Judgment and Decision Making, Vol. 4, No. 5, August 2009, pp. 335–354

How distinct are intuition and deliberation? An eye-tracking analysis of instruction-induced decision modes

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Abstract

In recent years, numerous studies comparing intuition and deliberation have been published. However, relatively little is known about the cognitive processes underlying the two decision modes. In two studies, we analyzed the effects of decision mode instructions on processes of information search and integration, using eye-tracking technology in a between-participants (Study 1) and a within-participants (Study 2) design. Our findings indicate that the instruction to deliberate does not necessarily lead to qualitatively different information processing compared to the instruction to decide intuitively. We found no difference in mean fixation duration and the distribution of short, medium and long fixations. Short fixations in particular prevailed under both decision mode instructions, while long fixations indicating a conscious and calculation-based information processing were rarely observed. Instruction-induced deliberation led to a higher number of fixations, a more complete information search and more repeated information inspections. We interpret our findings as support for the hypothesis that intuitive and deliberate decision modes share the same basic processes which are supplemented by additional operations in the deliberate decision mode.

Keywords: Decision making, decision mode, intuition, deliberation, eye-tracking.

1 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 widely 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. Different models that rely on automatic processes might be considered to account for intuition (see Glöckner & Witteman, in press, for an overview). 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, many theories concern the interplay between intuitive and deliberate processes. A long tradition of dual-process models postulates a clear distinction between intuition and deliberation. As Kahneman and Frederick (2002, p. 51) 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."

Despite the apparent consensus regarding basic properties of intuition and deliberation, the dual-process framework has been criticized for being not sufficiently specified (e.g., De Neys & Glumicic, 2008; Gigerenzer & Regier, 1996). A second crucial critique concerns the fact that evidence for dual-process theories is predominantly based on outcome measures, while cognitive processes underlying intuition and deliberation were mainly neglected (e.g., De Neys, 2006; Gigerenzer & Regier, 1996; Glöckner & Witteman, in press; Osman, 2004). Furthermore, theorizing on dual-process theories is inconsistent, and the wealth of models is hard to summarize according to simple criteria.

One suggestion of categorizing dual-process models into three classes according to the interplay of the two decision modes was made by Evans (2007). A first class of so-called *pre-emptive* theories is characterized by an initial selection between two rather distinct kinds of processes. For instance, mode selection models might be subsumed under this class (e.g., Petty & Cacioppo, 1986). A second class of theories denoted as *parallel-competitive* postulates a parallel activation of both processing modes and a kind of competition among them that might result in conflicting responses. This assumption is most strongly advocated by Sloman (1996, 2002), and other authors hold this view as well (Epstein, 1994;

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Epstein & Paccini, 1999) or present consistent evidence (De Neys, 2006; De Neys & Glumicic, 2008). A third class of theories, so-called *default-interventionist* models (Evans, 2007, 2008; Margolis, 2008), state that intuitive processes are always activated first as a default mode and deliberate processes may intervene upon these intuitive processes. Evans (2006), for instance, assumes that heuristic processes generate default responses and analytic processes might intervene to scrutinize and potentially correct the initial response. 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; Rumelhart, Smolensky, McClelland, & Hinton, 1986; Johnson, Zhang, & Wang, 1997; Zhang, Johnson, & Wang, 1998). In 1987, Hammond, Hamm, Grassia, and Pearson had 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 paper, we used eye-tracking technology to analyze, on a fine-grained level, how the instruction to decide intuitively or deliberately affects information search and integration. Specifically, we tested whether decision mode instructions induce qualitatively different information integration processes. We try to relate this at first glance methodological question to a theoretical issue on dual-processing models, namely whether it is reasonable to assume that intuition and deliberation are distinct or whether both might rely on similar basic processes which are just supplemented by additional processing steps. We proceed as follows: first, we discuss dual-process theories with a special focus on whether they postulate more distinct or more integrated processes. Second, we describe probabilistic inference tasks and discuss related cue-weighting schemes. Third, we introduce the core eye-tracking measure, single fixation duration, which is used to investigate qualitative differences in information processing. Fourth, we derive hypotheses from both a distinct and an integrated processes perspective. After giving a short overview of our empirical studies, we report them in detail and finally discuss the results and their implications for theorizing and methodology in decision making.

1.1 Dual-process theories: distinct versus integrated processes assumption

As outlined above, according to some dual-process theories, a clear distinction between intuition and deliberation 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 (e.g., Kahneman, 2003; Kahneman & Frederick, 2002; Sloman, 1996, 2002). A strong assumption regarding the interplay of intuitive and deliberate processes is made by Sloman (1996, 2002). He postulates that intuition and deliberation are completely distinct and separable processes. According to his assumption, "two systems, two algorithms that are designed to achieve different computational goals" (Sloman, 1996, p. 6) exist. Both systems can be activated simultaneously and may result in distinct responses. In the following, we will refer to this conception of intuition and deliberation as the *distinct processes assumption*.

