**Preprints of the
Max Planck Institute for
Research on Collective Goods
Bonn 2009/10**

How Distinct are Intuition and Deliberation? An Eye-Tracking Analysis of Instruction-Induced Decision Modes

Nina Horstmann
Andrea Ahlgrimm
Andreas Glöckner

MAX PLANCK SOCIETY

Preprints of the
Max Planck Institute
for Research on Collective Goods
Bonn 2009/10

How Distinct are Intuition and Deliberation? An Eye-Tracking Analysis of Instruction-Induced Decision Modes

Nina Horstmann / Andrea Ahlgrimm / Andreas Glöckner

März 2009

Max Planck Institute for Research on Collective Goods, Kurt-Schumacher-Str. 10, D-53113 Bonn
http://www.coll.mpg.de

How Distinct are Intuition and Deliberation?
An Eye-Tracking Analysis of Instruction-Induced Decision Modes

Nina Horstmann, Andrea Ahlgrimm, & Andreas Glöckner*

Abstract

In recent years, numerous studies comparing intuition and deliberation have been published. However, until now relatively little is known about the cognitive processes underlying the two decision modes. Therefore, we analyzed processes of information search and integration using eye-tracking technology. We tested hypotheses derived from dual-process models which postulate that intuition and deliberation are completely distinct processes against predictions of interventionist models. The latter assume that intuitive and deliberate decisions are based on the same basic process which is supplemented by additional processes in the deliberate decision mode. We manipulated decision mode between-participants by means of instructions and participants completed simple and complex city-size tasks as well as complex legal inference tasks. Our findings indicate that the instruction to deliberate does not necessarily increase levels of processing. We found no difference in mean fixation duration and the distribution of short, medium and long fixations. Instruction-induced deliberation led to a higher number of fixations, a more complete information search and more repeated information investigations. Overall, the data support interventionist models suggesting that decisions mainly rely on automatic processes which are supplemented by additional operations in the deliberate decision mode.

Keywords: Decision Making, Decision Mode, Intuition, Deliberation, Eye-Tracking

* Correspondence concerning this paper should be addressed to: Andreas Glöckner, Max Planck Institute for Research on Collective Goods, Kurt-Schumacher-Str. 10, D-53113 Bonn, Germany, Phone: +49-(0) 2 28 / 9 14 16 857, E-mail: gloeckner@coll.mpg.de

Introduction

According to commonly-held assumptions, individuals sometimes make decisions deliberately and sometimes rely on their intuition or gut feeling. Although a distinction between the two types of information processing is now highly accepted in judgment and decision making (JDM) research (for a critical review, see Evans, 2008), relatively little is known about the cognitive or affective processes that underlie them. This is particularly the case for the intuitive decision mode. Different models that rely on automatic processes might be considered to account for intuition. These models range from mainly cognitive evidence accumulation (Busemeyer & Townsend, 1993), sampling (Dougherty, Gettys, & Ogden, 1999; Fiedler, 2008) or network models (Busemeyer & Johnson, 2004; Glöckner & Betsch, 2008b; Holyoak & Simon, 1999) to more affect-based approaches (Damasio, 1994; Finucane, Alhakami, Slovic, & Johnson, 2000). Furthermore, numerous theories modeling the interplay between intuitive and deliberate processes exist. There is a long tradition of dual-process models that postulate a clear distinction between intuition and deliberation. As Kahneman and Frederick (2002) pointed out, "dual-process models come in many flavors, but all distinguish cognitive operations that are quick and associative from others that are slow and rule-governed" (p. 51). For instance, mode selection models imply that there is an initial selection between two rather distinct kinds of processes (Chen & Chaiken, 1999; Petty & Cacioppo, 1986). Other models postulate a concurrent activation of two distinct systems and a kind of competition among them (Sloman, 2002). In contrast, so-called default-interventionist models (Evans, 2007, 2008) state that intuition is always activated first as a default mode and deliberate processes may intervene upon these intuitive processes. In a similar vein, network models argue that automatic processes build the basis of every decision and are only supplemented by deliberate processes if necessary (Glöckner & Betsch, 2008b; cf. Rumelhart, Smolensky, McClelland, & Hinton, 1986). The latter view implies that the processes underlying different modes of decision making might only be partially distinct and that basic automatic processes should be observed in a deliberate decision mode as well. In an early work, Hammond, Hamm, Grassia, and Pearson (1987) already suggested that intuition and deliberation are not completely distinct categories of cognitive processes between which people switch. Rather, they are seen as poles of a cognitive continuum, and task factors influence how far one moves toward one or the other pole. In the present study, we analyzed, on a fine-grained level, how the instruction to decide intuitively or deliberately affects information search and integration using eye-tracking technology. We aimed to show that intuitive and deliberate decisions are not clearly distinct and that the instruction to deliberate does not lead to completely different processes of rule-based decision making, but that deliberation only adds to the automatic processes.

Obviously, many different factors, including the context of the decision task, might influence the selection and processing of decision modes. We focused our investigation on probabilistic inference tasks (e.g., Bröder, 2000), in which judgments are made about options based on a set of dichotomous probabilistic cues that differ in their validity (i.e., predictive accuracy, defined as conditional probability that the option has a higher value on the criterion given a positive cue value; Gigerenzer, Hoffrage, & Kleinbölting, 1991). The structure of probabilistic inference tasks allows for different information integration processes which, in a paramorphic perspective (Hoffman, 1960), can be described by different weighting schemes for cues. According to a lexicographic strategy (LEX, Fishburn, 1974), individuals select the option that is highest on the most valid differentiating cue by weighting this particular cue higher than the sum of all less valid cues. Individuals can also apply an equal weight strategy (EQW, Fishburn, 1974). They decide by counting how many cues speak for each option, and hence implicitly give the same weight to all cues, i.e., ignore their validity. Finally, individuals can weight all cues differently, for instance according to their validity, and integrate them in a weighted additive manner (WADD, Payne, Bettman, & Johnson, 1988). Note that LEX and EQW are of course sub-models of WADD with specific restricted weights (Bröder & Schiffer, 2003a). For the sake of simplicity, we will nevertheless refer to them as separate "strategies" here.

The different cue-weighting schemes are theoretically independent from the application of intuitive or deliberate processes. In line with Hammond et al. (1987), many findings in JDM research indicate that intuition relies on the integration of cues according to a WADD scheme (Doherty & Brehmer, 1997; see also Glöckner & Betsch, 2008a; Glöckner & Betsch, 2008c). As a dissenting opinion it has, however, also been argued that simple heuristics based on LEX or EQW schemes might be the core of intuition (Gigerenzer, 2007): "Good intuitions ignore information. Gut feelings spring from rules of thumb that extract only a few pieces of information from a complex environment (…) and ignore the rest" (p. 38). There is also a controversial debate if and under which circumstances intuition or deliberation lead to 'good' decisions (Acker, 2008; Dijksterhuis, Bos, Nordgren, & van Baaren, 2006). In our investigation, we refrained from continuing this debate on decision quality, but focused on process properties which have been mainly neglected so far.

