowledge effects are additive, a pattern of effects that would provide strong evidence for a compensatory use of recognition in decision making. In Experiment 3, we tested the assumed non-compensatory character with an experiment based on the original city-size task used by Goldstein and Gigerenzer (2002, study 3), but avoiding the methodological problems associated with the original study. Thus, Experiment 3 directly scrutinized the available evidence for a non-compensatory use of recognition in a domain where recognition validity is high.

Experiment 1: Compensation of Recognition Effects in Judgments of Animal Population Sizes

Experiment 1 tested whether recognition is used in a non-compensatory manner in paired comparisons of animal names with their population sizes as criterion. Alternatively, recognition might be used as one cue among others, and thus be integrated with knowledge which could be used for inferences about the population size of the recognized animal. The pairs consisted of names of one animal with a large population and one animal with a small population. As established in extensive pretests, both were either consistently not recognized by the participants, or merely recognized but not accompanied by any task-relevant knowledge, or recognized and accompanied by task-relevant knowledge (knowledge about the endangerment of the species). In this design, there can be two kinds of recognition effects, one beneficial and one biasing. Beneficial recognition effects occur if the name of the animal with the large population is recognized and therefore selected, while the name of the animal with the small population is not. Reversely, biasing recognition effects occur if the name of the animal with the small population is recognized and therefore selected, and the name of the animal with the large population is not. If participants follow the recognition heuristic, large recognition effects of both kinds may be expected. Moreover, if recognition is used in a non-compensatory way, these recognition effects should occur regardless of whether participants merely recognize one animal, or whether they also know that the recognized animal species is endangered (knowledge predicting a small population) or that it is not endangered (knowledge predicting a large population). The recognition heuristic implies that the magnitude of the preference for the recognized animal should not be moderated in any way by further knowledge. In addition to participants' choices, we recorded the judgment latencies. As a fast and frugal heuristic, the recognition heuristic should be applied quickly, and the judgment latencies should not be influenced in any way by knowledge associated with the recognized animal. If recognition is used as a cue among others, in contrast, we would expect easy judgments and hence shorter judgment latencies when recognition and knowledge are congruent, and harder judgments accompanied by elaborate considerations resulting in longer judgments when recognition and knowledge are incongruent.

Method

Participants. Participants were 42 psychology undergraduates at the University of Cologne (39 women and 3 men).

Materials. The experimental stimuli included in Experiment 1 were common names of animal species whose population was either small or large. They were selected on the basis of the IUCN red list of endangered species (International Union for the Conservation of Nature, 2004) and a norming study. In a first step, we drew a sample of 42 names of animal species which are endangered or near threatened according to the IUCN red list (animals with a small population), and added another 42 names of animal species which are not on the IUCN red list (animals with a large population). A questionnaire with the 84 animal names compiled in the first step was then presented to a sample of 22 psychology undergraduates. Participants indicated for each animal name whether they had heard of it before. If they recognized the name, they were asked to judge if the animal was endangered or not, and to rate their confidence in this judgment on a six point scale (5=*very sure*, 0=*very unsure*). These data were used to select 24 names of animal species which differed in population size, in the probability of being recognized, and in the probability of being known as endangered species by members of the student population which our experimental sample was drawn from. Out of the 24 animal species, (1) four had a small population and were not recognized by any participant of the norming study, (2) four had a large population and were not recognized by any participant, (3) four had a small population, were recognized by more than 90% of participants, and were not associated with knowledge about the animal's population (mean confidence rating below 1.0), (4) four had a large population, were recognized by more than 90% of participants, and were not associated with knowledge about the animal's population, (5) four had a small population, were recognized by more than 90% of participants, and were associated with knowledge about the animal's population (100% correct answers, mean confidence ratings above 2.5), and (6) four had a large population, were recognized by at least 90% of participants, and were associated with knowledge about the animal's population (see Appendix A).

Procedure and design. Presentation of stimuli and recording of responses and response latencies were controlled by the experimenter software E-Prime (Schneider, Eschman & Zuccolotto, 2002). Participants read pairs of animal names, presented one by one on a computer screen. For each pair, they were asked to select the name of the animal species which had the larger population, and to make their choice as quickly as possible. There were 144 paired comparisons consisting of all possible combinations of the 12 common names of animal species with large populations (*large-population animal*) with the 12 common names of animal species with small populations (*small-population animal*). Accordingly, the design was a 3 (no recognition vs. recognition and no knowledge vs. recognition and knowledge of the large-population animal) X 3 (no recognition vs. recognition and no knowledge vs. recognition and knowledge of the small-population animal) design with repeated measures on both factors. The order of presentation and the order of animal names within each pair were randomized across participants. Since recognized animal names were distributed evenly across the recognition/no-recognition conditions, participants relying solely on recognition would not perform better than chance. After the paired comparisons, participants completed the same questionnaire that was used in the norming study. These data provided a manipulation check for the experimental manipulations. The eight animal names which were selected for not being recognized had a mean recognition rate of .05 (*SD* = .04) in the experimental sample, whereas the 16 animal names which were selected for being recognized had a mean recognition rate of .97 (*SD* = .04). The mean accuracy in the knowledge questions was .84 (*SD* = .12) for the eight animal names which were selected for being associated with knowledge about the animal's population, and it was only .28 (*SD* = .14) for the eight animal names which were selected for not being associated with knowledge about the animal's population.

Results and Discussion

For all significance tests reported in this paper, type-I-error probability was set to .05. For all significant effects, we report partial η^2 (Cohen, 1988) as a measure of effect size.