On the other hand, some theories do not postulate such a clear distinction between intuitive and deliberate processes. An example is the integrative model of automatic and deliberate decision making proposed by Glöckner and Betsch (2008b). The model assumes that every decision is based on an automatic process. If a person perceives a decision situation, a mental representation of the decision task which can be modeled by parallel constraint satisfaction (PCS) networks is automatically constructed. A core assumption of the model is that people can integrate a multitude of information in a weighted compensatory manner within a short time frame due to automatic-intuitive processes. However, these automatic-intuitive processes can be supervised and modified by additional operations of the deliberate system. Crucially, the deliberate decision mode is not conceived as a completely distinct and separable system. Rather, processes of information search, information production or information change affect the basic automatic process that finally determines the decision. Therefore, we label the latter conception of intuition and deliberation the *integrated processes assumption*. This view implies that the processes underlying different modes of decision making might be only partially distinct and that that basic automatic-intuitive processes should be activated in a deliberate decision mode as well.

In summary, the purpose of our study was not to test broad groups of dual-process models, but to investigate if instruction-induced decision modes are more in line with the *distinct processes assumption* or the *integrated processes assumption*. We aimed to show that intuitive and deliberate decisions are not clearly distinct in that the instruction to deliberate does not necessarily lead to completely different processes of rule-based decision making, but that deliberation only adds to automatic processes. In general, we are most interested in big differences indicating qualitatively different behavior.

1.2 Probabilistic inference tasks and cue-weighting schemes

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, from 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 (e.g., Doherty & Brehmer, 1997; Birnbaum & Mellers, 1983; Brehmer, 1994; Glöckner & Betsch, 2008a; Glöckner & Betsch, 2008c). Crucially, as Glöckner and Betsch (2008c) point out, choices in line with a WADD scheme do not necessarily imply a conscious calculation of weighted sums. Rather, a weighted additive cue integration can be approximated by automatic processes within a short amount of time. 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). Here, we put aside this debate on decision quality in order to focus on process properties which have been mainly neglected so far.

1.3 Fixation duration and cognitive processes

It has been shown that classic decision methodology such as Mouselab (Payne et al., 1988) sometimes hinders 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. 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; 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 ($N = 10$) to deliberately apply a WADD strategy by calculating weighted sums in a city-size task. Participants completed ten city-size tasks with 3 cues and eye-tracking parameters were recorded. In line with our hypothesis, long fixations (> 500 ms) were observed very often (see Figure 1). The mean fixation duration was 386 ms and long fixations accounted on average for 18.5 percent of all fixations. These pre-study results suggest that conscious and calculation-based processes are associated with a relatively high number of long fixations taking into account that also short fixations due to pre-attentive scanning processes, which are inherent to visual search (e.g. Velichkovsky et al., 1995), occur. Consequently, fixation duration is a reliable parameter for levels of processing, for the probabilistic inference tasks we employed in our study.[1]

[1] It should be kept in mind, however, that eye-tracking has some limitations. We can, for instance, move our attention without moving our eyes and there can be spillover effects in which the time processing one

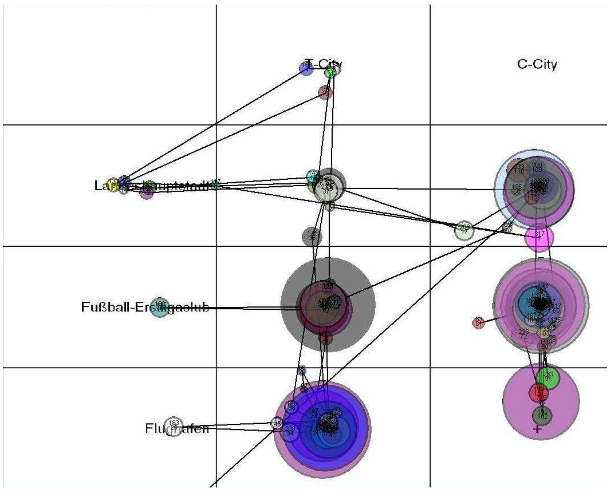

Figure 1: Example of a scanpath for a participant instructed to calculate weighted sums in a simple city-size task. Fixations are illustrated by circles and circle diameter indicates fixation duration. The lines represent saccades.

1.4 Detailed research questions and hypotheses

We aimed to test whether intuitive and deliberate decisions induced by instructions are indeed based on very different and separable processes, as implied by the *distinct processes assumption*: do people really switch between a deliberate serial and rule-based integration of information on the one hand, and automatic-intuitive processes on the other hand? Or is decision behavior more in line with the *integrated processes assumption* stating a common automatic process which underlies all kinds of decision making that is only supplemented with additional processing steps in the deliberate decision mode? As mentioned above, most dual-process theories are not well specified and no single theory makes predictions concerning eye-tracking parameters. Therefore, we focused on broad predictions following the *distinct processes assumption* or the *integrated processes assumption* and tried to translate them into well-established eye-tracking parameters.

According to the *distinct processes assumption*, intuition should be based on less controlled, fast information integration processes. In contrast, in a hypothetical pure deliberate decision mode, information is likely to be investigated in a serial, stepwise manner and it should be directly integrated because of working memory capacity constraints. Such a process would be similar to the conscious mathematical calculation that we investigated in our pre-study.