Fixation Duration and Cognitive Processes

It has been shown that classic decision paradigms such as Mouselab (Payne et al., 1988) sometimes hinder the application of intuitive processes by limiting information search and not allowing for quick comparisons between information (Glöckner & Betsch, 2008c). Eye-tracking is a less intrusive alternative to record information search, which we employed in our study. Moreover, and critically, eye-tracking records single fixation durations. This parameter is a reliable proxy for levels of processing, in that fixation duration increases with increasing levels of processing (Pomplun, Ritter, & Velichkovsky, 1996; see also Rayner, 1998; Velichkovsky, 1999; Velichkovsky, Rothert, Kopf, Dornhofer, & Joos, 2002). In a search-for-a-difference task, Velichkovsky, Challis, and Pomplun (1995) could, for instance, demonstrate that the temporal parameters of eye-movements can be separated into two phases. In an early phase of automatic information search and scanning, participants show mainly short fixations, whereas in a later phase, "when the crucial difference is about to be found, the fixation durations rise to 500 ms and more. […] Obviously, this final phase of visual search can be attributed to some higher level of cognitive processing, which culminates in a conscious decision" (Velichkovsky, 1999, p. 214). For the domain of language processing, Rayner (1998) summarizes in a similar vein that more automatic processes like silent reading lead to shorter fixations than more effortful processes such as typing. Cognitive processes comprising conscious mathematical steps of information integration should therefore go along with long fixations, whereas scanning and automatic processes should mainly produce short fixations. To test this crucial assumption, in a pre-study we instructed participants to deliberately apply a WADD strategy by calculating weighted sums in a city-size task. In line with our hypothesis, long fixations (> 500 ms) occurred very often (see Figure 1). These pre-study results suggest that fixation duration is a reliable parameter for levels of processing also, for the probabilistic inference tasks we employed in our study.

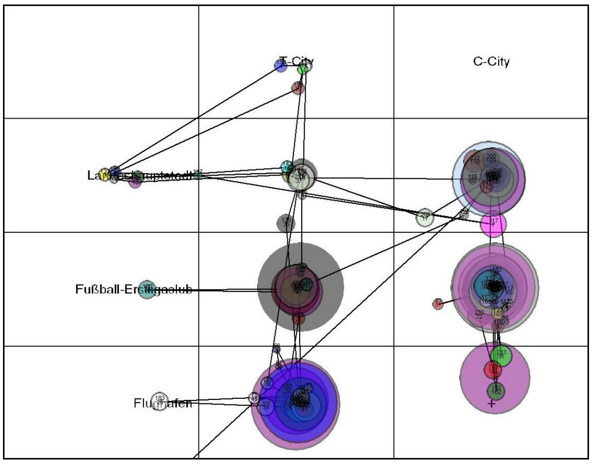

Figure 1. Example of a scanpath for a participant instructed to calculate weighted sums in a simple city-size task. Fixations are illustrated by circles and circle diameter indicates fixation duration. The lines represent saccades.

Detailed Research Questions and Model Predictions

The purpose of our study was to investigate how the instruction to decide intuitively or deliberately affects process parameters of information search and integration. We tested whether intuitive and deliberate decisions induced by instruction are indeed based on very different and separable processes, as implied by traditional dual-processing models: do persons really switch between a deliberate serial and rule-based integration of information as indicated by long fixations, on the one hand, and automatic-intuitive processes that go along with short fixations due to quick holistic information scanning, on the other hand? Or is decision behavior more in line with default-interventionist and network models stating a common automatic process which underlies all kinds of decision making and is only supplemented with additional processing steps in the deliberate decision mode?

As mentioned above, according to traditional dual-process models a clear distinction between intuitive and deliberate decision modes is assumed. Intuitive processes, on the one hand, are described as unconscious, automatic, fast, parallel, effortless, and having a high capacity. Deliberate processes, on the other hand, are thought to be accessible to conscious awareness, slow, sequential, effortful, rule-governed and having a limited capacity (see Evans, 2008).

Hence, in a hypothetical pure deliberate decision mode, information is likely to be investigated in a stepwise manner and it should be directly integrated because of working memory capacity constraints. Such a process would be similar to conscious mathematical calculation that we investigated in our pre-study. In contrast, intuition should be based on less controlled, fast information integration processes. However, default-interventionist models postulate the primacy of intuitive processes which are always activated as a default mode (Evans, 2006; Glöckner & Betsch, 2008b). Network models, in particular, assume that there is not necessarily a clear distinction between decision behavior if individuals are instructed to use one or the other mode. According to these models, a pure deliberate decision mode does not exist. Intuitive automatic processes are always activated in advance and/or simultaneously, and they are only supplemented by additional deliberate processes. Consequently, we expect that persons supposedly deciding "deliberately" do something completely different than integrating information in a serial and rule-based manner or using mathematical calculation: They extend intuitive processes by increasing information search and adding repeated inspections of previously seen information. For reasons of simplicity, we will label the latter class of models "interventionist models".

Taking for granted that individuals comply with instructions to decide intuitively or deliberately, we examined effects on well-established eye-tracking parameters, namely the fixation duration, the number of fixations, and corresponding indices such as the amount of inspected information, the number of repeated information inspections, and the direction of information search as well as information integration strategies. For these dependent measures, we generated the following hypotheses for the traditional dual-process view and for the interventionist models.

Fixation duration. According to classic dual-process models, in a deliberate decision mode individuals should judge or decide in a serial way. Because of working memory capacity constraints, information is likely to be investigated in a stepwise manner and should be directly integrated. Hence, in a pure deliberate decision mode a sequence of long fixations would be expected, similar to the pattern of long fixations we observed in our pre-study when instructing participants to calculate weighted sums. Short fixations should be rare. In contrast, intuition should be based on less controlled, fast information integration processes. Thus, intuitive decisions should go along with predominantly short fixation durations. From an interventionist model perspective, intuitive automatic processes are always activated when making a decision. Deliberation only adds to this basic process and a pure deliberate decision mode does not exist. Because of the underlying automatic processes, short fixations should prevail in both decision modes. Taking into account that supplementary processing steps in the deliberate decision mode could result in longer inspections of single information, a higher number of long fixations might be observed under the instruction to deliberate. However, due to the primacy of automatic processes there should be no dramatic shift in fixation durations under the instruction to decide deliberately as compared to the instruction to decide intuitively.

Number of fixations. To make specific predictions concerning the number of fixations it is useful to distinguish between the amount of inspected information and the number of repeated information inspections, because the number of fixations obviously increases with both factors. As we outline in the following, from a traditional dual-process view the amount of inspected information and the number of repeated information inspections is assumed to be lower in the deliberate decision mode compared to the intuitive decision mode. Therefore, the number of fixations should be lower in a pure deliberate decision mode. In contrast, according to interventionist models, a higher amount of inspected information and a higher number of repeated information inspections are expected under the instruction to deliberate. Consequently, also a higher number of fixations should be observed in the deliberate decision mode.

Amount of inspected information. As postulated by classic dual-process models, the capacity of the deliberate decision mode is limited compared to the intuitive mode. Therefore, the amount of inspected information should be lower under the instruction to deliberate than under the instruction to decide intuitively. Assuming that intuitive and deliberate decision modes build on a similar basic process of quick information search and automatic scanning as postulated by interventionist models, the amount of inspected information should at least be equal in both decision modes. Taking additional processing steps into consideration that extend this basic process, the amount of inspected information could even be higher under the instruction to deliberate.

Repeated information inspections. From a classic dual-process perspective, relatively few repeated information inspections should be observed in the deliberate decision mode because it is assumed that information is searched in a serial manner and is directly integrated. According to interventionist models, intuitive and deliberate decisions are based on a similar basic process which is supplemented by additional processing steps in the deliberate decision mode. These additional processes might be repeated information investigations that could result in general double-ckecking or detailed investigation of specific pieces of information. That is, the instruction to deliberate should increase the number of repeated information inspections compared to the intuitive condition.