Choice data. The proportions of correct choices (choices of the large-population animal) varied markedly between experimental conditions (Figure 1a). An ANOVA for repeated measures was conducted on the arcsine transformed proportions. Arcsine transformation was applied because it stabilizes the variances of proportions, which are bounded towards the lower and upper ends of the scale (0 and 1), across experimental conditions which differ in mean proportions (cf., for example, Cohen, Cohen, West & Aiken, 2003, Ch. 6.4). The main effects of both factors and their interaction were significant. We will report results concerning the main effects first and then report details on the interaction effect. (1) The main effect of recognition/knowledge of the large-population animal was very large, $F(2,40) = 82.7$, $p < .001$, $\eta^2 = .81$. When participants did not recognize the large-population animal, the proportion of correct choices was not better than chance (*M* = .49, *SE* = .03; cp. the three leftmost columns in Figure 1a). The proportion of correct choices was higher when participants simply recognized the large-population animal and had no knowledge about its population size (*M* = .71, *SE* = .02; cp. the three middle columns in Figure 1a), and it was highest when participants had knowledge about its population size (*M* = .90, *SE* = .02; cp. the three rightmost columns in Figure 1a). Both repeated contrasts between adjacent levels (no recognition vs. recognition/no knowledge, recognition/no knowledge vs. recognition/knowledge) were significant (for both contrasts: $p < .001$, $\eta^2 > .44$). Obviously, participants used recognition of the large-population animal as a cue, but knowledge about its population size also contributed positively to correct judgments. (2) There was also a large main effect of recognition/knowledge of the small-population animal, $F(2,40) = 45.7$, $p < .001$, $\eta^2 = .70$. The proportion of correct choices was generally high when participants did not recognize the low-population animal (*M* = .78, *SE* = .02; cp. the black columns in Figure 1a) or when they had knowledge about its population size (*M* = .74, *SE* = .03; cp. the white columns in Figure 1a). It was considerably lower when participants recognized the low-population animal but had no knowledge about its population size (*M* = .58, *SE* = .03; cp. the hatched columns in Figure 1a). Again, both contrasts between adjacent levels were significant, indicating a biasing effect of recognition of the small-population animal when recognition was not accompanied by knowledge about its population size. (3) The main effects were qualified by a large ordinal interaction, $F(4,38) = 11.9$, $p < .001$, $\eta^2 = .54$. The magnitude of the biasing effect of recognition of the small-population animal varied with the recognition/knowledge of the large-population animal: When participants did not recognize the large-population animal, there was a large recognition bias towards choosing the small-population animal, with $F(2,40) = 32.5$, $p < .001$, $\eta^2 = .62$, for the simple main effect. In this case, the mean proportion of correct choices dropped to a value well below chance (*M* = .33, *SE* = .05). When participants recognized the large-population animal and had no knowledge of its population size, the recognition bias towards choosing the small-population animal was equally large, with $F(2,40) = 36.9$, $p < .001$, $\eta^2 = .65$, for the simple main effect. Here, the mean proportion of correct choices matched chance level for pairs where both animals were recognized but recognition was not accompanied by knowledge about population size ($M = .55$, $SE = .03$). When participants had knowledge about the population size of the large-population animal, there was a less strong but still substantial recognition bias towards choosing the small-population animal, with $F(2,40) = 9.0$, $p < .01$, $\eta^2 = .31$, for the simple main effect. In this case, the proportion of correct choices was high when participants recognized the small-population animal ($M = .86$, $SE = .03$), but it was even higher when they did not recognize it ($M = .92$, $SE = .02$, $p < .01$). Thus, there was a general bias due to recognition of the small-population animal, but the magnitude of this bias was reduced when participants had knowledge about the population size of the large-population animal.

In sum, these results suggest two conclusions. First, recognition plays a major role in judgments of the population sizes of animal species. Second, it is used in a compensatory manner: When there are other cues available, i.e. when there is task-relevant knowledge concerning the recognized alternative, the influence of recognition on judgments is strongly reduced (although it does not disappear).

Decision latencies. Decision latencies were checked for potential outliers, and latencies which departed more than two standard deviations from the person mean (less than 0.3% of all latencies) were eliminated from further analyses. The results for the decision latencies support the conclusions drawn from the choice data. Again, an ANOVA for repeated measures revealed substantial main effects of both factors and an interaction were significant. We will report results concerning the main effects first and then give details on the interaction effect. (1) The main effect for recognition/knowledge of the large population animal was very large, $F(2,40) = 23.0$,

$p < .001$, $\eta^2 = .54$. Judgments were generally fast when participants had knowledge about the population of the large-population animal (*M* = 1343 ms, *SE* = 54; cp. the three rightmost columns in Figure 1b) and slower when they did not recognize it (*M* = 1526 ms, *SE* = 64; cp. the three leftmost columns in Figure 1b) or had no knowledge about it (*M* = 1573 ms, *SE* = 76; cp. the three middle columns in Figure 1b). (2) The main effect for recognition/knowledge of the small population animal was also large, $F(2,40) = 10.8$, $p < .001$, $\eta^2 = .35$. Similarly to the results reported previously, judgments were fast when participants had knowledge about the population of the small-population animal (*M* = 1369 ms, *SE* = 58; cp. the white columns in Figure 1b) and slower when they did not recognize it (*M* = 1528 ms, *SE* = 64; cp. the black columns in Figure 1b) or had no knowledge about its population (*M* = 1545 ms, *SE* = 73; cp. the hatched columns in Figure 1b). (3) Both main effects were qualified further by a large interaction effect, $F(4,38) = 6.6$, $p < .001$, $\eta^2 = .41$. When participants did not recognize the large-population animal, judgments were slowest when they also did not recognize the small-population animal (*M* = 1697 ms, *SE* = 83), faster when they recognized the small-population animal (*M* = 1496 ms, *SE* = 65), and fastest when they had knowledge about the population size of the small-population animal (*M* = 1384 ms, *SE* = 64), with $F(2,40) = 14.2$, $p < .001$, $\eta^2 = .41$, for the simple main effect. When participants recognized the large-population animal, judgments were slowest when they also recognized the small-population animal (*M* = 1717 ms, *SE* = 105), and faster when they either did not recognize the small-population animal (*M* = 1525 ms, *SE* = 67) or had knowledge about its population size (*M* = 1477 ms, *SE* = 70), with $F(2,40) = 7.7$, $p < .01$, $\eta^2 = .28$. When participants had knowledge about the population size of the large-population animal, a comparable pattern emerged. Judgments were slowest when participants simply recognized the small population animal (*M* = 1422 ms, *SE* = 67), they were slightly faster when they did not recognize it (*M* = 1362 ms, *SE* = 59), and fastest when they had knowledge about its population size (*M* = 1246 ms, *SE* = 53).