Following the *integrated processes assumption*, a primacy of intuitive processes is assumed which are always activated as a default mode. Accordingly, there is not necessarily a clear distinction between decision behavior if individuals are instructed to use one or the other mode. Intuitive processes of quick information search and automatic scanning are always activated in advance and/or simultaneously, and they are only supplemented by additional deliberate processes. Therefore, a pure deliberate decision mode does not exist. 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.

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 *distinct processes assumption* and the *integrated processes assumption.*

Fixation duration. According to the *distinct processes assumption*, 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 *integrated processes 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

object can "spill over" onto the next object (Rayner, 1998). Nevertheless, "in all eye-tracking work, a tacit but very important assumption is usually accepted: we assume that attention is linked to foveal gaze direction, but we acknowledge that it may not always be so" (Duchowski, 2007, p12).

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 *distinct processes perspective* 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 the *integrated processes assumption,* 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. According to the *distinct processes assumption*, the capacity of the deliberate decision mode is more 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 consistent with the *integrated processes assumption*, 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 *distinct processes 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 the *integrated processes assumption*, 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-checking 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/EQW) or complex (WADD) cue-weighting schemes. Please note that choices in line with a WADD scheme do not necessarily imply that the decision is based on conscious calculation, as induced in our pre-study. According to the PCS-model (Glöckner & Betsch, 2008b), as well as to decision field theory (Busemeyer & Johnson, 2004; Busemeyer & Townsend, 1993), a weighted additive information integration can be approximated by automatic processes.

Table 1: Overview of experimental design for Study 1.

	Between-participant manipulation of decision mode (INT vs. DEL)	
Task characteristics	Part 1	Part 2
Material	city-size task	legal task
Complexity	high vs. low	high

Note. INT = Intuition; DEL = Deliberation.

Table 2: Overview of experimental design for Study 2.

	Within-participant manipulation of decision mode		
Order	t1	t2	t3
1	DEL	INT	DEL
2	INT	DEL	INT

Note. INT = Intuition; DEL = Deliberation; t1 = test time 1; t2 = test time 2; t3 = test time 3.

1.5 Overview of studies

In two eye-tracking studies, we tested these hypotheses in the classic city-size task, using different levels of complexity (Study 1, Part 1), in complex content-rich legal inference tasks (Study 1, Part 2; see Table 1) as well as in an extended within-participants design (Study 2; see Table 2). 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; it might, however, influence strategies of information search in explicit information display-boards. Hence, we investigated task complexity in Part 1 of Study 1.

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, in press; Pennington & Hastie, 1992; Pennington & Hastie, 1993). Accordingly, we also investigated decision behavior in a content-rich legal setting in Part 2 of Study 1. Note that in Study 1 the same participants worked on Part 1 and 2 and we counterbalanced order. For pragmatic reasons, we report the results of both parts separately, starting with the part concerning our complexity manipulation.

A third issue concerns the manipulation of decision modes. Several different methods have been employed to induce intuitive and deliberate decision making (Horstmann, Hausmann, & Ryf, in press); however, as direct instructions to use one or the other mode have been applied most frequently (e.g., Wilson & Schooler, 1991), we also implemented instructions in our studies. Of course, instructions might be misunderstood or ignored by participants and one cannot be completely certain that the instruction was effective (see Horstmann et al., in press). Aside from using standard manipulation checks, we aimed to weaken this critique by replicating the results in a second study, in which we tested a few participants in an extended within-participants design over several days (see Table 2). A second purpose of Study 2 was to test the stability of specific instructions over two separate test times.

2 Study 1, Part 1: Manipulation of decision mode in simple and complex city-size tasks

2.1 Method

Participants and design. Twenty students (age: M = 26.3, SD = 5.0), seven of them females, 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. We manipulated Decision Mode 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).