Direction of information search and information integration strategies. Taking a merely exploratory account, we furthermore examined whether the direction of information search (i.e., cue-wise vs. option-wise) also depends on decision mode. Additionally, we investigated choices and analyzed whether decision mode is related to the usage of simplified (LEX/TTB) or complex (WADD) cue-weighting schemes.

In a comprehensive eye-tracking study, we tested these hypotheses and research questions in the classic city-size task, using different levels of complexity (Part 1), and in complex content-rich legal inference tasks (Part 2; see Table 1). It has been shown that task complexity is a crucial factor for the application of decision strategies, as it considerably increases the costs of deliberately applying strategies (Payne et al., 1988). This is particularly the case for strategies that rely on complex weighting schemes (e.g., WADD), whereas simple strategies (e.g., LEX) are influenced less strongly. Hence, from a merely deliberate perspective, everything else being equal, the increase of complexity should lead to the application of simpler strategies. On the other hand, when taking into account intuitive processes, increasing complexity might not have such a strong effect on cue-weighting schemes (cf. Dijksterhuis et al., 2006); it might, however, influence strategies of information search in explicit information display-boards. Hence, we investigated task complexity in Part 1 of our study. A second issue concerns the generalization of findings from simple, somewhat artificial settings to more content-rich domains, because intuition might be more domain-specific. It might, for instance, be argued that intuition is particularly and successfully applied in content-rich settings in which stories can be constructed, such as legal decision tasks (but see Glöckner, Betsch, & Schindler, under review; cf. Pennington & Hastie, 1992; Pennington & Hastie, 1993). Accordingly, we also investigated decision behavior in a content-rich legal setting in Part 2 of the study. Note that all our participants worked on both parts and we counterbalanced order. For pragmatic reasons, we report the results of both parts separately, starting with the part concerning our complexity manipulation.

Table 1
Overview of Experimental Design for Part 1 and 2

	Manipulation of Decision Mode (Intuition vs. Deliberation)	
Task Characteristics	Part 1	Part 2
material	city-size task	legal task
complexity	high vs. low	high

Study – Part 1: Manipulation of Decision Mode in Simple and Complex City-Size Tasks

Method

Participants and design. Twenty students with different majors from the University of Bonn participated in the study which was part of a one-hour experimental battery. They were paid a flat fee of €18 for participation. Participants completed different decision tasks and, besides standard behavioral measures, information search was recorded using eye-tracking technology. The Decision Mode was manipulated between-participants with respect to intuition and deliberation. Additionally, the Complexity of the tasks was varied within-participants regarding simple and complex decision tasks.

Materials and procedure. The experiment comprised 20 probabilistic inferences using city-size decision tasks (e.g., Gigerenzer & Goldstein, 1996). Participants were asked to decide which of two cities has more inhabitants, on the basis of probabilistic cues. Participants were informed that probabilistic inferences rested upon real German cities. To eliminate previous knowledge, options were presented with artificial names (e.g., “City A”). Cue value information was given in a binary format, “plus” indicating the existence of the cue (e.g., the city has an airport) or “minus” denoting the non-existence of the cue (e.g., the city has no first-league soccer team). Complexity was manipulated by the number of cues available from simple (3 cues) to high (12 cues; see Appendix B).

First, participants were introduced to the cues and memorized abbreviated cue labels, followed by a paper-based assessment of subjective cue validities (i.e., the conditional probability that one of two cities is bigger given a certain cue). They rated the subjective validity of each cue on a scale ranging from 50 to 100 percent and subsequently were familiarized with the decision task. Participants in the deliberate condition were instructed to balance reasons before making their decision. In contrast, participants in the intuitive condition were instructed to decide fast and spontaneously and in correspondence with their gut feeling (for complete instructions, see Appendix A). In the literature, these kinds of instructions are frequently used to manipulate decision modes (see Horstmann, Hausmann & Ryf, in press, for an overview).

The decision tasks were presented on a computer screen in a fixed-random order. Each decision trial started with a blank screen (3 s), followed by a fixation cross (1 s), which was located in the middle of the screen. Then, the decision task was presented in a matrix-format (see Appendix B) and simple and complex decision tasks alternated in a fixed-random order. Cues were sorted in a fixed-random order which was held constant over all trials. Participants selected one option by pressing a marked key on the left (“y”) or right (“m”) side of the keyboard.

Eye-movements were recorded using the Eyegaze binocular system (LC Technologies), with remote binocular sampling rate of 120 Hz and an accuracy of about 0.45°. The system is based on pupil-center/corneal reflection method to determine eyegaze. This method captures voluntary, saccadic eye movements that fixate a target object on fovea. An infrared-sensitive video camera, positioned below the computer monitor, observes the participant’s eye and specialized image software generates x, y coordinates for the gaze point on the monitor screen. Images were presented on a 17-inch color monitor (Samsung Synchmaster 740B, refresh rate 60 Hz, reaction time 5 ms) with a native resolution of 1280 x 1024 pixels. Viewed from a distance of 60 cm, the screen subtended a visual angle of 28° horizontally and 21° vertically. Fixations were identified using a fixation radius of 20 pixels and a minimum fixation duration of 50 ms. Before starting the experiment, a 9-point calibration routine was executed.

Choices, decision times, and basic eye-tracking parameters such as fixation duration, number of fixations, and coordinates were recorded. To avoid methodological artifacts, first fixations were excluded for each decision trial. We defined non-overlapping areas of interest (AOIs) around each cell in the matrix, each containing one piece of information (i.e., option labels, cue labels or cue values). Hence, we obtained 12 AOIs with the size of 426 x 256 pixels for simple tasks and 39 AOIs with the size of 426 x 78 pixels for complex tasks. For each participant and each decision the number of fixations within each AOI was calculated. AOIs were used to determine the amount of inspected information and whether participants inspected AOIs repeatedly. Furthermore, all direct transitions of fixations between AOIs containing cue value information were coded to identify direction of information search. Single fixations were categorized in short (< 150 ms), medium (≥ 150 and < 500 ms) and long (≥ 500 ms) fixation durations (Velichkovsky, 1999) resulting in the variable Time Category. In general, all statistical analyses reported below did not include fixations to AOIs with cue or option labels, because we wanted to separate pure information search processes from reading.

Results

To illustrate a typical pattern of eye-movements for a decision in the intuitive and deliberate condition, we exemplarily show two individual scanpaths (see Figure 2). The scanpath examples in Figure 2 look rather similar concerning fixation durations (i.e., indicated by the diameter of the circles). The instruction to deliberate obviously just lead to an increase in the number of fixations and repeated information inspections. Under the instruction to deliberate, single fixation durations were much shorter than one would expect for deliberate calculation strategies (cf. Figure 1). We found very few long fixations (≥ 500 ms) which would indicate a high level of processing, as observed when individuals were instructed to calculate weighted sums. Hence, on a descriptive level, the data are more in line with the assumptions of interventionist models. Next, the corresponding statistical analyses are reported in detail.