In sum, the more discriminating information was available, the faster the decisions were. The slowest decisions were found in the two conditions where neither recognition nor knowledge about population size could be used as a basis for the decision, i.e. when both animals were unrecognized or when both animals were recognized but participants had no knowledge about their population sizes. These are cases where neither an application of the recognition heuristic nor a cue-based decision was possible. The fastest decisions, in contrast, were made when participants had knowledge about the population sizes of both the small-population animal and the large-population animal, i.e. when information for a recognition-plus-cue-based decision was available. Whereas these results are at odds with the assumption that a fast and frugal recognition heuristic was operative, they are consistent with the notion that decisions were based on recognition as well as on available knowledge about the animals' population sizes.

Despite its clear findings, Experiment 1 suffers from at least one limitation which is due to the judgment domain under study. The recognition validity for inferences concerning animal populations is possibly low, and since the criterion values themselves are hard to estimate, it might even be impossible to determine the recognition validity at all. As a consequence, Experiment 1 might be an adequate test only of Goldstein and Gigerenzer's (2002) strong descriptive claim that the recognition heuristic is applied in paired comparisons whenever one alternative is recognized and the other is not. It is not an adequate test, however, for the weaker claim that people use the recognition heuristic whenever recognition discriminates *and* it is normatively justified, i.e. ecologically rational, to apply the recognition heuristic. The weaker, but not the strong claim would be compatible with Newell and Shank's (2004) finding that people are sensitive to the recognition validity in a given domain. To overcome this limitation of

Experiment 1, both of the following experiments were based on domains where the recognition validity is medium or high.

Experiment 2: Additive Compensation of Recognition Effects in Decision Making

With the (hypothetical) scenario of choosing a safe airline when booking a flight, Experiment 2 extends the focus to decision making in a naturalistic domain where a medium validity of recognition for inferences concerning the unknown criterion may be supposed. Again, an experimental design was combined with realistic stimuli. Thus, similar to the preceding experiment, Experiment 2 should fit in with the ecological grounding of the recognition heuristic and enable a fair test of its assumed non-compensatory nature. Instead of a single global cue, we varied the values of three distinct cues which were selected for their subjective validity. In this way, a more detailed investigation of the non-compensatory nature of the recognition heuristic was possible. If Goldstein and Gigerenzer (1999, 2002) were wrong and recognition was (partly) compensated by decision-relevant cues, these compensatory effects should be strictly additive: The preference for recognized objects should decrease monotonically with the number of negative cues, i.e. cues which are incongruent with recognition. Again, in addition to participants' choices decision latencies were recorded. For these data, the predictions parallel those of Experiment 1. The purported fast and frugal character of the recognition heuristic implies quick decisions whenever the heuristic is applied, and the latencies of these decisions should not be affected by the number of positive or negative cues in any way. If recognition is used in a compensatory manner, in contrast, the presence of negative cues is supposed to slow down decisions because the negative knowledge cues and positive recognition information have to be balanced in order to reach a decision.

Method

Participants. Thirty-two psychology undergraduates (22 women and 10 men) participated in Experiment 2.

Recognition validity in predicting airline safety. We obtained normative recognition data for the 100 largest airlines in the world (according to the number of revenue passenger kilometers in 2003, Air Transport World Magazine, 2004) to establish the validity of recognition in predicting airline safety. Participants (29 psychology undergraduates) were drawn from the same population as (but were not identical to) our experimental samples. When year established was controlled for, there was a correlation of -.28 ($p < .01$, one-tailed) between the recognition rates of airlines and the number of passenger kilometers per fatality between 1973 and 2001 (Jet Airliner Crash Data Evaluation Centre, 2004), indicating a substantial validity of recognition for the prediction of airline safety. (Given the fact that flight accidents are rare incidents, the year in which an airline is established must be controlled for when past accidents are used as an indicator of future safety. This is because the older the airline, the more likely it is that planes of this particular airline have been involved in an accident).

Materials. The stimuli used in Experiment 2 were selected on the basis of two pilot studies and objective statistical data. The main objective of the first pilot study was to identify cues with a high subjective validity for the prediction of airline safety. We asked participants (32 psychology undergraduates not identical to the experimental sample) to list all cues which came to their minds, and then rate its perceived validity for the prediction of airline safety on a scale from 0 to 1. The three cues mentioned most consistently by the participants were the economic status of the airline's home country (mentioned by 45%, mean subjective validity: $M = .72$, $SD = 0.12$), the general reputation of the airline (84%, $M = .67$, $SD = 0.13$), and past accidents with one of the airline's planes involved (48%, $M = .32$, $SD = 0.17$). In addition, participants wrote down the names of all of the airlines they could remember. In the second pilot study, the names of these airlines as well as airlines not mentioned by any participant of the first pilot study were presented to a new sample of participants (13 psychology undergraduates). The aims of the second pilot study were (a) to select airlines with a high and a low probability of being recognized, and (b) to obtain normative ratings of the airline's general reputation, one of the cues consistently mentioned in the first pilot study. Values for the two other cues, economic status of the airline's home country and past accidents, were derived from statistical databases. As an indicator for economic status, we selected the gross national product per capita for 2001 (United Nations Statistics Division, 2004). As an indicator for past accidents, we chose the number of passenger kilometers per fatality between 1973 and 2001 (Jet Airliner Crash Data Evaluation Centre, 2004). Based on these data and on the results of the pilot studies, 20 airlines were selected to be included as stimuli in Experiment 2 (see Appendix B). Out of these 20 airlines, (1) four airlines had not been recognized by any participant of the second pilot study (*unrecognized airline*), (2) four airlines had been recognized by the majority of participants and all three cues indicated a high safety (above the upper quartile of the cue distribution) of the airline (*positive/positive/positive*), (3) for four airlines, one cue with a high subjective validity (reputation) indicated a low safety (below the lower quartile of the cue distribution) whereas the other two cues (economic status and number of past accidents) indicated a high safety (*negative/positive/positive*), (4) for four airlines, one cue with a high subjective validity (reputation) indicated a high safety whereas the other two cues indicated a low safety (*positive/negative/negative*), and (5) for four airlines, all three cues indicated a low safety of the airline (*negative/negative/negative*).