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 pix-

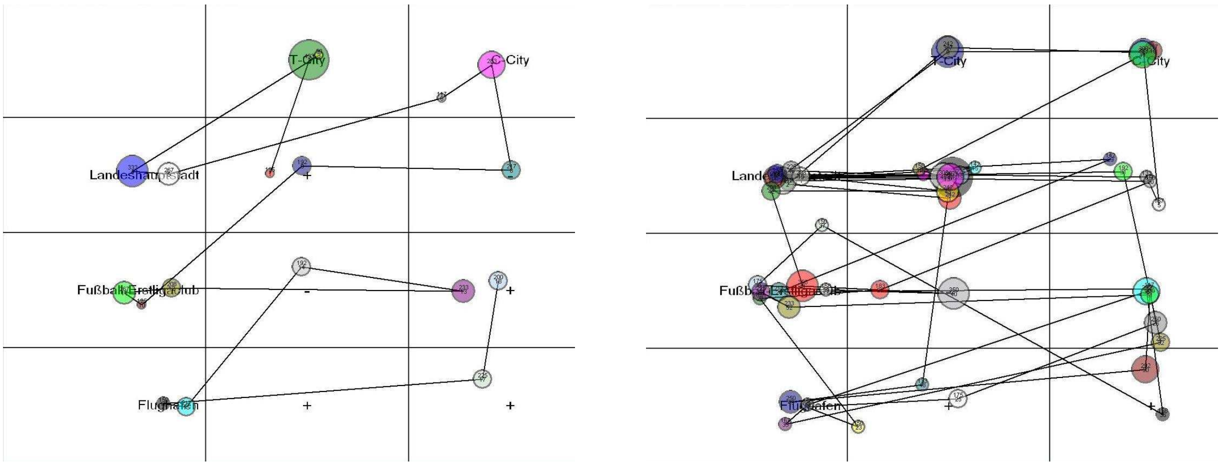

Figure 2: Example of scanpaths in a simple city-size task under the instruction to decide intuitively (left) and deliberately (right). Fixations are illustrated by circles and circle diameter indicates fixation duration. The lines represent saccades.

els 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 ($\geq$ 150 and < 500 ms) and long ($\geq$ 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.

2.2 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 (as shown in Figure 1). We found (as we report in detail below) very few long fixations ($\geq$ 500 ms) which would indicate a high level of processing, as compared to the fixations observed when individuals were instructed to calculate weighted sums. Hence, on a descriptive level, the data are more in line with the *integrated processes assumptions*.

Table 3: Means and standard errors for eye-tracking parameters study 1.

	Part 1[a]				Part 2[a]	
	3 cues		12 cues		12 cues	
Eye-tracking parameters	INT	DEL	INT	DEL	INT	DEL
Decision time in s	4.99	6.76	12.82	17.59	8.59	13.06
Single fixation duration in ms	168.35	167.70	177.37	181.20	180.51	185.51
Number of fixations	10.35 (0.85)	16.11 (2.50)	34.36 (2.97)	51.35 (5.25)	21.44 (2.51)	31.30 (3.67)
Amount of inspected information in %	79.17 (3.51)	87.33 (2.29)	67.50 (2.21)	75.54 (2.35)	48.71 (3.44)	58.20 (2.41)
Number of repeated information inspections	4.50 (0.60)	8.54 (1.58)	13.26 (2.14)	25.57 (3.63)	6.53 (1.27)	12.56 (2.40)
Direction of information search (SM-index)	−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.

Manipulation check / decision time. To determine whether our manipulation of Decision Mode was efficient, we analyzed individuals' decision times (as done by 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, $F(1, 18) = 5.17$, $p = .04$, $\eta^2 = .22$ (for all descriptive statistics see Table 3). 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 level 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.

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, $F(1, 18) = 8.17$, $p = .01$, $\eta^2 = .31$. 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, $F(1, 18) = 5.38$, $p = .03$, $\eta^2 = .23$. 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 amount of information was indeed taken into account when making a decision, the total number of fixations reported above is only partially meaningful. We therefore calculated the percentage of information the participants attended to before reaching their decisions 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 the amount of inspected information. The main effect of Decision Mode was significant, with participants in the deliberate condition searching for more information, $F(1, 18) = 6.52$, $p = .02$, $\eta^2 = .27$. 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 took into account 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, $F(1, 18) = 5.93$, $p = .03$, $\eta^2 = .25$, 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, $F(1, 18) = 6.68$, $p = .02$, $\eta^2 = .27$. 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 regard-