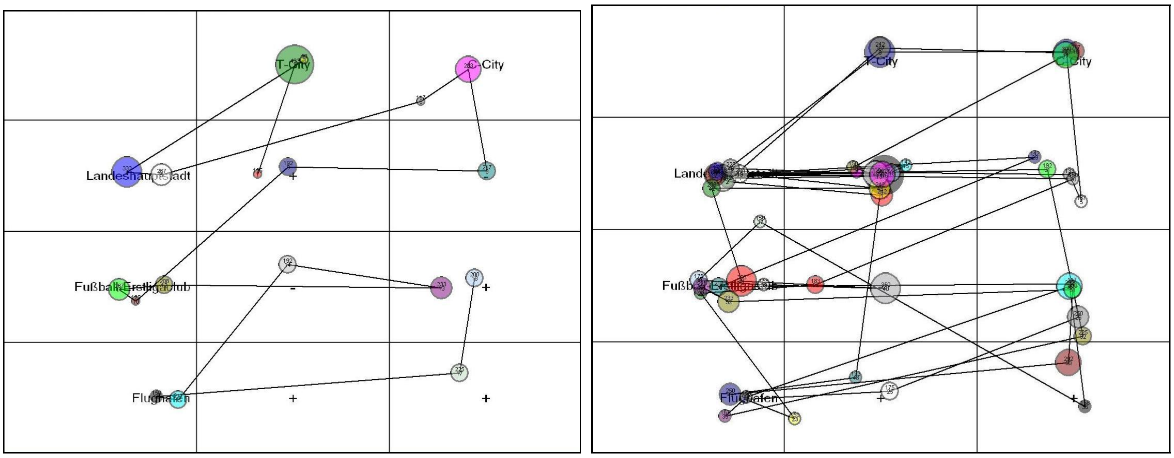

Figure 2. Example of scanpaths in a simple city-size task under the instruction to decide intuitively (left) and deliberately (right). Fixations are illustrated by circles and circle diameter indicates fixation duration. The lines represent saccades.

Manipulation check / decision time. To determine whether our manipulation of Decision Mode was efficient, we analyzed individuals' decision times (cf. De Vries, Holland, & Witteman, 2008; Finucane et al., 2000). A 2 (Decision Mode) x 2 (Complexity) x 10 (Task) repeated-measurement ANOVA was conducted with log-transformed decision time as dependent variable and Complexity and Task as within-participants factors. The factor Task represented different decision task patterns which were nested under the factor Complexity. The main effect of Decision Mode was significant, with participants in the intuitive condition deciding faster compared to participants in the deliberate condition, $F(1, 18) = 5.17$, $p < .05$, $\eta^2 = .22$ (for all descriptive statistics see Table 2). This indicates that our manipulation was successful. Additionally, a significant main effect of Complexity was found, $F(1, 18) = 334.64$, $p < .001$, $\eta^2 = .95$. Participants decided more slowly in complex tasks, as compared to the simple ones.

Fixation duration. The duration of single fixations is an important indicator for the levels of processing. Hence, in a first step we analyzed fixation duration by conducting a 2 (Decision Mode) x 2 (Complexity) ANOVA with log-transformed single fixation duration as dependent variable (and Participants as additional random factor accounting for the repeated-measurement design). Interestingly, there was no difference concerning mean single fixation duration between the intuitive and deliberate condition, $F(1, 18.2) = .04$, $p = .85$, $\eta^2 = .002$. A significant main effect of Complexity was found, revealing a longer fixation duration in complex tasks, $F(1, 19.6) = 16.38$, $p = .001$, $\eta^2 = .45$.

To investigate the influence of Decision Mode on single fixation duration in more detail, we tested for differences in the overall proportion of short, medium, and long fixations. χ^2-tests of independence between Decision Mode and Time Category were calculated separately for simple and complex tasks with number of short, medium, and long fixations averaged across participants. In both complexity conditions, the decision mode manipulation did not influence the distribution of single fixation duration, simple tasks: $\chi^2(2, N = 265) = .99$, $p = .61$, $\hat{w}^2 = .003$, complex tasks: $\chi^2(2, N = 857) = .05$, $p = .97$, $\hat{w}^2 < .001$. Overall, fixations of the medium time category prevailed, accounting for 67 percent of fixations. Furthermore, short fixations represented 31 percent of fixations, while long fixations (2 percent) were rarely observed (see Figure 3).

To test whether the distribution of single fixation duration varies over time, we looked at fixations divided in consecutive blocks of 10 fixations. We included all fixation blocks containing fixations of at least 25 percent of the participants. Over the decision mode and complexity conditions, the proportion of short fixations ranged from 25 to 35 percent. Medium and long fixations accounted for 65 to 74 percent, and 1 to 4 percent of the fixations, respectively. This finding indicates that the distribution of single fixation duration remained relatively stable over time.

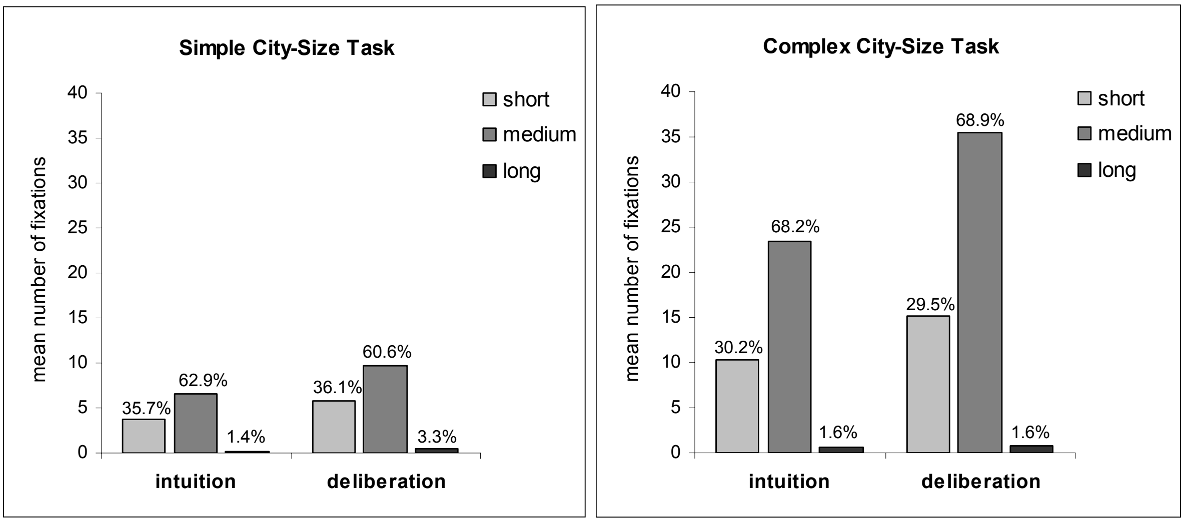

Figure 3. Number of short, medium, and long fixations averaged across participants and tasks for complexity and decision mode conditions in Part 1. Bar labels indicate the proportion of fixations for each category.

Number of fixations. One of the basic indicators for information integration processes in eye-tracking studies is the total number of fixations. Therefore, we analyzed the total number of fixations to AOIs containing cue value information. A 2 (Decision Mode) x 2 (Complexity) x 10 (Task) repeated-measurement ANOVA was conducted to analyze the average amount of fixations per decision task. The main effect of Decision Mode turned out to be significant, $F(1, 18) = 8.17$, $p < .05$, $\eta^2 = .31$. In the deliberate condition a significantly higher number of fixations was observed compared to the intuitive condition. Moreover, a significant main effect of Complexity was found, $F(1, 18) = 149.80$, $p < .001$, $\eta^2 = .89$, revealing a higher number of fixations in complex tasks. Furthermore, the interaction between Complexity and Decision Mode turned out to be significant, $F(1, 18) = 5.38$, $p < .05$, $\eta^2 = .23$. In complex tasks the difference in number of fixations between the intuitive and deliberate condition became more pronounced.