Procedure and design. Presentation of stimuli and recording of responses and response latencies were controlled by E-Prime (Schneider et al., 2002). The experiment consisted of a study phase and a judgment phase. In the *study phase*, the names of the sixteen airlines recognized by the majority of the participants of the pilot study were presented one by one (in randomized order), along with the values of the three cues with the highest subjective validity in binary form (e.g., general reputation: high/low). Participants were told that the gross national product of the airline's home country was the cue with the highest validity, followed by general reputation and the amount of past accidents. Participants' task was to memorize the information presented about each airline carefully. They were able to move on to the presentation of information on the next airline by pressing a key. The cue information was presented in two blocks of eight airlines which were displayed in randomized order. After each block, the recently learned information was tested by 24 questions of the form "Does cue X have a *low* or a *high* value for airline Y?" The questions were presented in randomized order. Participants provided their answers by pressing one of two response keys. They received feedback on the accuracy and speed of their responses. Both accuracy and speed were consistently high (accuracy of responses: $M = .85$, $SD = 0.07$; latency: $M = 2340$ ms, $SD = 586$), indicating that all participants had learned the cue information well. In the subsequent *judgment phase*, participants were presented pairs of airline names with the task to choose the safer airline out of each pair. They were asked to keep the scenario in mind that they were to book a flight and wanted to choose an airline which was as safe as possible, but were required to make their decision as fast as possible. There were 190 paired comparisons consisting of all possible combinations of the 20 airlines with each other. Accordingly, 5 X 6 comparisons were done for pairs of airlines that belonged to the same type (e.g., unrecognized vs. unrecognized, or positive/negative/negative vs. positive/negative/negative), and 10 X 16 comparisons were done for pairs of airlines that belonged to different types (e.g., unrecognized vs. positive/negative/negative, or positive/negative/negative vs. negative/positive/positive). Here, only results for the comparisons with one recognized and one unrecognized airline are reported because these data are informative with regard to the recognition heuristic (additional results are provided as supplementary online material). The order of pairs and the order of airline names within each pair were randomized across participants.

Results and Discussion

Choice data. The proportion of choices of the unrecognized airline increased markedly and monotonically with the number of negative cues for the known alternative, from a mean proportion of .02 (*SE* = .01) when the recognized airline had three positive cues to a mean proportion of .33 (*SE* = .05) when the known airline had three negative cues (Figure 2a). A one-factorial repeated measures ANOVA was performed on the arcsine-transformed proportions. There was a large effect for the number of positive cues of the recognized alternative, $F(3,29) = 28.2$, $p < .001$, $\eta^2 = .75$. Repeated contrasts revealed that the proportions of adjacent levels (three vs. two positive cues, two vs. one positive cue(s), and one vs. no positive cue) were different from each other (for all three contrasts: $p < .05$, $\eta^2 > .17$). Thus, the choice data corroborate the hypothesis that participants did indeed attend to the number of positive cues for the recognized alternative. But even when the recognized alternative had no positive cue at all, there was a higher proportion of choices for the recognized airline (.66) than for the unrecognized one (.33). These proportions differ significantly from .50 ($p < .05$), i.e. the expected proportion under the assumption that decisions are completely at random. Obviously, participants still adhered to recognition when all cues of the recognized airline were negative. A possible cause for the persistent recognition effect might be the substantial recognition validity in the environment used in Experiment 2. In line with the results of Newell and Shanks (2004) and in contrast to the approach of fast and frugal heuristics, it seems plausible to assume that participants were sensitive to the validity of recognition in different environments and, thus, weigh recognition according to its (perceived) high validity. Taken together, the results suggest that recognition was used as one (albeit important) cue among others.

Decision latencies. Decision latencies were checked for potential outliers, and latencies which departed more than two standard deviations from the person mean (less than 0.5% of all latencies) were eliminated from further analyses. Similar to the proportion of choices for the unrecognized airline, the decision latencies increased monotonically with the number of negative cues for the known alternative, from a mean latency of 951 ms (SE = 37) when the recognized airline had three positive cues to a mean latency of 1465 ms (SE = 86) when the recognized airline had three negative cues (Figure 2b). A one-factorial repeated measures ANOVA revealed a large effect for the number of positive cues, $F(3,29) = 75.5$, $p < .001$, $\eta^2 = .71$. In repeated contrasts, the difference between pairs containing an airline with three positive cues and pairs containing an airline with two positive cues was significant, $F(1,31) = 50.3$, $p < .001$, $\eta^2 = .61$. There was also a medium difference between pairs containing an airline with one positive cue and pairs containing an airline with no positive cues, $F(1,31) = 3.2$, $p < .10$, $\eta^2 = .09$. The difference between pairs containing an airline with two positive cues and pairs containing an airline with one positive cue was not significant, $F(1,31) < 1.0$. In sum, decisions were slowed by the presence of negative cues which contradicted the recognition information, a result which is not consistent with the assumption that participants applied a fast and frugal recognition heuristic without considering further knowledge about the recognized alternative.