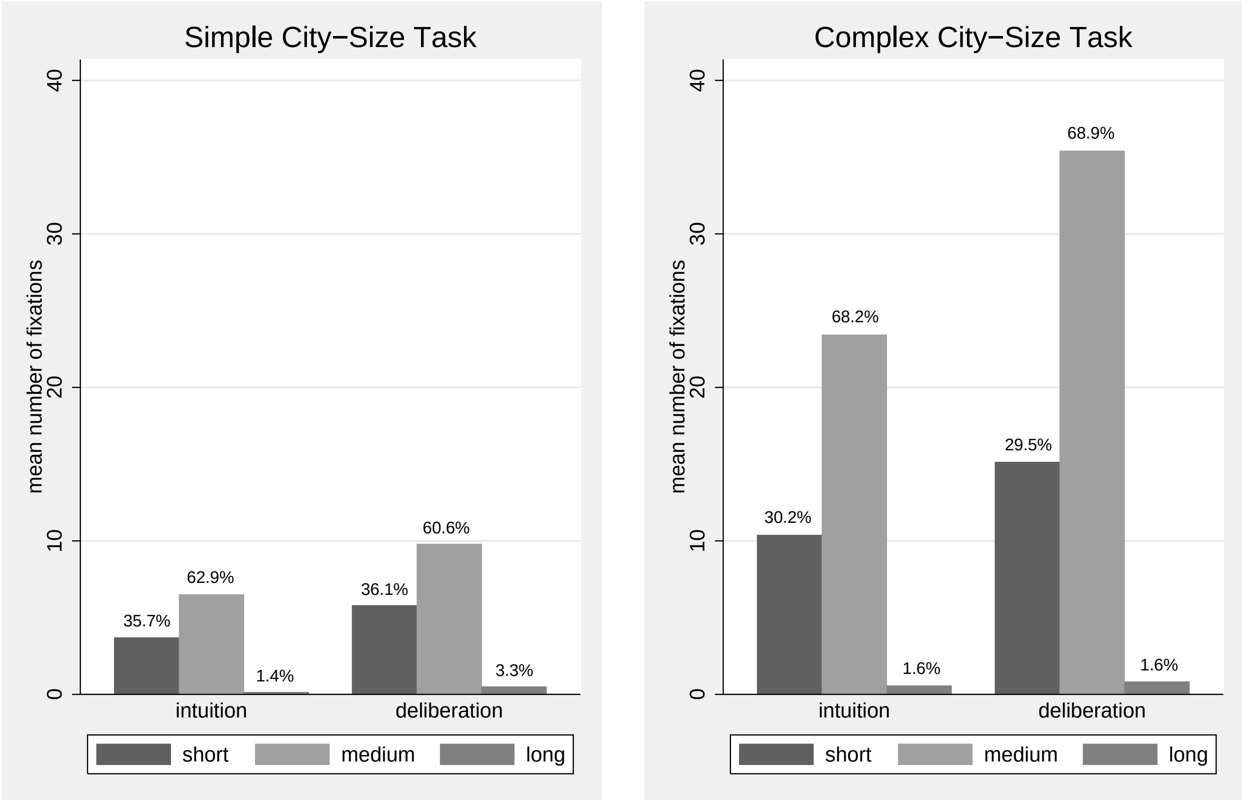

Figure 3: Number of short, medium, and long fixations averaged across participants and tasks for complexity and decision mode conditions in Part 1 of Study 1. Bar labels indicate the proportion of fixations for each category.

ing this strategy. If empirical and expected choices diverge, two points are ascribed. To 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 that participants assessed at the beginning of the experiment 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.

2.3 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 the *integrated processes assumption*, 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 decision mode showed a higher number of fixations compared to participants deciding intuitively. Further analyses revealed that the higher number of fixations in the deliberate decision mode was due to a higher percentage of inspected information and to more repeated information inspections. Hence, these analyses again support the *integrated processes assumption*.

The exploratory 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 decision mode 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 decision mode 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, because the 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.

Additionally, we investigated how complexity of the decision task 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 complex tasks and that participants use them more extensively if they are instructed to deliberate without having time constraints.

As mentioned above, Study 1 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 supplementary testing of the hypotheses in an enriched decision environment. In addition to 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).

3 Study 1, Part 2: Manipulation of decision mode in content-rich criminal cases

3.1 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 that content-rich legal inferences were used instead of the classic city-size task (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.

3.2 Results

Our results mainly replicate 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 Table 3).

Manipulation check / decision time. Again, intuitive decisions were made significantly faster than deliberate ones, indicating the successful manipulation of decision modes, $F(1, 18) = 5.16$, $p = .036$, $\eta^2 = .22$.

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, $F(1, 18) = 4.78$, $p = .042$, $\eta^2 = .21$.

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, $F(1, 18) = 4.89$, $p = .04$, $\eta^2 = .21$. 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, $F(1, 18) = 4.93$, $p = .039$, $\eta^2 = .22$.

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).

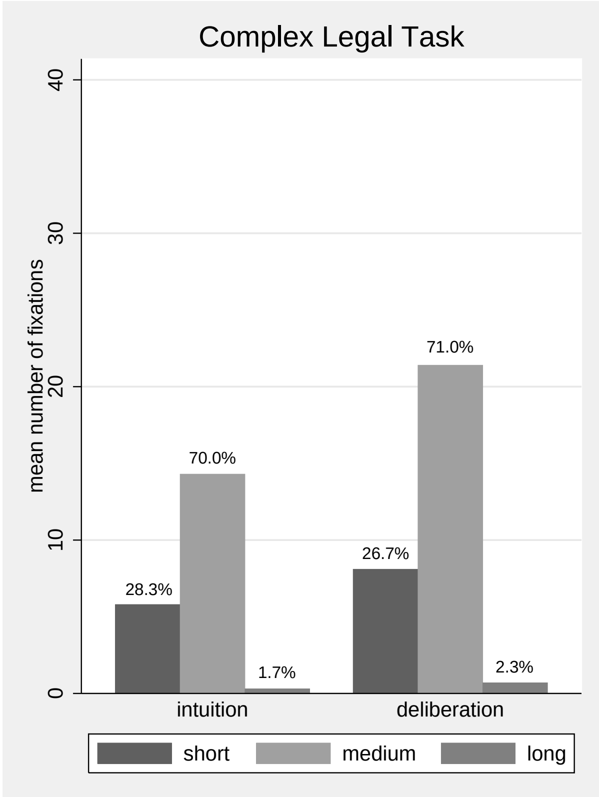

Figure 4: Number of short, medium and long fixations averaged across participants and tasks for decision mode conditions in Part 2 of Study 1. Bar labels indicate the proportion of fixations for each category.

3.3 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 the *integrated processes assumption* 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

Table 4: Means and standard errors for eye-tracking parameters study 2.