Amount of inspected information. Concerning the question which proportion of the information was indeed taken into account when making a decision, the total number of fixations reported above is only partially meaningful. We therefore calculated an information inspection index which denotes the proportion of information the participants attended to before reaching their decisions. This index was computed by dividing the number of AOIs, inspected at least once, by the total number of AOIs with cue value information (i.e., “plus” or “minus”). A 2 (Decision Mode) x 2 (Complexity) x 10 (Task) repeated-measurement ANOVA was conducted to analyze this inspection index. The main effect of Decision Mode was significant, with participants in the deliberate condition searching for more information, $F(1, 18) = 6.52$, $p < .05$, $\eta^2 = .27$. Moreover, in simple tasks, the percentage of inspected information was higher compared to complex tasks, $F(1, 18) = 35.11$, $p < .001$, $\eta^2 = .66$. Interestingly, even participants in the intuitive condition attended to more than two thirds of the cue value information before deciding.

Number of repeated information inspections. To account for the fact that information is often repeatedly attended to in the decision process, an analysis of repeated cue value inspections was conducted. Repeated inspections were defined as fixations that did not directly follow each other, but were located in the same AOI. A 2 (Decision Mode) x 2 (Complexity) x 10 (Task) repeated-measurement ANOVA was computed, with number of repeated inspections as dependent variable. The main effect of Decision Mode turned out to be significant, $F(1, 18) = 9.01$, $p < .01$, $\eta^2 = .33$. Participants who were instructed to deliberate showed a higher number of repeated inspections of previously fixated information than participants deciding intuitively. Furthermore, complex tasks were associated with a higher number of repeated inspections than simple tasks, $F(1, 18) = 57.68$, $p < .001$, $\eta^2 = .76$. Additionally, the interaction between Decision Mode and Complexity was significant, $F(1, 18) = 5.93$, $p < .05$, $\eta^2 = .25$, indicating stronger differences between the intuitive and deliberate condition with regard to the number of repeated inspections in complex tasks.

Direction of information search. Different decision strategies are claimed to be associated with different directions of information search. It is usually assumed that non-compensatory strategies such as LEX are related to cue-wise information search, whereas compensatory strategies such as WADD are linked to more option-wise information search (Payne et al., 1988). The direction of information search was analyzed on the basis of the SM-index (Böckenholt & Hynan, 1994). This index takes the probabilities of cue- and option-wise transitions into account and therefore describes information selection strategies as standardized deviations from a random search pattern. Additionally, the SM-index considers the number of "other" transitions (i.e., not strictly cue- or option-wise transitions) and therefore allows for a more precise classification of a search pattern than the classical Payne-index (Payne, 1976). Negative SM-values indicate a cue-wise and positive SM-values an option-wise information search. To investigate differences in information search direction with regard to decision mode, a 2 (Decision Mode) x 2 (Complexity) x 10 (Task) repeated-measurement ANOVA was calculated with SM-index as dependent variable. The main effect of Decision Mode was significant, $F(1, 18) = 4.56$, $p < .05$, $\eta^2 = .20$. In both conditions a cue-wise information search prevailed, but participants in the deliberate condition showed this search direction to a higher extent. Furthermore, a significant main effect of Complexity was found indicating a tendency to search more cue-wise in complex tasks, $F(1, 18) = 56.02$, $p < .001$, $\eta^2 = .76$. Additionally, the interaction between Decision Mode and Complexity turned out to be significant, $F(1, 18) = 6.68$, $p < .05$, $\eta^2 = .27$. In complex tasks, the difference in SM-Index between the intuitive and deliberate condition became more pronounced.

Information integration strategies. To test whether Decision Mode influences information integration, we classified strategy utilization separately for complexity conditions by means of the linear scoring rule regarding WADD, LEX, and EQW (Bröder, in press). According to this classification method, empirical and expected choices corresponding to each strategy are compared. This comparison is done for every participant and decision task. If there is a match between empirical choice and choice predicted by the particular strategy, no points are assigned to the respective participant and task regarding this strategy. If empirical and expected choices diverge, two points are ascribed. For strategies making no prediction for a particular task one point is assigned. Finally, the points are summed up separately for each strategy and the participant is classified as a user of the strategy with the lowest score. Corrected, subjective cue validities were used to calculate expected choices. According to Glöckner and Betsch (2008c), we corrected cue weights for the fact that a cue with a validity of 50 percent has no predictive power ($w_{cue} = p_{cue} - .50$). Concerning simple tasks, in the intuitive condition, six participants were classified as WADD users, two participants as LEX users and two participants could not be classified. With regard to the deliberate condition five participants were classified as WADD users, two participants as LEX users and three participants as EQW users. In complex tasks, in the intuitive condition, one participant was classified as a WADD user, three participants as LEX users and six participants could not be classified. In the deliberate condition, four participants applied WADD, three participants were LEX users and three participants could not be classified. Hence, there was no clear trend that the decision mode is related to a certain information integration strategy.

Table 2
Means and Standard Errors for Eye-Tracking Parameters Part 1 and 2

	Part 1[a]				Part 2[a]	
	3 cues		12 cues		12 cues	
Eye-tracking parameters	INT	DEL	INT	DEL	INT	DEL
decision time in sec	4.99	6.76	12.82	17.59	8.59	13.06
single fixation duration in msec	168.35	167.70	177.37	181.20	180.51	185.51
number of fixations in cue value AOIs	10.35 (0.85)	16.11 (2.50)	34.36 (2.97)	51.35 (5.25)	22.44 (2.51)	31.30 (3.67)
information inspection index	.79 (.04)	.87 (.02)	.67 (.02)	.75 (.02)	.48 (.03)	.58 (.02)
repeated information inspection score	4.50 (0.60)	8.45 (1.58)	13.26 (2.14)	25.57 (3.63)	6.53 (1.27)	12.56 (2.40)
SM-index (direction of search)	-0.18 (0.22)	-0.41 (0.23)	-1.38 (0.51)	-2.88 (0.29)	0.38 (0.31)	-0.18 (0.26)

Note. INT = Intuition; DEL = Deliberation. *SE*s are given in parentheses. Due to log-transformation no *SEs* are reported for decision time and single fixation duration.
[a]*N* = 20.

Discussion

To investigate whether instruction-induced intuition and deliberation are completely distinct processes or whether the underlying processes are rather similar, we manipulated the decision mode in simple and complex city-size tasks. Significantly lower decision times in the intuitive as compared to the deliberate condition indicated that our manipulation was effective according to frequently-used manipulation checks.

In line with interventionist models, the results reveal an astoundingly high similarity of intuition and deliberation regarding different measures of fixation duration. First, we found no difference in mean fixation duration regarding decision modes. Second, the classification of single fixation durations showed an equal distribution of short, medium and long fixations for intuition and deliberation. Third, in both decision modes this distribution remained relatively stable in the course of decision making. Besides this high similarity regarding fixation duration, the manipulation of decision modes influenced several further eye-tracking parameters significantly. Participants in the deliberate condition showed a higher number of fixations compared to participants deciding intuitively, again supporting interventionist models. Further analyses revealed that the higher number of fixations in the deliberate condition is due to a higher percentage of inspected information and to more repeated information inspections. Hence, these analyses also support interventionist models.