To conclude, choices and decision latencies provide converging evidence for a compensatory use of recognition in a domain where recognition is a valid predictor for the attribute in question. Thus, the results of the present experiment stand in contrast to the results reported by Goldstein and Gigerenzer (2002, study 3) which seem to suggest a non-compensatory use of recognition. How may these contradicting results be explained? Owing to the fact that unlike Goldstein and Gigerenzer's study, Experiment 2 used airline safety and not city sizes as the to-be-inferred criterion, the contradicting results might be attributable to peculiarities of the judgment domains under study. To rule out this possibility, we conducted a third experiment which employed a variant of the original city size task.

Experiment 3: Compensation of Recognition Effects in the City-Size Task

Experiment 3 resembled closely the original study which Goldstein and Gigerenzer (2002, study 3) reported as evidence for the assumed non-compensatory use of recognition in judgments of unknown quantities. German university students worked on a city-size task with stimuli taken from the population of the largest cities in the USA, an environment where the validity of recognition is high. Just like the participants in Goldstein and Gigerenzer's study, our participants learned the values of a binary cue with high knowledge validity. Apart from these commonalities, however, we attempted to improve the design of the original study in three relevant respects. First, we varied experimentally not only the judgment-relevant cues, but also the recognition of the stimuli in the city-size task. Second, we took care that participants learned cue values only for those cities which, in all probability, they would already have recognized before the experiment. By this means, the recognition manipulation was strengthened, allowing a quite conservative test of the recognition heuristic. Third, we manipulated a knowledge cue which was not only objectively valid for inferences concerning city sizes, but which was also perceived as a valid cue by members of the student population which the experimental sample was drawn from.

Method

Participants. Participants were 28 undergraduates with various majors at the University of Cologne (11 women and 17 men).

Materials. The stimuli used in Experiment 3 were taken from the population of all 136 cities in the USA with a population of more than 150,000 inhabitants. We conducted a pilot study (a) to identify a cue with a high subjective validity for inferences concerning city sizes, and (b) to select those cities which are recognized and those cities which are not recognized by most members of the student population which our sample was drawn from. In the first part of the pilot study, participants (16 undergraduates not identical to the experimental sample) rated the validity of six binary cues for paired comparisons in a city-size task with US cities. For each cue, they were asked to estimate the percentage of correct judgments in pairs where the cue discriminated. The cues were similar to those which Gigerenzer et al. (1996) used in their simulations for the German city size-task, and all six had a medium to high recognition validity (e.g., international airport, baseball team in the Major League, football team in the National Football League). The information whether a city hosts an international airport received the highest validity ratings (mean subjective validity on a percentage scale: $M = 82$, $SD = 12$). The objective knowledge validity of this cue is .71 ($p < .001$, one-tailed; biserial rank correlation with the population size ranks of the 136 largest US cities). In the second part of the pilot study, participants indicated for each of the 136 largest cities in the USA (listed in alphabetical order) if they had ever heard or read of it before (mean recognition rates: $M = .46$, $SD = .38$). The recognition rates were strongly correlated with the population rank of the 136 cities. The rank correlation was -.56 ($p < .001$, one-tailed), indicating that the recognition validity for this environment and the population which our participants were drawn from was high. Based on the data of the pilot study, we drew samples of (1) eight cities which were recognized by no participant of the pilot study (*low recognition rate*), (2) four cities which were recognized by all participants and host an international airport (*positive cue information*), (3) four cities which were recognized by all participants and do not host an international airport (*negative cue information*), and (3) a sample of four more cities which were recognized by all participants, with two cities with and two cities without an international airport (see Appendix C for a complete list of stimuli). We classified a city as hosting an international airport if it had an airport which was listed by the Federal Aviation Administration (2005) as serving international operations with scheduled passenger service in large aircrafts.

Procedure and design. Participants were presented a booklet that consisted of three consecutive parts: a learning task, a paired-comparisons city-size task, and a manipulation check. (1) In the first part, participants learned that the four cities of the first stimulus category host an international airport (positive cue information) and that the four cities in the second category do not host an international airport (negative cue information). The eight cities and the corresponding cue information were listed in alphabetical order on the first sheet of the booklet. Participants were instructed to memorize the cue information thoroughly. In addition, they were told that 34% of all US cities with more than 150,000 inhabitants host an international airport. They were also told that when two US cities are compared, those with an international airport will often be larger than those without an international airport, i.e. that the airport information is a highly valid cue in the city-size task. On the next sheet of the booklet, participants were asked to write down the four cities with an international airport and the four without one. They should go back to the first page in case they felt their memory of the cue information was inaccurate. (2) The second part consisted of the city-size task with 190 paired comparisons between all the 20 cities selected as stimuli. Among the 190 paired comparisons, there were 32 (8 X 4) comparisons between cities with a low recognition rate and cities with positive cue information, 32 comparisons between cities with a low recognition rate and cities with negative cue information, and 32 comparisons between cities with a low recognition rate and well recognized cities for which no cue information was given. Four different versions of the experimental materials were constructed and counterbalanced across participants, with two different randomly determined sequences of city pairs and two different orders of cities within the pairs. (3) In the third part of the experiment, participants were asked to indicate for each of the 20 cities used as stimuli (1) whether they had ever heard of the city before the experiment (manipulation check for the recognition manipulation) and (2) on a separate sheet whether the city had an international airport or not (manipulation check for the knowledge cue manipulation). For both tasks, the city names were listed alphabetically. The results of the manipulation checks supported the validity of the manipulations used. The participants of the experimental sample indicated for most of the stimuli selected for their high recognition rate that they had heard of the city before the experiment (recognition rates: $M = .95$, $SD = .08$), whereas they indicated for most of the stimuli selected for their low recognition rate that they had never heard of the city before (recognition rates: $M = .13$, $SD = .18$). Accuracy of responses to the airport cue questions was consistently high for the cities which were presented in the learning phase ($M = .91$, $SD = .15$). It was considerably lower for the cities which had a high recognition rate and for which no cue information was given ($M = .34$, $SD = .30$). For these cities, the majority of participants ($M = .56$, $SD = .40$) indicated that they did not know whether the city has an international airport or not.

Results and Discussion

The proportion of choices of the unrecognized city was near zero in pairs where the known alternative was associated with positive cue information ($M = .02$, $SE = .01$). It was higher when no cue information was given ($M = .06$, $SE = .01$), and it was highest when the known alternative was associated with negative cue information ($M = .18$, $SE = .05$). A one-factorial repeated measures ANOVA performed on the arcsine-transformed proportions revealed a large effect for the cue manipulation, $F(2,23) = 13.3$, $p < .001$, $\eta^2 = .54$. Repeated contrasts revealed that the proportions of adjacent levels (positive vs. no cue, no cue vs. negative cue) were different from each other (for all three contrasts: $p < .05$, $\eta^2 > .18$). Neither the sequence of pairs nor the order of cities within pairs had any significant effect (for all main and interaction effects: $F < 1.2$, $p > .34$). Compared to the results obtained by Goldstein and Gigerenzer (2002, study 3), considerably less choices in the critical condition were consistent with the recognition heuristic (82% in our study versus 92% in Goldstein & Gigerenzer, 2002). More importantly, this proportion was much lower than in pairs where the recognized alternative was associated with positive cues (difference 16%), and it was also lower than in pairs were no cue information was given (difference 12%). Stated differently, when knowledge cue and recognition information conflicted, a considerable proportion of choices were consistent with the knowledge cue but inconsistent with the recognition information.

Thus, in agreement with the results obtained by Goldstein and Gigerenzer (2002, study 3), recognition seemed to play a major role in the city-size task used in the present experiment. Contrary to the conclusions drawn from the original study, however, our results support the view that recognition information and the airport cue were integrated to infer which one out of two cities was larger – at least in a substantial number of judgments. Apart from an experimental manipulation of recognition, Experiment 3 differed from Goldstein and Gigerenzer's (2002) original study primarily in the kind of knowledge cue which was employed to investigate compensatory effects. With the airport cue, we employed a cue which is not only an objectively valid predictor of city sizes, but which is also subjectively valid from the participants' point of view. It might well be that the participants in the original study did not use the soccer team cue they learned because despite the experimental instructions, they did not feel that soccer teams are strongly related to city sizes.

General Discussion

Three experiments with paired comparisons were conducted to test the recognition heuristic's defining characteristic that recognition is used in a non-compensatory manner when entities are to be selected according to a quantitative criterion whose values are not known to the individual (Goldstein & Gigerenzer, 2002). Although the experiments were carefully designed to take into account the ecological, correspondence view of rationality which has motivated the theoretical development of the recognition heuristic, no evidence was found in favor of a non-compensatory use of recognition. On the contrary, all three experiments yielded clear evidence for the alternative assumption that recognition information is integrated with knowledge about the recognized alternative when the other alternative is unrecognized. Experiment 1 employed a paired-comparison task similar to the original city-size task used by Goldstein and Gigerenzer (1999, 2002), with population sizes of animal species as the to-be-inferred criterion. Although recognition influenced choices in pairs with one recognized and one unrecognized alternative, participants considered task-relevant knowledge about the recognized animal as well. In a considerable proportion of pairs, knowledge was able to offset the influence of recognition, a clear indication of a compensatory use of recognition. When recognition and knowledge consistently pointed to the same alternative, judgments were perspicuously faster than in pairs with inconsistent combinations of recognition and knowledge. Experiment 2 was based on a naturalistic decision task in a domain where a medium recognition validity may be expected. The safer one out of two airlines had to be selected, and recognition and values of three different knowledge cues were varied. In line with the results of Experiment 1, recognition as well as knowledge about the recognized alternative contributed to decisions. Knowledge partly compensated for recognition effects and the proportion of decisions in favor of the recognized alternative decreased markedly and monotonically with the number of negative knowledge cues. Again, decision latencies supported the view that participants pondered recognition information and knowledge cues rather than used recognition in a fast and frugal way. Experiment 3 demonstrated compensatory effects of recognition and knowledge in a city-size task with US cities and German participants, i.e. with a domain and task very similar to the study by Goldstein and Gigerenzer (2002, study 3) which has been conducted to support the assumption of a non-compensatory use of recognition.

What do these results mean for the validity of the recognition heuristic as an adaptive tool in judgment and decision making? First of all, the recognition heuristic is not as universally applied a mechanism as described by Goldstein and Gigerenzer (1999, 2002). This is not to say that recognition does not play a role in judgment and decision making. Similar to the studies conducted by proponents of the research program on fast and frugal heuristics, the present experiments found strong recognition effects. But in line with other previous studies (Newell & Shanks, 2004; Oppenheimer, 2003), the present results demonstrate that people do not always rely on recognition blindly whenever it discriminates between two alternatives. Rather, they consider additional information and integrate this information with knowledge about the recognized alternative. In this respect, the experiments reported here provide stronger evidence than the single study conducted so far which demonstrated a non-compensatory use of recognition (Goldstein and Gigerenzer, 2002, Study 3) because recognition was varied experimentally and independent of task-relevant knowledge.

The conclusion that the recognition heuristic is not universally applied leaves us with the question whether there are situations in which people use recognition in a non-compensatory way, and if so, which factors yield a non-compensatory use of recognition. Despite the theoretical plausibility of the recognition heuristic's adaptive value, even the general question whether the recognition heuristic has any psychological reality at all has not been answered yet because the non-experimental studies demonstrating its application leave ample room for alternative explanations (for example, recognition might be confounded with other cues, Oppenheimer, 2003). If recognition is used in non-compensatory fashion at all, a synopsis of the existing studies suggests that the perceived validity of knowledge cues might moderate the use of these cues against recognition information. Recent work by McCloy and Beaman (2004) demonstrated for stimuli from Oppenheimer's (2003) study that the proportion of choices consistent with the recognition heuristic increases when participants are put under time pressure. So it remains a possibility that people use indeed a fast and frugal recognition heuristic when they are forced to make their judgment very quickly. More experimental research has been conducted on another non-compensatory heuristic from the adaptive toolbox, the take-the-best heuristic (Gigerenzer & Goldstein, 1996, 1999). These experiments suggest that similar to the recognition heuristic, application of the take-the-best heuristic is not guided by simple stopping rules. Instead, people seem to be able to switch adaptively between take-the-best and compensatory decision strategies according to the payoff-structure of the environment, with intelligence moderating the amount of strategy switching (Bröder, 2003). Other factors influencing the use of the take-the-best heuristic seem to be the cost for acquiring knowledge necessary for applying a compensatory decision strategy (Bröder, 2000; Newell & Shanks, 2003) and the format in which the task-relevant information is represented (Bröder & Schiffer, 2003). All of these studies also report large inter-individual variability in strategy use. These findings have led to the proposal of unifying models which do not regard simple, "one-reason" decisions as qualitatively different to decisions which rely on more complex knowledge (Lee & Cummins, 2004; Newell, 2005). Rather, the unifying models conceptualize judgments and decision making as the accumulation of evidence which is based on sequential sampling of information. The accumulation of evidence continues until a threshold is reached (evidence accrual threshold). Due to the fact that the threshold may vary within and between individuals, simple as well as complex judgments and decisions may be modeled within one single framework. Newell (2005) has proposed the metaphor of a continuously adjustable spanner to replace the metaphor of an adaptive toolbox. Whereas the results reported here are not consistent with the adaptive toolbox and its simple stopping rules, they would be well compatible with an adjustable spanner model that projects judgments and decisions on a continuum from simple (low threshold) to complex (high threshold). In contrast to the adaptive toolbox of fast and frugal heuristics, such a model would allow for a compensatory use of recognition.

Two limitations of this theoretical interpretation must be noted. The first one is that the results reported here are in principle compatible with other compensatory models of judgment as well. However, since adjustable spanner models are able to handle incomplete data quite flexibly, they are slightly more attractive than traditional compensatory models such as multiple regression. Whenever recognition information and knowledge cues are integrated to reach a judgment, the available data are incomplete because the cue values for unrecognized entities are not known to the individual who makes the judgment. The second limitation is that adjustable spanner models do not imply predictions concerning factors which may be expected to adjust the evidence accrual threshold and thereby the complexity of a given decision. Even though there are some well-conducted experimental studies investigating the use of take-the-best vs. compensatory strategies, comparable studies investigating pure recognition vs. recognition-plus-knowledge strategies are still lacking. A good starting point for future research on the use of recognition in judgment and decision making would be experiments varying those factors which turned out to discriminate between one-reason and more complex decision making. Here, the unifying view that underlies the adjustable spanner models would predict that a compensatory use of recognition should occur under conditions similar to those which promote a compensatory use of knowledge.

References

Air Transport World Magazine (2004). *World airline traffic results 2003* [online document]. Retrieved August 21, 2005, from http://www.atwonline.com/channels/dataAirlineEconomics/world_airline_report_2003.pdf

Borges, B., Goldstein, D.G., Ortmann, A., & Gigerenzer, G. (1999). Can ignorance beat the stock market? In G. Gigerenzer, P. M. Todd, & ABC Research Group (Eds.), *Simple heuristics that make us smart* (pp. 59-72). London: Oxford University Press.

Boyd, M. (2001). On ignorance, intuition, and investing: A bear market test of the recognition heuristic. *The Journal of Psychology and Financial Markets, 2*, 150-156.

Brehmer, B. (1994). The psychology of linear judgment models. *Acta Psychologica, 87*, 137-154.

Bröder, A. (2000). Assessing the empirical validity of the “Take-the-best” heuristic as a model of human probabilistic inference. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1332-1346.

Bröder, A. (2003). Decision making with the “adaptive toolbox”: Influence of environmental structure, intelligence, and working memory load. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 611-625.

Bröder, A., & Schiffer, S. (2003). Take The Best versus simultaneous feature matching: Probabilistic inference from memory and effects of representation format. *Journal of Experimental Psychology: General, 132*, 277-293.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mawah, NJ: Erlbaum.

Dawes, R.M., & Corrigan, B. (1974). Linear models in decision making. *Psychological Bulletin, 81*, 97-106.

Federal Aviation Administration (2005). *International flight information manual* [online document]. Retrieved July 13, 2005, from http://www.faa.gov/ATs/aat/ifim/index.htm

Gigerenzer, G., & Hoffrage, U. (1995). How to improve Bayesian reasoning without instruction: Frequency formats. *Psychological Review, 102*, 684-704.

Gigerenzer, G., Todd, P.M., & the ABC Research Group (1999). *Simple heuristics that make us smart*. Oxford: Oxford University Press.

Gigerenzer, G., & Goldstein, D.G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review, 104*, 650-669.

Gigerenzer, G., & Goldstein, D.G. (1999). Betting on one good reason: The take the best heuristic. In G. Gigerenzer, P.M. Todd, & the ABC Research Group (Eds.), *Simple heuristics that make us smart* (pp. 75-95). New York: Oxford University Press.

Gigerenzer, G., & Todd, P.M. (1999). Fast and frugal heuristics: The adaptive toolbox. In G. Gigerenzer, P. M. Todd, & ABC Research Group (Eds.), *Simple heuristics that make us smart* (pp. 3-34). London: Oxford University Press.

Goldstein, D.G., & Gigerenzer, G. (1999). The recognition heuristic: How ignorance makes us smart. In G. Gigerenzer, P. M. Todd, & ABC Research Group (Eds.), *Simple heuristics that make us smart* (pp. 37-58). London: Oxford University Press.

Goldstein, D.G., & Gigerenzer, G. (2002). Models of ecological rationality: The recognition heuristic. *Psychological Review, 109*, 75-90.

Hammond, K.R. (2000). Coherence and correspondence theories in judgment and decision making. In T. Connolly, H.R. Arkes & K.R. Hammond (Eds.), *Judgment and decision making: An interdisciplinary reader* (2nd ed., pp. 53-65). New York: Cambridge University Press.

International Union for the Conservation of Nature (2004). *2004 IUCN red list of threatened species* [online document]. Retrieved November 23, 2004, from http://www.redlist.org

Jet Airliner Crash Data Evaluation Centre (2004). *JACDEC Airliner safety statistics: Part II, major airlines* [online document]. Retrieved November 23, 2004, from http://www.jacdec.de/

Lee, M.D., & Cummins, T.D.R. (2004). Evidence accumulation in decision making: Unifying the "take the best" and the "rational" models. *Psychonomic Bulletin & Review, 11*, 343-352.

McCloy, R., & Beaman, C.P. (2004). The recognition heuristic: Fast and frugal, but not as simple as it seems [online document]. In *Proceedings of the 26th Meeting of the Cognitive Science Society*. Retrieved July 11, 2005, from http://www.cogsci.northwestern.edu/cogsci2004/papers/paper327.pdf

Newell, B.R. (2005). Re-visions of rationality? *Trends in Cognitive Sciences, 9*, 11-15.

Newell, B.R., & Shanks, D.R. (2003). Take the best or look at the rest? Factors influencing "one-reason" decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 53-65.

Newell, B.R., & Shanks, D.R. (2004). On the role of recognition in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*, 923-935.

Oppenheimer, D.M. (2003). Not so fast! (and not so frugal): Rethinking the recognition heuristic. *Cognition, 90*, B1-B9.

Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburgh, PA: Psychology Software Tools.

Schwarz, N., Bless, H., Strack, F., Klumpp, G., Rittenauer-Schatka, H., & Simons, A. (1991). Ease of retrieval as information: Another look at the availability heuristic. *Journal of Personality and Social Psychology, 61*, 195-202.

United Nations Statistics Division (2004). *Gross Domestic Product per capita, current prices, US$, current prices* (series code no. 19510) [online document]. Retrieved November 23, 2004, from http://unstats.un.org/unsd/cdb/cdb_series_xrxx.asp?series_code=19510

Author note

Tobias Richter, University of Cologne; Pamela Späth, University of Cologne

We would like to thank Nina Keith for a critical reading of an earlier version of this manuscript and Daniela Ahrens, Ruth Bönisch, Vasilena Lilkova, and Kareen Portz for their help in data collection for Experiment 1.

Mailing address:

Tobias Richter

University of Cologne

Department of Psychology, General Psychology

Herbert-Lewin-Straße 2

D-50931 Köln

Germany

E-mail: tobias.richter@uni-koeln.de

Appendix A: Names of animal species used as stimuli in Experiment 1

(The actual stimuli were German common animal names.)

Small population, unrecognized:

Corn crake (Crex crex)

Hainan partridge (Arborophila ardens)

Magnificent quetzal (Pharomachrus mocinno)

Striped civet (Fossa fossana)

Large population, unrecognized:

Asp (Aspius aspius)

Mottled umber (Erannis defoliaria)

Pill millipede (Glomeris marginata)

White bream (Blicca bjoerkna)

Small population, recognized, no knowledge about population size:

Cuckoo (Cuculus canorus)

Orang-utan (Pongo pygmaeus)

Otter (Lutra lutra)

Wolf (Canis lupus)

Large population, recognized, no knowledge about population size:

Arctic hare (Lepus arcticus)

Eurasian crane (Grus grus)

Piranha (Pygocentrus cariba)

Red fox (Vulpes vulpes)

Small population, recognized, knowledge of population size:

Blue whale (Balaenoptera musculus)

Giant panda (Ailuropoda melanoleuca)

Siberian tiger (Panthera tigris altaica)

White-tailed eagle (Haliaeetus albicilla)

Large population, recognized, knowledge of population size:

Black bird (Turdus merula)

German shepherd dog (Alsatian dog)

Guinea pig (Cavia porcellus)

Wood louse (Oniscus porcellio)

Appendix B: Names of airlines used as stimuli in Experiment 2

Unrecognized airlines:

Wideroes

Braathens

Biman

Avianca

Three positive cues:

Air Berlin

Deutsche BA

Hapag Lloyd

Ryanair

One negative, two positive cues:

Finnair

Austral Lineas Aereas

Kuwait Airways

Gulf Air

One positive, two negative cues:

Turkish Airlines

Egypt Air

Aeroflot

Air India

Three negative cues:

Malev

Tarom

TAM

Aerolineas Argentinas

Appendix C: Names of US cities used as stimuli in Experiment 3

Unrecognized cities:

Chandler, AZ

Glendale, AZ

Lexington-Fayette, KY

Nashville-Davidson, TN

Plano, TX

Shreveport, LA

Spokane, WA

Wichita, KS

Recognized cities with an international airport (positive cue information given):

Atlanta, GA

Cleveland, OH

Dallas, TX

Indianapolis, IN

Recognized cities without an international airport (negative cue information given):

Austin, TX

Buffalo, NY

Colorado Springs, CO

Long Beach, CA

Additional recognized cities (no cue information given):

Boston, MA

Oklahoma City, OK

Sacramento, CA

San Diego, CA

Figure Captions

Figure 1. (a) Mean proportions of choices of the animal species with a larger population (correct choices) and (b) decision latencies in paired comparisons of animal species with large and small populations. (The error bars represent the standard error of the mean.)

Figure 2. (a) Mean proportions of choices of the unrecognized airline (*U*) and (b) decision latencies in paired comparisons of choices of the unrecognized airline (*U*) to alternatives with three positive cues (*PPP*), one negative and two positive cues (*NPP*), one positive and two negative cues (*PNN*), and three negative cues (*NNN*). (The error bars represent the standard error of the mean.)