	Order 1[a]			Order 2[b]		
	t1	t2	t3	t1	t2	t3
Eye-tracking parameters	DEL	INT	DEL	INT	DEL	INT
Decision time in s	11.62	3.84	10.05	8.32	14.60	2.99
Single fixation duration in ms	206.18	191.88	204.28	187.16	193.83	180.13
Number of fixations	21.28 (3.58)	8.20 (1.21)	17.92 (5.32)	17.93 (4.12)	24.05 (4.52)	8.37 (1.76)
Amount of inspected information in %	47.22 (4.62)	25.56 (3.25)	42.57 (8.26)	44.24 (5.60)	49.86 (3.91)	27.50 (5.75)
Number of repeated information inspections	7.58 (1.78)	1.47 (0.35)	5.60 (2.35)	4.82 (1.72)	8.27 (2.17)	1.17 (0.27)

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 = 3. [b]n = 3.

complex tasks in Part 1 and Part 2 of Study 1 (i.e., lower decision times, smaller number of fixations, smaller amount of inspected information and less repeated inspections in Part 2, see Table 3). 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. In any case, we cannot rule out that the presentation format also partially accounts for the effect.

In Study 1, we induced decision modes by means of instructions in a between-participants design. In Study 2, we investigated whether the effects can be replicated with different participants and whether they hold in a within-participants design.

4 Study 2: Within-participant manipulation of decision mode

4.1 Method

Participants and design. In an extended within-participants design, six students (age: M = 21.5, SD = 1.0), five females and one male, with different majors from the University of Bonn, were tested over several days, again using eye-tracking technology. During one week, they were tested on three different days (Monday, Wednesday, and Friday), representing the factor Test Time, and each time they completed 20 decision trials (factor Task). Participants were paid a flat fee of € 25. The Decision Mode was manipulated within-participants and Order was manipulated between-participants. Participants assigned to order 1 (DEL — INT – DEL) were administered the instruction to decide deliberately at test time 1 (t1), followed by the intuitive decision mode instruction at time 2 (t2), and finally had to decide deliberately again at time 3 (t3). In order 2 (INT — DEL –INT), the other half of the participants started with the intuitive decision mode instruction (t1), then had to decide deliberately (t2) and finished by making intuitive decisions again (t3).

Materials and procedure. The experimental procedure was completely matched to Study 1, Part 2, except for the fact that the decision mode instructions for t2 and t3 emphasized to decide intuitively or deliberately in contrast to the last time (see Appendix C). The material was also held constant by again using the complex content-rich legal inferences from Study 1, Part 2. For t1 and t3, the same 20 cue patterns were used, but their presentation order was randomized differently, whereas for t2 an inverted version (i.e., options were presented in different order) was provided.

Table 5: Analyses for eye-tracking parameters Study 2.

Eye-tracking parameters	Order 1[a]				Order 2[b]			
	df	*F*	*p*	η^2	*df*	*F*	*p*	η^2
Decision time								
Test Time	2,4	69.99	.001	.97	2,4	19.31	.009	.91
L_{mode}	1,2	120.97	.008	.98	1,2	37.94	.025	.95
L_{stab}	1,2	2.37	.263	.54	1,2	11.23	.079	.85
Single fixation duration								
Test Time	2,6.1	0.54	.610	.15	2,6.4	1.18	.368	.27
Number of fixations								
Test Time	2,4	8.89	.034	.82	2,4	12.71	.018	.86
L_{mode}	1,2	12.98	.069	.87	1,2	24.75	.038	.93
L_{stab}	1,2	1.53	.342	.43	1,2	6.90	.120	.78
Amount of inspected information								
Test Time	2,4	15.12	.014	.88	2,4	20.27	.008	.91
L_{mode}	1,2	34.33	.028	.95	1,2	137.29	.007	.99
L_{stab}	1,2	1.09	.406	.35	1,2	11.29	.078	.85
Number of repeated information inspections								
Test Time	2,4	7.22	.047	.78	2,4	8.91	.034	.82
L_{mode}	1,2	9.63	.090	.83	1,2	15.58	.059	.89
L_{stab}	1,2	2.24	.273	.53	1,2	4.06	.181	.67

Note. Decision time was analyzed by a 3(Test Time) x 20(Task) repeated-measurement ANOVA with log-transformed decision time as dependent variable. Number of fixations, amount of inspected information and repeated information inspections were analyzed by equivalent analyses with the respective dependent variables. Log-transformed single fixation duration was analyzed by means of an ANOVA with Test Time as independent variable and Participants as additional random factor accounting for the repeated-measurement design. L_{mode} denotes the contrast between test time 1 and 3 vs. test time 2, L_{stab} denotes the contrast between test time 1 vs. 3.

[a]n = 3. [b]n = 3.

4.2 Results

All within-participant analyses were conducted separately for order 1 and 2 (for descriptive statistics, see Table 4). In case the main effect of Test Time turned out significant, we computed two orthogonal contrasts: one comparing differences between decision modes (L_{mode}) and the other investigating stability over time (L_{stab}). Specifically, L_{mode} denotes the comparison between t1 and t3 versus t2 and L_{stab} represents the comparison between t1 and t3. We expected differences for the former and no or smaller differences for the latter. Due to small sample size (N = 6), we did not analyze choices. Furthermore, we did not include analysis of search direction either.