The explorative analysis of information integration provided no evidence that the decision mode influences the usage of simplified or complex decision strategies. Due to an incomplete classification of participants and the low number of participants, no definite statements concerning exact frequencies of strategy use (i.e., cue-weighting scheme) can be made. Descriptively, in simple tasks the application of WADD prevailed, whereas in complex tasks many participants could not be classified (the results from Part 2 reported below indicate that this difference might have been due to the less diagnostic tasks in the complex condition). Interestingly, regardless of complexity conditions, the high amount of inspected information even in the intuitive condition rather points to a predominant usage of complex strategies. Regarding the direction of information search, deliberation seemed to be associated with a more cue-wise search. Note, however, that even in the intuitive condition the search direction was slightly cue-wise. At first sight, these findings seem to be inconsistent with the results of the strategy classification, which indicated a prevailing application of complex strategies (WADD) that are usually assumed to be associated with an option-wise search direction. However, one might speculate that due to the fact that cues were not sorted by their validity, information could have been sought in a more cue-wise direction to save the effort of checking cue labels again. Nevertheless, information could still have been integrated according to a weighted additive scheme.

In Part 1, we investigated how complexity of the decision task as operationalized by number of cues influences intuitive and deliberate information processing. In more complex tasks, an increased fixation duration, a higher number of fixations and repeated information inspections, and a more cue-wise search pattern was observed compared to simple tasks. However, in contrast to simple tasks, the percentage of inspected information was lower. These parameters indicate that regardless of the decision mode, complex tasks require a higher processing effort that is additionally underlined by longer decision times with increased complexity. Furthermore, significant interactions between Decision Mode and Complexity regarding number of fixations, repeated information inspections and direction of information search reveal that the differences between intuition and deliberation became more pronounced in complex tasks. It is reasonable to assume that more comprehensive supplementary processes are necessary in more complex tasks and that participants use them more extensively if they are instructed to deliberate without having time constraints.

As mentioned above, the experiment consisted of two parts which were presented in counterbalanced order and separated by a break which gave the participants the possibility to relax. The aim of Part 2 was the additional testing of the hypotheses in an enriched decision environment. Besides for its immediate practical relevance, legal content was selected because it has been repeatedly argued that intuition might play an important role in moral and legal judgments by judges as well as lay jurors (Glöckner, 2008; Glöckner & Engel, 2008; Guthrie, Rachlinski, & Wistrich, 2007; Hutcheson, 1929; see also Simon, 2004).

Study – Part 2: Manipulation of Decision Mode in Content-Rich Criminal Cases

Method

Participants and design. Decision Mode was manipulated between-participants. Participants were assigned to the same decision mode condition as in Part 1 and completed 20 complex tasks with 12 cues. We did not change participants' assignment to the decision mode conditions to avoid carry-over effects.

Materials and procedure. The general procedure was very similar to Part 1, except for the fact that instead of the classic city-size material content-rich legal inferences were used (see Appendix B). In hypothetical murder cases, participants had to decide which of two suspects was more likely to have committed the crime based on probabilistic cues (cf. Bröder & Schiffer, 2003b). Pieces of evidence were provided as cues for guilt and could be present (i.e., "plus") or absent ("minus") for one, both or none of the suspects. Unlike Part 1, the cues were sorted by their mean subjective validity, which was assessed in a pre-test. To clearly identify the information integration schemes, we designed cue patterns that sufficiently differed in their choice predictions for the strategies WADD, LEX, and EQW. The resulting 20 different cue patterns constitute the within-participants factor Task. Assessment of subjective cue validities, instruction of decision mode, and the definition of AOIs was the same as in the complex task condition in Part 1.

Results

Our results mainly replicated the findings of the first part of the study in an enriched environment. All analyses reported below were calculated in correspondence to Part 1, but did not include the factor Complexity, since only complex 12-cue tasks were used (for all descriptive statistics, see again Table 2).

Manipulation check / decision time. Again, intuitive decisions were made significantly faster than deliberate ones, indicating the successful manipulation of decision modes, $F(1, 18) = 5.16$, $p < .05$, $\eta^2 = .22$.

Fixation duration and number of fixations. As in Part 1, we found no difference for mean fixation duration when comparing the two conditions, $F(1, 18.4) = 0.62$, $p = .44$, $\eta^2 = .03$, and Decision Mode did not influence the overall distribution of single fixation durations, $\chi^2(2; N = 1012) = 0.74$, $p = .69$, $\hat{w}^2 = 0.001$. Aggregated over intuitive and deliberate decisions, we observed 27 percent short fixations, 71 percent fixations in the medium time category and only 2 percent long fixations (Figure 4). This distribution remained stable over time with the proportion of short fixation ranging from 20 to 29 percent, medium fixations from 70 to 78 and long fixations from 1 to 3 percent. Again, participants in the deliberate condition showed a higher number of fixations compared to the intuitive condition, $F(1, 18) = 4.78$, $p < .05$, $\eta^2 = .21$.

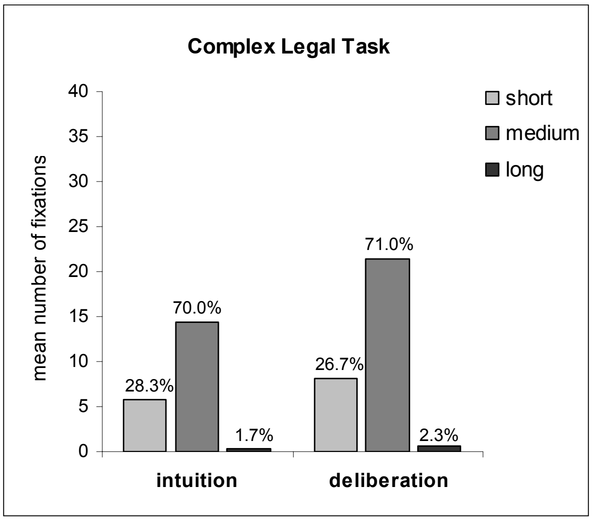

Figure 4. Number of short, medium and long fixations averaged across participants and tasks for decision mode conditions in Part 2. Bar labels indicate the proportion of fixations for each category.

Amount of inspected information and number of repeated inspections. In the more content-rich tasks also, participants that had to base their decisions on deliberation examined significantly more cue value information than participants deciding intuitively, $F(1, 18) = 4.89$, $p < .05$, $\eta^2 = .21$. In the intuitive condition, about half of the information was inspected, whereas nearly two thirds were examined in the deliberate condition. Furthermore, we replicated the finding that participants in the deliberate condition reexamined cue value information more frequently than participants in the intuitive condition, $F(1, 18) = 4.93$, $p < .05$, $\eta^2 = .22$.

Direction of information search and information integration strategies. The results concerning the SM-index, measuring direction of information search, in tendency replicated the higher cue-wise search in the deliberate condition, but this difference did not reach conventional significance levels, $F(1, 18) = 1.90$, $p = .19$, $\eta^2 = .10$. Interestingly, in contrast to Part 1, we observed a general tendency for more option-wise information search in content-rich tasks. In the intuitive condition, the SM-index turned out to be positive, indicating that option-wise search dominated. According to the linear scoring rule, for the majority of participants in both decision modes choices could best be predicted by a WADD scheme (deliberation: eight of ten participants, intuition: seven of ten participants).

Discussion

In Part 2, we aimed to generalize our comparison of deliberate and intuitive decisions by employing an enriched environment, namely complex legal inference tasks. As in Part 1, we found no differences concerning mean fixation duration and overall distribution of fixation duration categories (short, medium, long) as well as their distribution over time. Hence, we provide further support for interventionist models and validate the assumed similarities between intuitive and deliberate decision modes regarding basic information processing across different materials. For deliberate decisions, the furthermore hypothesized supplementary cognitive processes could also be verified again, as indicated by the differences in number of fixations, amount of inspected information and number of repeated information inspections.

Descriptively, we found a general difference in level for all dependent variables when comparing the means of complex tasks in Part 1 and Part 2 of the study (i.e., lower decision times, smaller number of fixations, smaller amount of inspected information and less repeated inspections in Part 2, cf. Table 2). Also, we observed an increased usage of a WADD scheme for both decision modes in Part 2. This can be explained by the more diagnostic decision tasks that allowed us to differentiate better between non-compensatory and compensatory strategies (cf. Glöckner & Betsch, 2008a). Besides, we found a tendency for more option-wise information search, which could be due to surface features of the decision task: The cues were sorted according to their validity and the designed cue patterns were more structured than the ones used in the city-size task. Thus, the higher proportion of WADD usage, in contrast to Part 1, was most likely due to the fact that we were better able to identify weighted compensatory cue integration in Part 2. Anyhow, we cannot rule out that the presentation format also partially accounts for the effect.

General Discussion

In recent years, an increasing number of studies comparing intuition and deliberation have been published. These studies mainly focused on decision quality and often neglected the specific cognitive processes underlying intuitive and deliberate decision modes (e.g., Dijksterhuis et al., 2006). We went one step further by examining processes of information search and integration using eye-tracking technology. We thereby investigated the general question whether intuitive and deliberate decisions are indeed based on completely different and separable processes or whether deliberation just adds some additional features to the basic intuitive process as indicated by interventionist models. We investigated this research question by manipulating the decision mode using different instructions in simple and complex city-size tasks (Part 1), and in complex legal inference tasks (Part 2). Hence, we captured a somewhat artificial as well as a more content-rich setting.

Altogether, our findings are in line with assumptions of interventionist models. In both parts of the study, mean fixation durations and the distribution of short, medium and long fixations were equal for intuition and deliberation. The dominance of short and medium fixations indicates that quick information scanning prevails over the entire decision process. In contrast to a pattern of particularly long fixations observed under the instruction to consciously calculate weighted sums (see pre-study, Figure 1), even under the deliberate instruction long fixations that point to a calculation or rule-based, thorough, slow and serial information integration were rarely found. Hence, our findings suggest a very similar basic process underlying intuitive and deliberate decisions, namely an automatic process of information integration. Nevertheless, we found some crucial differences regarding intuition and deliberation. A higher number of fixations caused by a higher amount of inspected information and more repeated information inspections under the instruction to deliberate reveal that the basic process of automatic information integration is supplemented by additional processing steps. Hence, deliberation seems to be associated with a more thorough and extensive information search.

Our explorative analyses suggest that deliberation might be associated with a more cue-wise information search compared to intuition. Whereas deliberation was related to a cue-wise search pattern in both parts of the study, intuition resulted in a cue-wise search by trend in Part 1 and in a slightly option-wise search in Part 2. Despite these differences in information search pattern, we found no evidence that decision mode is related to the application of simplified or complex cue-weighting schemes. As indicated by Part 1 and confirmed by Part 2, information is predominantly integrated according to a WADD scheme regardless of decision mode. However, relatively short decision times and the dominance of short and medium fixation durations indicate that even participants deciding deliberately do not apply conscious calculations. Our findings are in line with the observation that participants seem to approximate a WADD scheme by using automatic processes (Glöckner & Betsch, 2008a, 2008b, 2008c; Glöckner & Herbold, 2008).

Nevertheless, three caveats of our study should be noted. First, our participants were assigned to the same decision mode condition in Part 1 and 2 to avoid carry-over effects. Although we counterbalanced order, the low number of participants does not allow to analyze order effects reliably. Hence, observations in the two parts were not independent which lowers the validity of the within-participants replication of the effects. A second issue is that there are several different methods to induce deliberation by instruction (Horstmann et al., in press). We instructed participants to balance reasons before making a decision. Although this is a well-established method to manipulate deliberation, this procedure might induce a specific kind of deliberation. Hence, it is not unlikely that the results are partially dependent on the specific wording of the instruction. It has to be shown in future studies whether our findings also hold for instructions which highlight other aspects of deliberation (e.g., to think carefully and thoroughly). Finally, future research should exceed the framework of probabilistic inferences and investigate other types of decision tasks because intuition might be task- and context-dependent.

In conclusion, intuition and deliberation do not seem to be completely distinct processes as implied by the traditional dual-process view. To account for the underlying processes of intuitive and deliberate decision-making, models that postulate a common underlying process such as a parallel constraint satisfaction mechanism (Glöckner & Betsch, 2008b; see also Hammond et al., 1987; Holyoak & Simon, 1999; cf. Rumelhart et al., 1986; Thagard & Millgram, 1995) seem to be more suitable. Overall, this study adds to the accumulating body of evidence that automatic information integration plays a crucial role in decision making, independent of whether people decide intuitively or deliberately. Eye-tracking technology seems to be a promising approach to investigate these automatic processes.

References

Acker, F. (2008). New findings on unconscious versus conscious thought in decision making: Additional empirical data and meta-analysis. *Judgment and Decision Making, 3*, 292-303.

Böckenholt, U., & Hynan, L. S. (1994). Caveats on a process-tracing measure and a remedy. *Journal of Behavioral Decision Making, 7*, 103-117.

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. (in press). Choice based strategy classification. In A. Glöckner & C. L. Witteman (Eds.), *Tracing intuition: Recent methods in measuring intuitive and deliberate processes in decision making* (pp. xxx). London: Psychology Press.

Bröder, A., & Schiffer, S. (2003a). Bayesian strategy assessment in multi-attribute decision making. *Journal of Behavioral Decision Making, 16*, 193-213.

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

Busemeyer, J. R., & Johnson, J. G. (2004). Computational models of decision making. In D. J. Koehler & N. Harvey (Eds.), *Blackwell handbook of judgment and decision making* (pp. 133-154). Malden, MA: Blackwell Publishing.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review, 100*, 432-459.

Chen, S., & Chaiken, S. (1999). The heuristic-systematic model in its broader context. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 73-96). New York, NY: Guilford Press.

Damasio, A. R. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: Putnam Publishing.

De Vries, M., Holland, R. W., & Witteman, C. L. (2008). Fitting decisions: Mood and intuitive versus deliberative decision strategies. *Cognition & Emotion, 22*, 931-943.

Dijksterhuis, A., Bos, M. W., Nordgren, L. F., & van Baaren, R. B. (2006). On making the right choice: The deliberation-without-attention effect. *Science, 311*, 1005-1007.

Doherty, M. E., & Brehmer, B. (1997). The paramorphic representation of clinical judgment: A thirty-year retrospective. In W. M. Goldstein & R. M. Hogarth (Eds.), *Research on judgment and decision making: Currents, connections, and controversies* (pp. 537-551). New York, NY: Cambridge University Press.

Dougherty, M. R. P., Gettys, C. F., & Ogden, E. E. (1999). MINERVA-DM: A memory processes model for judgments of likelihood. *Psychological Review, 106*, 180-209.

Evans, J. S. B. T. (2006). The heuristic-analytic theory of reasoning: Extension and evaluation. *Psychonomic Bulletin & Review, 13*, 378-395.

Evans, J. S. B. T. (2007). On the resolution of conflict in dual process theories of reasoning. *Thinking & Reasoning, 13*, 321-339.

Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology, 59*, 255-278.

Fiedler, K. (2008). The ultimate sampling dilemma in experience-based decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 186-203.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making, 13*, 1-17.

Fishburn, P. C. (1974). Lexicographic orders, utilities, and decision rules: A survey. *Management Science, 20*, 1442–1472.

Gigerenzer, G. (2007). *Gut feelings: The intelligence of the unconscious*. New York: Viking Press.

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review, 103*, 650-669.

Gigerenzer, G., Hoffrage, U., & Kleinbölting, H. (1991). Probabilistic mental models: A Brunswikian theory of confidence. *Psychological Review, 98*, 506-528.

Glöckner, A. (2008). How evolution outwits bounded rationality: The efficient interaction of automatic and deliberate processes in decision making and implications for institutions. In C. Engel & W. Singer (Eds.), *Better than conscious? Decision making, the human mind, and implications for institutions* (pp. 259-284). Cambridge, MA: MIT Press.

Glöckner, A., & Betsch, T. (2008a). Do people make decisions under risk based on ignorance? An empirical test of the Priority Heuristic against Cumulative Prospect Theory. *Organizational Behavior and Human Decision Processes, 107*, 75–95.

Glöckner, A., & Betsch, T. (2008b). Modeling option and strategy choices with connectionist networks: Towards an integrative model of automatic and deliberate decision making. *Judgment and Decision Making, 3*, 215–228.

Glöckner, A., & Betsch, T. (2008c). Multiple-reason decision making based on automatic processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 1055-1075.

Glöckner, A., Betsch, T., & Schindler, N. (under review). Coherence shifts in probabilistic inference tasks.

Glöckner, A., & Engel, C. (2008). Can we trust intuitive jurors? An experimental analysis. *MPI Collective Goods Preprint, No. 38. Available at SSRN: http://ssrn.com/abstract=1307580*.

Glöckner, A., & Herbold, A.-K. (2008). Information processing in decisions under risk: Evidence for compensatory strategies based on automatic processes. *MPI Collective Goods Preprint, No. 42. Available at SSRN: http://ssrn.com/abstract=1307664*.

Guthrie, C., Rachlinski, J. J., & Wistrich, A. J. (2007). Blinking on the bench: How judges decide cases. *Cornell Law Review, 93*, 1-44.

Hammond, K. R., Hamm, R. M., Grassia, J., & Pearson, T. (1987). Direct comparison of the efficacy of intuitive and analytical cognition in expert judgment. *IEEE Transactions on Systems, Man, & Cybernetics, 17*, 753-770.

Hoffman, P. J. (1960). The paramorphic representation of clinical judgment. *Psychological Bulletin, 57*, 116-131.

Holyoak, K. J., & Simon, D. (1999). Bidirectional reasoning in decision making by constraint satisfaction. *Journal of Experimental Psychology: General, 128*, 3-31.

Horstmann, N., Hausmann, D., & Ryf, S. (in press). Methods for inducing intuitive and deliberate processing modes. In A. Glöckner & C. L. Witteman (Eds.), *Tracing intuition: Recent methods in measuring intuitive and deliberate processes in decision making* (pp. xxx). London: Psychology Press.

Hutcheson, J. C. (1929). The judgment intuitive: the function of the "hunch" in judicial decision making. *Cornell Law Quarterly, 14*, 274-288.

Kahneman, D., & Frederick, S. (2002). Representativeness revisited: Attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 49-81). New York, NY: Cambridge University Press.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior & Human Performance, 16*, 366-387.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1988). Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*, 534-552.

Pennington, N., & Hastie, R. (1992). Explaining the evidence: Tests of the Story Model for juror decision making. *Journal of Personality and Social Psychology, 62*, 189-206.

Pennington, N., & Hastie, R. (1993). A theory of explanation-based decision making. In G. A. Klein, J. Orasanu, R. Calderwood & C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 188-201). Westport, CT: Ablex Publishing.

Petty, R., & Cacioppo, J. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York Springer.

Pomplun, M., Ritter, H., & Velichkovsky, B. (1996). Disambiguating complex visual information: Towards communication of personal views of a scene. *Perception, 25*, 931-948.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124*, 372-422.

Rumelhart, D. E., Smolensky, P., McClelland, J. L., & Hinton, G. E. (1986). Schemata and sequential thought processes in PDP models. In J. L. McClelland & D. E. Rumelhart (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition - Vol. 2: Psychological and biological models* (pp. 7-57). Cambridge, MA: MIT Press.

Simon, D. (2004). A third view of the black box: cognitive coherence in legal decision making. *University of Chicago Law Review, 71*, 511-586.

Sloman, S. A. (2002). Two systems of reasoning. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: The psychology of intuitive judgment* (pp. 379-396). New York, NY: Cambridge University Press.

Thagard, P., & Millgram, E. (1995). Inference to the best plan: A coherence theory of decision. In A. Ram & D. B. Leake (Eds.), *Goal-driven learning* (pp. 439-454). Cambridge, MA: MIT Press.

Velichkovsky, B. M. (1999). From levels of processing to stratification of cognition: Converging evidence from three domains of research. In B. H. Challis & B. M. Velichkovsky (Eds.), *Stratification in cognition and consciousness* (pp. 203-235). Amsterdam, Netherlands: John Benjamins Publishing Company.

Velichkovsky, B. M., Challis, B. H., & Pomplun, M. (1995). Working memory and work with memory: Visuospatial and further components of processing. *Zeitschrift fur Experimentelle Psychologie, 42*, 672-701.

Velichkovsky, B. M., Rothert, A., Kopf, M., Dornhofer, S. M., & Joos, M. (2002). Towards an express-diagnostics for level of processing and hazard perception. *Transportation Research Part F: Traffic Psychology and Behaviour, 5*, 145-156.

Appendix A:
Instructions to manipulate intuitive and deliberate decision modes

Intuitive Condition

It is important that you make your decision spontaneously and as fast as possible. This means that you should decide intuitively or according to your "gut feeling".

Deliberate Condition

It is important that you balance reasons for both cities (suspects) which speak for or against the fact that the city (suspect) is the bigger one (is more likely to have committed the crime). Please do not decide until you have finished this reflection.

Appendix B:
Example of decision tasks and presentation format

Simple City-Size Task

	E-City	R-City
Capital	+	-
First League Soccer Team	-	+
Airport	+	-

Complex City-Size Task

	C-Town	F-Town
Zoo	+	+
Cathedral	-	+
Former West Germany	-	+
Capital	-	-
License Plate	+	+
Opera	+	-
First League Soccer Team	-	-
Trade Fair Location	+	-
Underground	-	-
University	+	+
Airport	+	-
DAX-Company	-	-

Complex Legal Task

	Suspect Y	Suspect M
DNA traces at the crime scene	-	+
Blood stains on the shoes	+	-
Covered-up tracks	+	-
Threatened to commit crime	+	-
Contradictory statements	+	-
Was seen prior to the crime	-	-
Suspicious phone call	+	-
No alibi	-	+
Violent	-	-
Seems nervous	-	+
Criminal record	-	+
Family member	-	+