Overall, within-participants results nicely replicate the findings from Study 1 (for statistical details, see Table 5). Participants showed lower decision times, less fixations, fewer repeated information inspections and investigated a lower proportion of the available information under the intuitive as compared to the deliberate instruction. The mean duration of single fixations did not differ significantly between conditions. Nevertheless, there was a slight trend towards longer fixations under the instruction to deliberate (Table 4). For order 1, in which participants were instructed to deliberate on the first test time, there was a relatively high stability of parameters between t1 and t3. In order 2, in which participants were asked to decide intuitively on the first test time, although

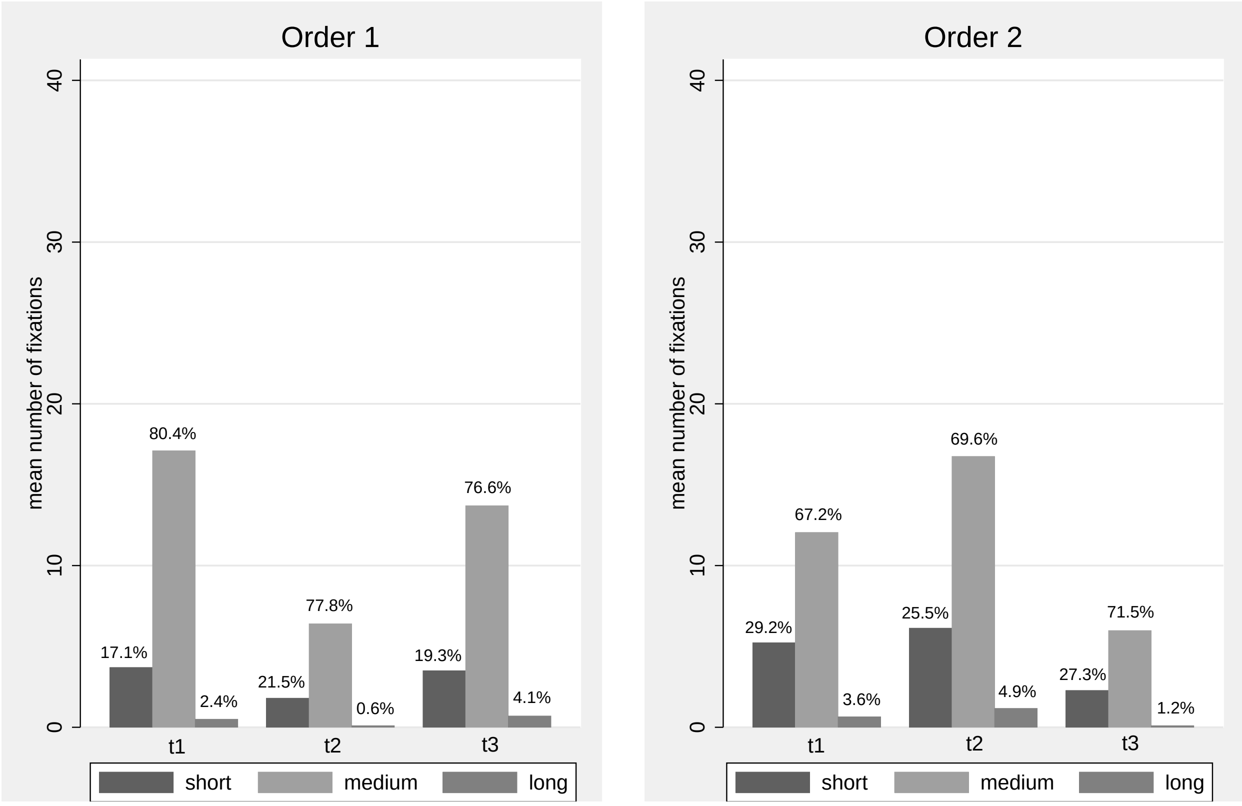

Figure 5: Number of short, medium, and long fixations averaged across participants and tasks for test times in order 1 (DEL — INT – DEL) and order 2 (INT — DEL — INT) in Study 2. Bar labels indicate the proportion of fixations for each category.

the general pattern did hold, there was a decrease in all parameters from t1 to t3, suggesting that intuition profits stronger from repetition than deliberation.

To test in more detail if decision mode instructions influenced fixation duration, χ^2 tests of independence between Test Time and Time Category were calculated separately for order 1 and order 2 with the number of short, medium, and long fixations averaged across participants. In both orders, the decision mode instruction did not influence the distribution of single fixation duration, order 1: $\chi^2(4, N = 948) = 6.97.$, $p = .137$, $\hat{w}^2 = .01$; order 2: $\chi^2(4, N = 1007) = 5.79$, $p = .216$, $\hat{w}^2 = .01$. Overall, fixations of the medium and short time category prevailed, accounting for 74 and 23 percent of fixations, whereas long fixations (3 percent) rarely occurred (Figure 5). Nevertheless, a slight tendency towards more long fixations in the deliberate condition can also be observed in the time category data presented in Figure 5.

4.3 Discussion

In Study 2, we aimed to replicate our results concerning the effects of decision mode instructions from Study 1 in an extended within-participants design over three consecutive test times. Overall, the results are in line with previous findings: namely, decision times were again longer under the deliberate instruction and more fixations, a higher amount of inspected information as well as a higher number of repeated inspections were observed compared to intuitive decisions. In contrast to Study 1, we descriptively saw a slight but consistent tendency towards longer fixations in deliberate decisions. Due to the small number of participants resulting in low power of the analysis, we cannot rule out a corresponding effect (i.e., the beta-error level can be expected to be rather high). Nevertheless, in both orders, the mean fixation durations for t1, t2 and t3 differ by only about 12 ms and fall into the medium time category (see time classification Study 1). Furthermore, the distribution of short, medium and long fixations did not differ between decision modes. Hence, the data in Study 2 do not indicate a qualitative shift in processing between the decision mode instructions either. In sum, the results provide additional support for the *integrated processes assumption*.

A second purpose of Study 2 was to test the stability of the effects induced by decision mode instructions. For the deliberate instruction, we found no difference in crucial eye-tracking parameters over two separate test times, indicating stable effects. Concerning the intuitive instruction, all eye-tracking parameters were lower by trend when participants were tested again. These findings suggest that intuition might have benefited from repeated experience with a decision task and training effects occurred (cf. Hogarth, 2001; Klein, 1993; Sadler-Smith, 2008).

5 General discussion

Recent studies comparing intuition and deliberation have often focused on decision quality and neglected the specific cognitive processes underlying intuitive and deliberate decision modes. We manipulated decision modes experimentally and examined effects on information search and integration using eye-tracking technology.

We asked whether intuitive and deliberate decisions induced by instructions are indeed based on completely different and separable processes (*distinct processes assumption*) or, alternatively, whether deliberation just adds some additional features to the basic intuitive process (*integrated processes assumption*)? In Study 1, 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. In Study 2, we extended our analysis to a within-participants design, in which we additionally tested the stability of the effects induced by decision mode instructions.

Altogether, our findings indicate that the instruction to deliberate does not induce qualitatively different information processing compared to instructions to decide intuitively. Our results seem to be in line with the *integrated processes assumption*. In both studies, mean single fixation duration and the distribution of short, medium and long fixations did not differ between the intuitive and the deliberate decision mode. 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. However, we do not intend to say that deliberation is never calculation- or rule-based. In fact, the results from our pre-study suggest that participants are able to calculate weighted sums if they are explicitly instructed to use calculation. Rather, we argue that instruction-induced deliberation is not necessarily a completely serial, stepwise and rule-based process.

Our exploratory analyses in Study 1 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 Study 1, intuition resulted in a cue-wise search 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 of Study 1, 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). They are also in line with process analyses of decisions under risk showing that expected-value choices rarely result from deliberate calculations of weighted sums (Cokely & Kelley, 2009; Glöckner & Herbold, 2008).

Three caveats of our study should be noted. First, although our results concerning the effects of specific instructions on decision mode are clear-cut, it is possible that instructions cannot be used to induce distinct processes efficiently, or that processes are in fact integrated. The former would highlight a fundamental methodological issue of intuition research; the latter would have broader theoretical implications. In light of the evidence we have presented, we think that a mere explanation by methodological issues will not be sufficient. Further research is, however, necessary to investigate this question more thoroughly.

Second, our participants were assigned to the same decision mode condition in Part 1 and 2 of Study 1 to avoid carry-over effects. Although we counterbalanced order, the low number of participants does not allow a reliable analysis of order effects. Hence, observations in the two parts were not independent, thus lowering the validity of the within-participants replication of the effects for different material. However, Study 2 validates the generalization of the decision mode manipulation from simple to more content-rich material in an independent sample. Furthermore, in Study 2 we used a more sensitive design in that we manipulated decision modes within participants. We not only replicated our findings from Study 1 but we also found even stronger effects of our decision mode manipulation on all basic process measures.

A third issue which is related to the first one 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). However, independent of the question which kind of deliberation is induced by a specific instruction, a crucial finding of Study 2 was that deliberate instructions induced stable effects over different test times. In contrast, intuitive instructions seem to be less stable over repeated measurements, possibly due to training effects.

In conclusion, intuition and deliberation do not seem to be completely distinct processes. 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, the reported studies add 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.

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Appendix A: Instructions to manipulate intuitive and deliberate decision modes in Study 1

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

	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	-	+

Complex city-size task

	C-Town	F-Town
Zoo	+	+
Dom	-	+
Westdeutschland	-	+
Landeshauptstadt	-	-
Autokennzeichen	+	+
Opernhaus	+	-
Fußball-Erstligaclub	-	-
Messestadt	+	-
U-Bahn	-	-
Universität	+	+
Flughafen	+	-
DAX-Unternehmen	-	-

Complex legal task

	E-City	R-City
Landeshauptstadt	+	-
Fußball-Erstligaclub	-	+
Flughafen	+	-

Appendix C: Supplement to decision mode instructions for test time 2 and 3 in Study 2

Please note that in contrast to the last test time you are now asked to decide according to the following instruction: