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Scrutinizing the Emotional Nature of Intuitive Coherence Judgments

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ABSTRACT

Dual-system models propose that cognitive processing can occur either intuitively or deliberately. Unlike deliberate decision strategies, intuitive ones are assumed to have an emotional component attached to the decision process. We tested if intuitive decisions are indeed accompanied by an emotional response while deliberate decisions are not. Specifically, we conducted a psychophysiological study in which participants were instructed to decide either intuitively or deliberately if three simultaneously presented words were semantically coherent or incoherent (triad task). The degree of emotionality of these two decision strategies (intuitive vs. deliberate) was compared using changes in electrodermal activity (EDA) and the reaction time (RT) effect of an affective priming paradigm as primary measurements. Based on a valence-arousal model, our results revealed that intuitive and deliberate judgments do not differ as to their emotional *valence* but that they do differ in emotional *arousal*. Most notably, sympathetic activation during intuitive judgments was significantly lower compared to sympathetic activation during deliberate judgments. Our results reflect that a relaxed state of mind—manifested in low sympathetic activity—could underlie the holistic processing that is assumed to facilitate the proliferation of semantic associations during coherence judgments. This suggests that coherence judgments made under an (instructed) intuitive decision mode have a specific psychophysiological signature and that arousal is the differentiating component between intuitive and deliberate decision strategies. © 2016 The Authors Journal of Behavioral Decision Making Published by John Wiley & Sons Ltd.

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KEY WORDS dual-system models; intuition; semantic coherence judgments; emotional arousal; emotional valence; affective priming; skin conductance responses

INTRODUCTION

Imagine being offered two new jobs on the same day. What would you decide? And how would you make that decision? Sometimes, you might just *feel* which option to choose without being able to explicitly state why you would prefer the one over the other. You might have a strong impression that one of the options fits your needs better than the other and so *feels* best for you. At other times, you might spend quite a bit of effort painstakingly weighing the pros and cons of the different job options (e.g., scope of duties, salary, where the company is located) as you try to reach a decision.

Based on this processing phenomenology, scholars have argued that judgments are formed via two qualitatively distinct processes or systems, which have been neutrally termed System 1 (intuition) and System 2 (deliberation) (Epstein et al., 1996; Evans, 2003; Kahneman, 2003; Schneider & Shiffrin, 1977; Sloman, 1996; Stanovich & West, 2000; Strack & Deutsch, 2004). Such dual-system models characterize intuitive and deliberate judgments in terms of several presumably aligned aspects—one of which is emotional.[1] That is, intuitive judgments are suggested to specifically be emotional or emotionally charged in contrast to deliberate judgments, which are suggested to be affectively neutral (Kahneman, 2003; Dane & Pratt, 2007; Sadler-Smith, 2008; Zeelenberg et al., 2008). For instance, concerning intuitive judgments it has been argued that "If it doesn't feel right, the chances are slim that a person acts on it" (Zeelenberg et al., 2008, p. 173). Vaughan (1979) suggests that, conceptually, intuitions enter consciousness through feelings, that is, instances of immediate liking or disliking for no apparent reason. Along these lines, Strack and Deutsch (2004) argue that "[t]he impulsive system generates a simply structured state of core affect that, by reflective processes, can be transformed into more elaborate feelings and emotions" (p. 237). They suggest that people experience this core affect in the two dimensions of hedonic quality (valence) and arousal, and thus may "feel good or feel bad in a way that is accompanied by high or low activation" (p. 237). In this way, emotionality of intuitive judgments is conceptualized within a two-dimensional valence-arousal model, with valence referring to the degree of pleasantness/positivity versus unpleasantness/negativity, and arousal referring to the strength of the experienced emotion, ranging from calm to excited (Hamann, 2012; Russell, 1980; Russell & Barrett, 1999). Arousal within a two-dimensional

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[1]Despite the large number of contributions that support the dual-systems view both theoretically and empirically, such theories have nevertheless recently come under fire. For detailed critiques and neuronal evidence against the dual-system assumptions, please consider contributions by Keren and Schul (2009), Kruglanski and Gigerenzer (2011) and Mega et al. (2015), as well as volume 8 of *Perspectives on Psychological Science* (2013).

framework is generally considered to be represented by sympathetic forms of activation, such as heartbeat, sweating or readiness for action (Fontain et al., 2007).

According to dual-system models, deliberate judgments in contrast to intuitive judgments have been thought to be emotionally neutral, that is, free of any affective impulses or emotional signals that may *disturb* the deliberate processing (Kahneman, 2003; Epstein, 1994; Haidt, 2001; Hodgkinson et al., 2008; Metcalfe & Mischel, 1999). However, it has to be emphasized that this contradicts evidence on the exciting interplay between affect and thinking in judgment and decision making. For example, Schwarz (1998) and Forgas (1995) review work showing that positive affect fosters heuristic processing (in terms of relying on preexisting knowledge structures and with a gestalt-like apprehension of percepts) and negative affect promotes a systematic, deliberate and detail-focused cognitive style of information processing. In this vein, for example, Bodenhausen et al. (2000), Bodenhausen et al. (1994) and Raghunathan and Pham (1999), to name only a few, present data that lend empirical support to the theoretical idea that affect can have an influence on cognitive processing in decision making. Thus, a substantial amount of evidence have demonstrated that affect also interacts with deliberation and not only with intuition, which renders a complete affect-free System-2 processing rather doubtful.

In this study, we set out to empirically test the widely accepted but (to our knowledge) yet untested assumption that intuitive decisions are indeed affective or emotional and that deliberate processing is not. To pursue this end, it is of importance first to determine when and where in the decision process emotion comes into play, so as to design the ideally suited experiment; and second to determine how the effects of emotion on decision making could be shown empirically.

When and where in the decision process do emotions come into play?

Researchers differ in their opinions about exactly what part of the decision process is influenced by emotion. In her review, Sinclair (2010) outlines that, across the different definitions of intuition, affect can play several roles, depending on the point in time when it influences the decision process: (i) affect as antecedent, that is, when feelings (e.g., mood or discrete emotions) foster or reinforce intuition by preceding the entire process of intuitive decision making, thereby exerting influence (facilitating or hampering) on it; (ii) affect as a process component (i.e., affect accompanies the entire decision process, being inherently a part of it); and (iii) affect as confirmation (i.e., when affect arises as a consequence of the decision, thereby giving the confirmatory feeling of having decided rightly or wrongly).[2]

Our review of the literature on intuitive decision making indicates that most of the work falls within Sinclair's (2010) category "b"; that is, emotional or affective signals are conceived of as a process component and thus as inherent in the intuitive decision-making process (e.g., Epstein, 2010; Schwarz & Clore, 1988; Topolinski & Strack, 2009a; Topolinski & Strack, 2009b). For instance, one such model that sees emotions as a necessary process component as well as a component for intuitive decisions in the semantic domain is what is commonly known as the fluency-affect intuition model (for a recent review, see Topolinski, 2011). According to this model, processing fluency (resulting from the ease of processing the decision task at hand) and a brief positive affect (resulting from this fluent processing) are the driving mechanisms of intuitive decision making as it is revealed in intuitive semantic coherence judgments (i.e., when spontaneously judging the semantic relation of word triads). Particularly, an increase in fluent processing is suggested to trigger a brief, mild, positive affect subjectively experienced as a feeling, which is seen in the model as essential for a semantic intuition to occur.

This framework essentially agrees with the "affect-as-information account" by Schwarz, Clore and colleagues (e.g., Schwarz & Clore, 1988; Clore et al., 2001; Clore et al., 2001; Schwarz & Clore, 1983; Schwarz & Clore, 1996): Both accounts propose that feelings are used as diagnostic information about the target of judgment. That is, people seem to attend to their feelings elicited while they process the task at hand, as if asking themselves, "How do I feel about it?" and then using those feelings as a basis for their judgment. In this sense, people tend to like what they feel good about and dislike what they feel bad about, which may in fact have consequences on subsequent actions (Schwarz & Clore, 1988; Kahneman, 2011).

In sum, current conceptions of intuition see emotional or affective signals as an inherent process component, providing consciously available feedback from non-conscious cognitive processes, and thus having an influence throughout the entire decision-making process rather than at any specific time.

Empirical measurement of affective signals

In this light, how can one measure these affective signals resulting from an individual's cognitive processes? From a more minimalist perspective, a measure of valence (i.e., the positivity or negativity of an experience) suffices to determine the effects of affect. In particular, the effects of affective content or processing can be demonstrated via their later impact on judgments of emotional properties of objects—a phenomenon that has been called affective priming. According to Eder et al. (2012) "[A]ffective priming effects denote faster responses when two successively presented affective stimuli match in valence than when they mismatch" (p. 436). In early affective priming studies, when participants were presented with paired words within a short interval of time, it was found that the evaluation of target-word valence was significantly influenced by the connotation of the prime

[2]Please be aware, that there are also other conceptualizations of emotions exerting influence on human behavior. Baumeister et al. (2007), for example, conceive of emotion as an inner feedback system that helps to regulate behavior. In contrast to the view on emotion as directly causing behavior, the authors endorse an indirect influence of emotions on behavior in that emotions serve as feedback following human behavior that enables to learn for the future.

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word (Fazio et al., 1986; Kensinger & Schacter, 2006; Lang, 1993; Hermans et al., 2008).

A broader view, however, would determine the impact of affect by means of a combination of two measures, namely, emotional valence and emotional arousal (e.g., fluency-affect intuition model, Strack & Deutsch, 2004; Topolinski, 2011). When this two-dimensional model is applied, additional information about arousal, represented by sympathetic forms of activation, is acquired. In this way, emotional states may be differentiated based on the level of arousal even if there is no discernible difference in valence. For instance, looking into the barrel of a gun and looking at a crying child equally elicit negativity, yet the *level* of arousal certainly differs. Accordingly, the affective signals in intuitive decisions can be measured with valence ratings alone in the more minimalist method, but from the broader perspective, they will be determined through a combination of valence and arousal. Valence measures, as outlined above, are commonly realized in affective priming paradigms, whereas the measurement of arousal has been frequently realized via psychophysiological recordings such as electrodermal activity (EDA) (Andreassi, 2007; Asahina et al., 2003; Bierman et al., 2005; Dawson et al., 2007; Figner & Murphy, 2011).

In this study, we conducted an empirical investigation of the widely endorsed assumption that intuitive judgments are emotional in comparison with deliberate decision making by testing the theory in two ways. Similar to Topolinski and Strack (2009a), we used what is known as the triads task, which asks for semantic coherence judgments of word triads (i.e., whether three words semantically belong together and if so which fourth word might describe the association[3]; cf. Bowers et al., 1990). Using a within-subject design, participants were instructed to make their coherence judgments intuitively in some of the experimental blocks (i.e., in intuition blocks) and to make their judgments deliberately in others (i.e., in deliberation blocks). We thereby planned to directly compare semantic coherence judgments (i.e., specifically in the case when participants correctly judged coherent triads as coherent) instructed to be performed either under an intuitive or a deliberate decision strategy. This comparison between two instructed decision strategies required a strict adherence to the instructions, which was carefully monitored via additional questionnaires intermediately applied between single experimental blocks (i.e., the between-block questionnaires, cf. Methods section and SuppInf_1). We also pursued two strands of analysis: The empirical assessment of the occurrence of emotional/affective experience in intuition vs. deliberation blocks by (i) a valence rating alone, and (ii) a combination of valence and arousal measures. The emotional valence was assessed using an indirect affective priming procedure and the emotional arousal by measuring EDA.

[3]In case a semantic link exists between the three words and thus a fourth word describes this link, the triad is called semantically coherent. Note that the fourth word is here called common associate (CA). In contrast, in cases where no such associative link between the three words exists (and consequently no CA), the triad is called semantically incoherent (e.g., Topolinski & Strack, 2009a; Bolte & Goschke, 2005; Bowers et al., 1990).

HYPOTHESES

According to the minimalist view, emotional effects in intuitive judgments (as gathered in intuition blocks) can be determined if the component of affective valence is significantly stronger than the one that occurs in deliberate judgments (as gathered in deliberation blocks). According to the broader view, emotional effects can be determined if both components (i.e., emotional valence and emotional arousal) show a significant increase in the intuitive condition over the deliberate condition.

To measure the component of emotional valence, we worked from the premise that judging the coherence of semantically coherent word triads functions as an indirect affective priming, manifesting itself in a subsequent task, namely a valence rating. Thus, judging coherent word triads intuitively as coherent shall result in shorter reaction times (RT) in the subsequent evaluation of positively charged items compared with the RTs that occur for negatively charged items. This affective priming procedure was indirect because it is not the affective values of the three words of a triad that is expected to affectively prime subsequent valence ratings separately, but the increased core affect valence that is evoked by the *processing of the entire triad* (cf. Topolinski & Strack, 2009a; Topolinski & Strack, 2009b). Therefore, we expected that after participants had judged a coherent triad as semantically coherent, RTs of positively charged pictures would be significantly faster than the RTs of negatively charged items (on the 5% level) because coherent triads and positively charged items would provide valence-congruent pairs that have been shown to constitute affective priming effects (Hermans et al., 2008). This priming effect was expected to be specific for intuitively performed judgments, that is, occurring in the intuition blocks alone.

For the component of emotional arousal, we anticipated that the EDA signal for intuitive coherence judgments (i.e., judging coherent triads as coherent in intuition blocks) would be significantly higher than for deliberate coherence judgments (i.e., judging coherent triads as coherent in deliberation blocks). This follows the finding of anticipatory, greater EDA responses in decision-making tasks, believed to reflect non-conscious information processing prior to the feeling-based decision (Bierman et al., 2005; Figner & Murphy, 2011; Bechara et al., 1997; Bechara et al., 2005). We focused our analyses on the coherent triads correctly judged as coherent. According to the fluency-affect intuition model validated by Topolinski and Strack (2009a, 2009b), processing fluency and subtle positive affect—building up on each other—are elicited only when processing coherent triads that are correctly classified as coherent; both are a result of the partial semantic activation of the CA in associative memory. Importantly, the increase in fluency in coherent triads is not related to the correctness of the answer but to the semantic activation of the solution concept in memory. That is, incoherent triads even if correctly judged as incoherent do not trigger a change in fluency because there is no CA that could facilitate the processing of the triad. Similarly, coherent triads, falsely classified as incoherent, do not activate the CA —at least not in the same extent as the correctly judged

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coherent triads do. Note that if this were the case, participants would classify the words as coherent (Topolinski & Strack, 2009a; Topolinski & Strack, 2009b; Topolinski, 2011). Please see the Methods sections to gain more information about the triads task.

MATERIALS AND METHODS

Participants

Forty-one female students from the University of Tuebingen in Germany participated in the study. Four of them had to be excluded because of technical problems with the EDA recording. They were all healthy adults without any reported history of neurological or psychiatric disorders. The mean age was 23.52 (SD = 3.07). In order to be included in the study, participants had to be: aged between 20 and 30, right-handed, female and native German speakers. These criteria were chosen to attain a maximum homogeneous sample for testing emotional responsiveness. Homogeneity was important because prior studies have shown that men and women differ significantly in their emotional responsiveness to affective stimuli (Whittle et al., 2011), as well as in their ratings of emotional properties (i.e., emotional valence and emotional arousal) of valenced pictures (Lang et al., 2008), which we used for the indirect affective priming procedure.

Ethics statement

The experimental procedure and data collection followed the ethical guidelines of the "Declaration of Helsinki" (revised version, 2012) formulated by the World Medical Association. They were reviewed and approved by the local ethical committee "Ethics Commission of the Medical Department and the University Hospital Tübingen". Participants were informed that they could quit the experimental session at any time without giving any reasons for that. All participants provided their written informed consent prior to the experiment and were paid 12 Euro per hour for their participation.

Experimental procedure

Within one trial, participants were first presented with a word triad (coherent or incoherent) and had then to indicate in a forced-choice manner whether they assessed the triad as semantically coherent or not—the *semantic coherence judgment*. Subsequently, participants were presented with either a positively or negatively valenced picture from the International Affective Picture System (IAPS) database (Lang et al., 2008) and had to indicate whether the picture just seen was positive or negative—the *valence rating*. Afterwards they were asked to type in a word that described a possibly associative link between the three words of the formerly presented triad (at the beginning of the same trial). The decision strategy about the coherence of the triad, that is, either intuitive or deliberate, was instructed block wise (please see Figure 1 for an overview of an individual trial, and Figure 2 for an overview of the experimental design). Using this experimental design, it could be tested whether the processing of the entire word triad (coherence judgment) affected the subsequent valence rating. In order to capture a potential influence of the coherence judgment on the valence rating, we separated the coherence judgment and the generation of the solution word by the valence rating. Hence, an active (i.e., explicit) search for a potential solution word of the respective triad would not interfere with the cognitive

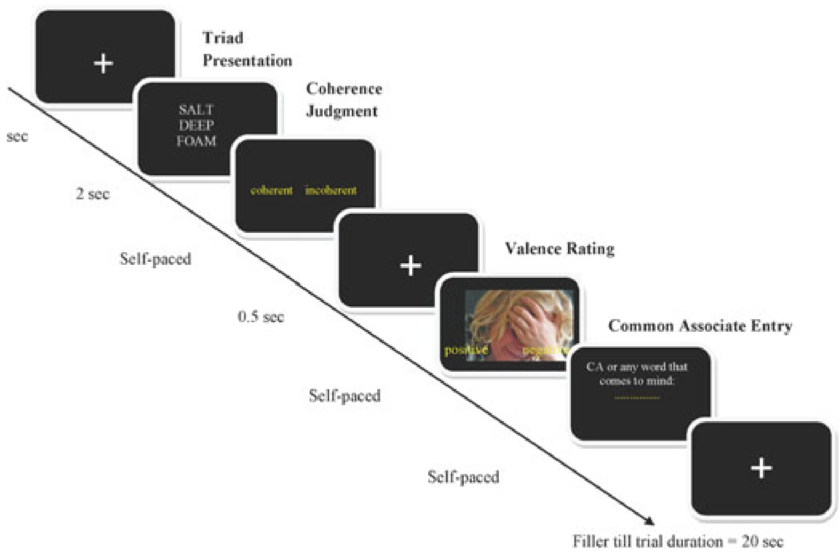

Figure 1. Schematic representation of a single trial. Each trial began with the presentation of a fixation cross. The triad was shown for 2 seconds. Afterwards the triad disappeared, and the participants immediately had to judge the semantic coherence of the triad (coherence versus incoherent). This semantic coherence judgment was self-paced insofar that only when participant had answered, the next part of the trial began. After that, valenced pictures from the international Affective Picture System database (IAPS) were presented and remained on the screen until the participant had judged its valence (positive versus negative). At the end of each trial, participants were asked to type in a possible common associate (CA) for the corresponding triad presented at the beginning of the same trial. Finally, the trial duration was filled up till a minimum 20 seconds was reached, which was important for the EDA measurement to avoid superimposing skin conductance responses (SCRs). [Colour figure can be viewed at wileyonlinelibrary.com]

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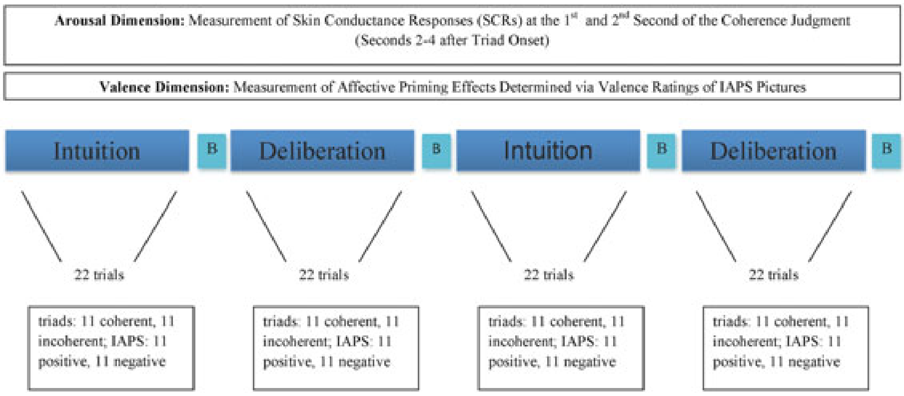

Figure 2. Schematic representation of the experimental paradigm. A within-subject design was applied in the participants instructed to work on the triads intuitively on some blocks (i.e., intuition blocks) and deliberatively on the other blocks (i.e., deliberation blocks). Half of the participants began the experiment with an intuition block, the other half with a deliberation block. Triads were randomized within and across the four blocks. Turquoise bars labeled with "B" depict the between-block questionnaires following each block of 22 triads, which serve as a control for strategy adherence (see SuppInfo_1). [Colour figure can be viewed at wileyonlinelibrary.com]

processing elicited by the judgment and thus would not disturb valence processing. Furthermore, by means of a within-subject procedure, it was tested whether this effect depended on the decision strategy, namely on an intuitive or a deliberate decision strategy.

In the following, we will describe in detail each of the components of the design; coherence judgment, valence rating, decision strategy instruction and specificities concerning the psychophysiological recordings.

Coherence judgment task

The semantic coherence task (i.e., the triads task) used in this study dates back to Bowers et al. (1990) and has been frequently used to study intuitive processing (e.g., Bolte & Goschke, 2005; Remmers et al., 2014; Topolinski & Strack, 2009a; Zander et al., 2015). For each trial of the task, participants were presented with word triads (i.e., three words at once presented below each other) that—unbeknownst to them—could be either semantically coherent or incoherent. The semantic coherence of the triads was characterized by the existence of a fourth concept that all of the words in the triad had (remotely) in common, the CA. For instance, the triad DEEP, FOAM, SALT has the CA SEA, or a close synonym. Semantically incoherent triads do not have such a fourth word in common. For instance, the different meanings of the triad's constituents DREAM, BALL, BOOK do not converge on a commonly associated word. After being presented with a particular triad for 2 seconds, participants had to assess its semantic coherence, that is, to indicate (via a button press) whether they thought the triad was coherent (index finger of the dominant hand) or incoherent (middle finger of the dominant hand). Participants could take their time when judging the semantic coherence. Response buttons for the coherent and incoherent options were balanced between participants.

The presentation of the triad (2 seconds) and the presentation of the response options (coherent/incoherent, unlimited time) were displayed consecutively. Accordingly, participants could only perform their coherence judgment when the triad had already vanished. This was done on grounds of the EDA recordings to specifically capture the coherence judgment process (for a detailed description please see section "EDA Recordings and Analyses"). At the end of the trial and after the valence rating participants were asked to type in a CA for the preceding triad. Participants could take their time when naming a possible CA. In order not to miss a possible CA, we applied a strict response criterion by which participants were obliged to type in a word in any case. If they could not think of an appropriate CA, participants were instructed to type in any word that came to mind at that moment. This procedure ruled out the possibility that a participant might refrain from naming a possible CA because of a lack of confidence (Bolte et al., 2003).

Altogether, participants worked on 88 triads (44 coherent and 44 incoherent) that were pseudo-randomized and organized in four blocks (i.e., 22 trials per block). Please consult SuppInf_2 for details regarding our careful selection of the judgment task material.

Affective valence rating of emotionally charged pictures (indirect affective priming procedure)

Based on our premise elaborated above, we assumed coherent triads to exert influence on subsequent valence ratings. Specifically, the RTs of positively charged pictures should be faster than RTs of negatively charged pictures. Because of the positive affect that drives the intuitive decision (Topolinski, 2011), this should only be the case in intuition blocks and not in deliberation blocks. Hence, directly after participants had judged the coherence of the triad, but before they typed in a CA, we presented them with mildly positive or negative pictures from the IAPS database (Lang et al., 2008). In the valence rating, they had to indicate whether that picture just seen was positive (index finger of the dominant hand) or negative (middle finger of the dominant hand). Response keys (positive/negative valence rating) were balanced between participants. The assignment of response keys (left versus right) was also counter-balanced across the two tasks semantic coherence judgment and IAPS valence rating. After

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this valence rating, participants had to type in a CA (or any word that came to mind) for that triad of the same trial (cf. Figure 1). Then the next trial began. Overall, 44 positive and 44 negative IAPS pictures were pseudo-randomly presented after the coherence judgments. Please consult SuppInf_3 for details regarding our careful selection of the valence task material.

Within-subject design: strategy instruction

We used a within-subject design in which two types of decision strategies—intuitive and deliberate—were instructed and counterbalanced across four experimental blocks. Each block started with brief instructions on how to solve the next 22 trials. In intuition blocks, participants were encouraged to respond *quickly and spontaneously*, and to rely only on their *gut feeling* to determine whether the triad was semantically coherent or not. Participants were told in the cover story that scientific studies had revealed that the next set of triads would best be answered by following a gut feeling *without expending any effort* in searching for the CA. In contrast, in the instructions for the two deliberation blocks, they were told that the next set of triads would best be answered by *thinking carefully* about the semantic relatedness of the three words, and they were encouraged in that way to *take their time before deciding* about the coherence of the triads. Because this study aimed at investigating the possibly emotional nature of intuitive responses (i.e., judging coherent triads as coherent in intuition blocks), the deliberate decision strategy was here used as a control condition. Moreover, we carefully checked whether participants indeed followed the instructed decision style, which was indispensable for our endeavor to compare intuitive and deliberate decision strategies in a within-subject design. In order to ensure that participants indeed adhered to the instructed strategy, we presented a between-block questionnaire after each experimental block, which consisted of 14 statements that reflected intuitive and deliberate processing (see Table 1). For a detailed explanation of the development and the rationale of the between-block questionnaire, please refer to SuppInf_1. In order to detect whether participants believed the cover story, we asked at the end of the experiment, whether they had found the instruction and the cover story plausible. No one reported having noticed any implausibility. Hence, with the application of the within-subject design, we successfully followed Horstmann et al. (2010)'s recommendation (i) to manipulate intuitive and deliberate processing by direct instructions and (ii) to use a strong manipulation check.

All instructions to participants were given on a computer screen. The experiment was programmed and run using Presentation software (version 14.9.07.19.11, www.neurobs.com) and was presented on a Samsung model T220 TFT display with a refresh rate of 60 Hz of a personal computer running Microsoft Windows XP 64bit.

EDA recordings and statistical analyses

As an indicator of emotional arousal, we measured skin conductance responses (SCRs), because this measure has been commonly used to study affective influences in judgment and decision-making research (Figner & Murphy, 2011). According to Figner and Murphy (2011), the "term electrodermal activity […] refers most generally to all (passive and active) electrical phenomena in the skin" (p.4), while SCRs, as one specific form of EDA, indicate "how well the skin conducts electricity" (p.4). SCR signals are based on changes in eccrine sweating. Eccrine sweat glands are innervated with sympathetic nerves, and thus the whole EDA process is related to activity in the sympathetic branch of the automatic nervous system. Therefore, SCRs can serve as indicators of sympathetic arousal. It has to be emphasized, however, that skin conductance is a "multifaceted phenomenon and does not reflect a single psychological process" (Figner & Murphy, 2011, p.2). But given that this method has been frequently used to indirectly study affective processes in decision making (e.g., Naqvi & Bechara, 2006), we decided to make use of it in the present study.

The EDA recording was conducted in accordance with the recommendations of previous psychophysiology research (Dawson et al., 2007; Figner & Murphy, 2011; Boucsein, 2012; Schandry, 1989; Stern et al., 2001). SCRs were recorded using BrainProducts (Munich, Germany) software via Ag/AgCl electrodes that were placed bipolarly on the index and middle fingers of the non-dominant hands of the participants. Because SCR signals are very prone to external influences like noise disturbance and weather changes

Table 1. Statements in the between-block questionnaires

Dimension	Contrary statements
1: Cognitive effort or exhaustion	"The last block was quite exhausting."
	"The last block was easy to complete."
2: Non-conscious processing	"I know the reasons why have decided the way I did for most of the triads."
	"I am not able to name the reasons for most of my decisions in the last block."
3: Fast processing (part 1)	"The decisions occurred mostly very sudden."
	"The decisions occurred slowly after a period of conscious reasoning."
4: Serial versus parallel processing	"I serially went through the triad, word for word"
	"I holistically looked at the triad"
5: Fast processing (part 2)	"I quickly arrived at a decision most of the time."
	"It took me some time to arrive at a decision."
6: Affect-driven processing	"My decisions were based on deliberation."
	"I spontaneously decided based on my gut feeling."
7: Positive affect	"Completing the last block was annoying."
	"Completing the last block was fun."

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(which could destabilize participants' thermoregulation), we reduced noise as much as possible and kept the room temperature at a constant 20 °C. To reduce possibly disturbing noise from the outside world to a minimum, participants wore earplugs during the whole experiment. Additionally, we always ran the experiments at the same time of day and followed a standard experimental procedure. No testing was done on days when weather conditions were markedly different from the days before.

The pre-amplification of the raw signal was done via a GSR MR module. The raw signal remained unchanged and was further processed offline. We conducted individual *z*-transformation for the SCRs before calculating inference-statistics to control for individual differences in the signal.

We took into account the fact that SCRs are relatively slow psychophysiological signals with a typical onset latency (i.e., time between the onset of the stimulus and the start of an SCR) between 1 and 3 seconds, and typical rise times (i.e., the time between the start of an SCR and its peak amplitude) ranging between 1 and 3 seconds as well (Figner & Murphy, 2011; Alexander et al., 2005) by setting the experiment's trial timing accordingly. Because we were interested in the EDA correlate of the intuitive coherence judgment, we carefully ensured that the time period between the two subsequent coherence judgments (i.e., the interstimulus interval) was sufficiently long enough for the SCR to reach its peak amplitude and after that to reestablish a new baseline before the next trial (see Figures 1 and 2). Thus, the minimum length of one trial was no fewer than 20 seconds.

The analysis of the psychophysiological data was completed using the program Ledalab (Benedek & Kaernbach, 2010a; Benedek & Kaernbach, 2010b). This approach avoids standard trough-to-peak techniques in favor of a continuous measurement of skin conductance. To cope with the problem of superimposing subsequent SCRs, Ledalab follows an extraction procedure of three steps that also controls for individual differences in the psychophysiological responses: (i) decomposition of the skin conductance data by means of deconvolution; (ii) estimation of tonic activity; and (iii) estimation of phasic activity. While tonic activity can be characterized as the stimulus-independent, slowly changing level that underlies the whole signal, phasic activity is the psychophysiological response directly evoked by the stimulus, which results in the SCRs that are used as indicators of the signal. In order to determine the magnitude of the response signal, Ledalab not only computes the amplitude of the response but considers temporal characteristics of the signal as well; by integrating the response signal (area under the curve), it circumvents the detection of local maxima and minima (Benedek & Kaernbach, 2010a; Benedek & Kaernbach, 2010b). Our results, detailed below, are derived from these integrated SCRs (iSCRs).

In order to exactly capture the psychophysiological correlate of the semantic coherence judgments made either intuitively or deliberately, we specifically analyzed the 1st and 2nd second of the coherence judgment. According to our trial timing, this means that we analyzed the seconds 2–4 after triad onset. Particularly, each triad was presented for 2 seconds; afterwards, the two response options were shown, and participants were asked for their coherence judgment. Note that at this time point the triad had already vanished (please refer to Figure 1). As Bolte and Goschke (2005) have demonstrated, intuitive judgments are fast; typically, participants are able to perform semantic coherence judgments in the first two seconds after the triad was shown. Thus, by analyzing the seconds 2–4 after triad onset, which takes into account that SCRs are slowly rising signals, we ensured that we psychophysiologically captured the exact time, when the semantic coherence judgments were made.

Statistical data analyses were carried out using IBM SPSS Statistics (version 20). We performed an outlier analysis for the RT data. All trials with latencies of more than 3 standard deviations above or below the individual mean for RTs of triad decision, IAPS decision and CA retrieval were excluded. A total of 127 (about 5%) of the trials were excluded according to this criterion.

RESULTS

Overall reaction times (RT) as a reflection of strategy adherence

The overall RTs of the coherence judgments in intuition and deliberation blocks differed significantly between the two decision strategies, that is, participants responded markedly faster in intuition block trials ($M = 2475$ ms $SD = 1352$) than they did in deliberation block trials (M = 6309 ms SD = 5622) ($t(27) = -4.3$, $p = .0001$). We take this finding to indicate—additionally to the results of the between-block questionnaires (see SuppInf_1)—that participants indeed followed our instructions, that is, they answered based on a feeling in the intuitive blocks and took more time to think about the triads in the deliberation blocks. This instruction effect on RTs seems to be specific to the coherence judgments, as intended, because there was no significant difference between intuition and deliberation blocks when participants indicated their IAPS valence ratings (RT of the IAPS judgment) ($t(27) = -1.79$, $p = .083$), nor was there a significant difference when they entered a CA (CA word RT) ($t(27) = .24$, $p = .806$).

Affective priming effects (RTs of the affective valence ratings)

From a minimalist point of view, we would expect shorter RTs in response to positively charged IAPS stimuli than in response to negatively charged IAPS stimuli after correct coherence judgments (i.e., coherent triads rated as coherent). This should be the case specifically in intuition blocks, as hypothesized above. For that reason, we used three different types of trials to determine a potential affective priming effect. Trial classification A contains coherent trials that are correctly classified as coherent, regardless of whether a CA was provided or not. On the other hand, Classifications B and C also took into account whether the triad was indeed solved (B) or unsolved (C). Paired samples *t*-tests of the IAPS RTs showed no significant differences between positively or negatively charged pictures for trial classification

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A (intuition blocks: $t(27) = -1.24$, $p = .225$; deliberation blocks: $t(27) = -1.32$, $p = .196$), trial classification B (intuition blocks: $t(25) = -.92$, $p = .364$; deliberation blocks: intuition blocks: $t(27) = -.65$, $p = .519$) or trial classification C (intuition blocks: $t(23) = -1.17$, $p = .251$; deliberation blocks: $t(27) = -1.43$, $p = .163$) (see Figure 3).

Affective priming effects for trials being most representative for intuitive and deliberate processing

A devil's advocate might argue that the instructed decision strategies were not adopted successfully by the participants, and we might thus not have selected trials that best reflected intuitive and/or deliberate processing. Accordingly, given the assumption that quickly answered trials probably reflect intuitive decision-making processes, and that more slowly answered trials reflect deliberate processes, we made a median-split based on individual RTs, irrespective of the objective-instructed condition (intuitive versus deliberate decision mode) for coherent triads that were correctly classified as coherent. As a result, we had trials answered below the median RT and trials answered above the median RT for each and every participant. Yet the results remained the same when we divided intuitive and deliberate coherent triads

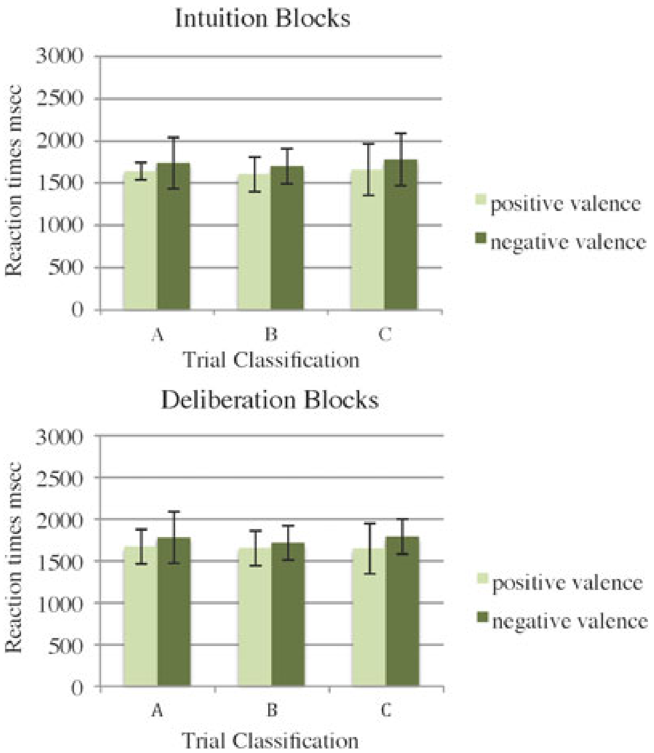

Figure 3. Reaction times of the valence rating. Reaction times (Rts) of the valence rating task are shown in milliseconds, separately for intuition blocks (A) and deliberation blocks (B) as well as for the three different kinds of trials. Error bars denote standard errors of the means. Abbreviation: A = Coherence triads that are correctly classified as coherent, regardless of whether a common associate (CA) was provide or not; B = Coherence triads that are correctly classified as coherent, and a CA could be provided; C = Coherent triads that are correctly classified as coherent, but a CA could not be provided (i.e., the triad remained unsolved). [Colour figure can be viewed at wileyonlinelibrary.com]

based on the RT median split: A *t*-test revealed that participants did not respond more quickly to positively charged pictures in the IAPS rating ($M = 1713$ ms, $SD = 524$ for the below-median trials; $M = 1680$ ms, $SD = 479$ for the above-median trials) than to negatively charged ones ($M = 1748$ ms, $SD = 447$ for the below-median trials; $M = 1725$ ms, $SD = 592$ for the above-median trials) after having classified coherent triads as coherent; neither did they do so for the individual trials answered below the median RT ($t(24) = -.37$, $p = .713$), nor for trials answered above the individual median RT ($t(24) = -.28$, $p = .783$).

Affective priming effects for small SOAs between coherence judgment and valence rating

As described in the methods section (cf. Figure 1), each experimental trial followed a self-paced procedure; whereas the triad was always shown for 2 seconds, the display of the coherence judgments, the valence ratings and the CA entries only ended after the participants' responses. Thus, the stimulus-onset asynchrony (SOA), that is, the time interval between the presentation of the affective prime (i.e. the word triad) and the presentation of the target (i.e. the IAPS) might be considered quite long here, which is different from standard research on direct affective priming processes. Yet, this long SOA was indispensable so as to investigate the EDA effects we are interested in. Specifically, as we have outlined above, it is not the valence of the triads' single constituents that is to produce the indirect affective priming, but the increased affect core valence that results specifically from *processing the entire coherent triad*. Thus, affect cannot be increased until the entire triad has been processed. Furthermore, as Bolte and Goschke (2005) have shown, these intuitive judgments are diagnostic only after 1500 milliseconds of processing a triad, but not after 1000 milliseconds or shorter, which indicates that the mechanism we are interested in needs time to develop. Along these lines, Topolinski and Strack (2009a) used an equally long SOA in a very similar priming paradigm and were able to report affective priming effects with this rather long SOA.

Furthermore, in order to rule out any objection concerning this issue, we considered only those trials for the affective-priming analysis in an additional analysis, where the SOA remained as short as possible. Separately for the objective-instructed conditions (intuitive versus deliberate decision mode), we only analyzed those triads that were (i) objectively coherent; (ii) correctly classified as coherent; and (iii) answered quickly (individually determined as below-median RT). To this end, we built on the before-mentioned median-split analysis and used only coherent trials for which RTs lay in the number range below the median RT in the coherence judgment, thus producing small SOAs. We were then able to compare the fastest RTs after correct coherence judgments for positive and negative IAPS pictures separately for the two objective-instructed conditions in a 2 (condition: intuitive versus deliberate) × 2 (IAPS valence: positive versus negative) ANOVA. In case an indirect affective priming effect was only present when SOAs are short, we should observe an interaction between the two factors in that responses to

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positive IAPS pictures (as compared with negative IAPS pictures) were faster in the intuitive condition than in the deliberate condition. Yet, this was not the case for our data (F (1,27) = .289, p = .595). We take this result to demonstrate that no indirect affective priming is present, not even for short SOAs.

Psycho-physiological results: lower arousal for instructed intuitive decisions

Following the two-dimensional model of affect (Hamann, 2012), we assessed the psychophysiological correlates of intuition blocks to complement the valence effects described in the previous section. The emotional arousal involved on the intuitive and deliberate decision strategies was assessed following the same classification that was used for the RT analysis (valence ratings) described on the *Affective Priming Effects* section, that is, the classifications A, B and C. The time interval analyzed contained the seconds 2–4 after triad onset (i.e., the 1st and 2nd of the coherence judgment).

In classification A (coherent trials that were correctly classified as coherent), significantly lower SCRs could be observed for intuition blocks than for deliberation blocks in both the 1st ($t(27) = -3.2$, $p = .003$) and 2nd ($t(27) = -2.6$, $p = .015$) second of the coherence judgment. Similarly, for classification B (coherent trials that participants indicated as coherent and for which they could come up with a correct CA) in the 1st ($t(27) = -2.53$, $p = .017$) and 2nd ($t(27) = -2.31$, $p = .028$) second of the coherence judgment, significantly lower SCRs were observed in intuition blocks than the deliberation blocks (see Figure 4). The psychophysiological pattern of classification C (coherent trials that are correctly judged as coherent but without the participant's being able to offer a correct CA) points in the same direction as the patterns for classifications A and B: Lower SCRs can be found for intuition blocks than for deliberation blocks, although the difference is only marginally significant in this comparison (see Figure 4). Yet, the values are comparable here to the other two classifications of trials ($t(27) = -1.8$, $p = .082$).

Furthermore, as in the RT analyses, SCRs based on a median-split of the trials were analyzed so as to preclude any objection that we might have picked trials that do not best reflect intuitive and/or deliberate processing. The arousal pattern remained the same when the median split analysis was done: SCRs were lower in trials answered below the median RT than in trials answered above the median RT for the 1st ($t(27) = -3.4$, $p = .002$) and 2nd ($t(27) = -2.5$, $p = .018$) second of the coherence judgment.

SCRs for trials being most representative for intuitive and deliberate processing

In addition, we compared the two decision strategies using their most representative trials according to dual-system views of cognitive processing (e.g., Stanovich & West, 2000). A dual-system framework would assume that decisions made under a deliberate mode of thinking (here implemented in deliberation blocks) are explicitly justified or

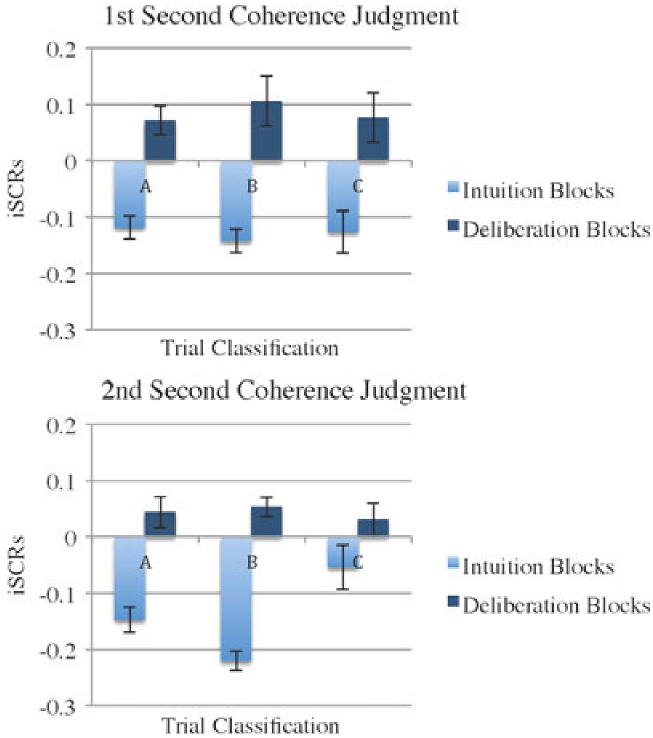

Figure 4. SCRs of the coherence judgment for intuition and deliberation blocks. Integrated skin conductance responses (iSCRs) are shown for intuition and deliberation blocks and the three different kinds of trials, separately for the 1st (A) and the 2nd (B) second of the coherence judgment. Error bars denote standard errors of the means. Abbreviation: A = Coherent triads that are correctly classified as coherent, regardless of whether a common associate (CA) was provided or not; B = Coherent triads that are correctly classified as coherent, and a CA could be provided; C = Coherent triads that are correctly classified as coherent, but a CA could not be provided (i.e., the triad remained unsolved). [Colour figure can be viewed at wileyonlinelibrary.com]

represented and thus reveal more solved triads. According to this, trials where participants provided a correct CA are the most representative of a deliberation mode. For decisions made under the intuitive decision style, a dual-system framework would assume that they are implicitly informed or represented and thus answers that are correct but have not yet become solved (in that no CA can be verbalized) are the most representative trials as they reflect the automatic and unconscious processing of System 1. Thus, for the intuitive condition, we looked only at coherent trials that were indicated as coherent but for which no CA was provided. For the deliberate condition, we looked at coherent trials that were indicated as coherent and for which a CA *was* provided. Again, we found the same pattern. Although most distinctive in the 1st second of the coherence judgment ($t(27) = -2.2$, $p = .037$), values in the 2nd second of the coherence judgment still point in the direction noted above, although not to a statistically significant degree ($t(27) = -88$, $p = .38$).

SCRs for solved and unsolved coherent triads

In order to directly compare the SCRs for solved and unsolved coherent triads separately for the two instructed decision strategies, we also ran two other ANOVAs with the two

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factors second (1st and 2nd second of the coherence judgment) and solution word (provided versus not provided), separately for intuition and deliberation blocks. We found a main effect of “solution word”, but interestingly only in intuition blocks ($F(1,27) = 4.402$, $p = .045$). There was no main effect of “solution word” for SCRs in deliberation blocks ($F(1,27) = .005$, $p = .942$). Data show that, at second 2, SCRs in intuition blocks were significantly different between solved and unsolved coherent triads, whereas in deliberation blocks there was no significant difference between solved and unsolved triads' SCRs. This effect manifests insofar as, in intuition blocks, solved coherent triads showed lower arousal levels than unsolved coherent triads (Figure 5).

Anticipatory SCRs

Given that increased SCRs have been reported specifically for decisions preceding incorrect choices (for instance, higher SCRs were observed before participants chose a card from the disadvantageous deck in the Iowa Gambling Task (Bechara et al., 1997; Bechara & Damasio, 2005), we tested—in a post-hoc analysis—whether our results would also show differential effects when split according to hits (a coherent triad is classified as coherent) and misses (a coherent triad is classified as incoherent). The effect that one would expect to find here is the interaction effect between ‘instructed decision mode’ (intuitive/deliberate) and ‘coherence judgment’ (coherent/incoherent). But the interaction effect was not significant ($F(1,26) = .07$, $p = .794$). That is, our results basically show as a main effect that the SCRs in the intuitive blocks are significantly lower than those in the deliberate blocks; this effect is not differentially affected by the coherence judgment being objectively right or wrong.

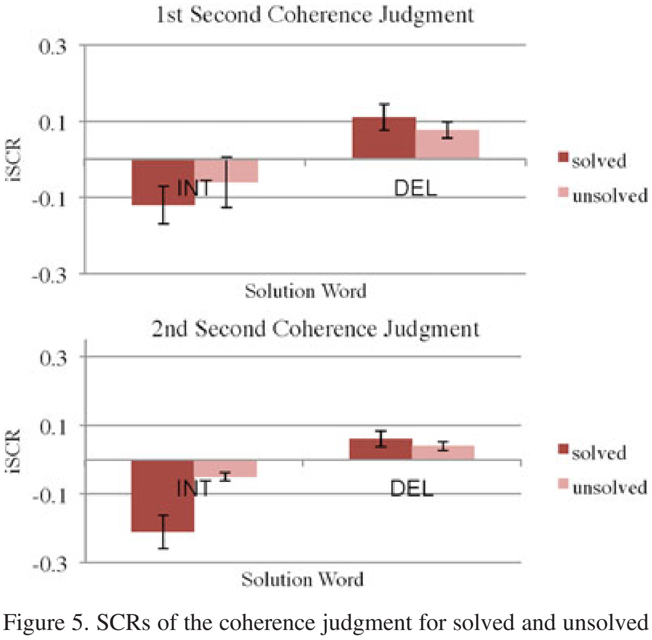

Figure 5. SCRs of the coherence judgment for solved and unsolved coherent triads. For intuition and deliberation blocks, integrated skin conductance responses (iSCRs) are shown for solved and unsolved coherent triads, separately for the 1st (A) and 2nd (B) second of the coherence judgment. Error bars denote standard errors of the means. [Colour figure can be viewed at wileyonlinelibrary.com]

DISCUSSION

Contrary to the widely held belief (very popular with parents and teachers) that one should thoroughly deliberate and carefully weigh the pros and cons of an important and/or complex decision, people often try to incorporate an intuitive path in the attempt to find a satisfactory solution to a problem. For instance, with the problem we mentioned earlier of choosing between two new jobs, an intuitive access might be to imagine how it would *feel* to perform either of the new jobs and then to compare those feelings with how it would *feel* to stay at the old job and turn down the new job offers. Obviously, such an intuitive access/strategy requires some kind of feeling that becomes *the crucial component*, essentially “telling” you which option to pursue. In contrast, when you thoroughly deliberate on the pros and cons of your options, the solution to the decision problem comes to mind by way of logic and sensible considerations of probable consequences, a process that does not need or even involve any emotional information.

Scientifically, this phenomenon resides in the framework of dual-system models that propose that cognitive processing can occur either intuitively or deliberately, executed via the independent Systems 1 and 2, respectively (Epstein et al., 1996; Evans, 2003; Kahneman, 2003; Schneider & Shiffrin, 1977; Sloman, 1996; Stanovich & West, 2000; Strack & Deutsch, 2004; Evans & Stanovich, 2013). Besides being conceptualized as holistic, associative, fast and automatic—to name only a few decisive attributes, intuitive decisions are conceived of as emotional; emotion is seen as a *necessary process component* inherently a part of intuitive decision processes. But—to our knowledge—whether intuitive processes can indeed be conceived of as emotional has not yet been empirically demonstrated. Accordingly, we addressed this lacuna by setting out to investigate the potentially emotional nature of intuitive decision making as captured through semantic coherence judgments in the triads task.

Tested within a valence-arousal framework (Russell, 1980; Russell & Barrett, 1999), our results revealed no significant differences between the two decision strategies on a valence dimension. That is, we did not observe any affective priming effects specific to intuitive judgments. In other words, we could not observe a marked speeding up of the valence ratings of pictorial stimuli following intuitive coherence judgments in comparison with the valence ratings of pictorial stimuli that followed deliberate coherence judgments. We thus take our RT results to not resonate with a dual-system hypothesis concerning the issue affect for intuitive decisions, at least on a valence dimension. Our RT results (valence dimension) are in line with recent neuronal evidence that speak against the assumptions of the dual-system framework of reasoning (Mega et al., 2015). The authors did a functional-magnetic-resonance-imaging study and let participants judge the authenticity of emotional facial expressions. Similar to our study, they let participants perform the face judgment task either intuitively or deliberately—yet, contrary to what we did, they applied a between-subject design. They found

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intuition and deliberation to rely on the same neurocognitive mechanisms as partially similar neuronal networks were activated for intuitive and deliberate judgment.

Arousal dimension

The arousal dimension, however, reveals a completely different picture than the valence dimension: What is most interesting in the present data, intuitive and deliberate coherence judgments were found to be indeed distinct in an arousal component, but in a way not encompassed by studies thus far. That is, we found a decrease in SCR signals instead of the expected increase for intuitive coherence judgments. In the valence-arousal model of emotions, according to Russell (1980), arousal refers to the level of alertness or activity that can range from calm to excited. In this study, we initially assumed that we would see increased arousal levels for intuitive judgments (as gathered in intuition blocks), given the data on anticipatory SCRs in the Iowa Gambling Task (i.e., the observation of larger SCRs in trials where individuals selected the disadvantageous option before being able to verbally explain their choices (Bechara et al., 1997; Bechara et al., 2000)). Increased anticipatory SCRs have been taken to reflect non-conscious information processing, one of the prime characteristics of intuitive decisions.

Our results do indeed show that intuitive judgments are specific to the arousal dimension, but in reverse of what has been the general consensus of the literature thus far. Instead of the expected increase in arousal level, we observed a decrease in arousal as a correlate of intuitive decisions. In fact, participants showed significantly lower SCRs in the intuitive blocks than in the deliberate control blocks, and this occurred in every trial classification. An explanation for our finding of significant but decreased rather than increased SCRs for intuitive judgments might, perhaps, be because of the experimental setup and processing state of the participants while solving the task.

Experimental setup (and arousal level)

In the experimental setup of studies that report increased anticipatory SCRs, participants have the choice between two options, one of them advantageous or correct, and the other disadvantageous or incorrect (Bierman et al., 2005; Bechara et al., 1997; Bechara et al., 2005; Bechara & Damasio, 2005; Damasio et al., 1991). The main finding when the Iowa Gambling Task is used is that participants improve their performance over the course of the experiment, that is, they make more advantageous choices as time passes. Interestingly, this occurs long before participants are able to explicitly verbalize the rules of the task that need to be followed to achieve correct responses. In terms of psychophysiology, participants develop anticipatory SCRs that increase most notably in the face of disadvantageous stimulus material. These kinds of SCRs are especially prevalent in the phase when participants have already improved their task performance but do not yet have explicit knowledge about the cause of the improvement. Bechara et al. (1997) report that " the autonomic responses […] are evidence for a complex process of nonconscious signaling, which reflects access to records of previous individual experience—specifically, of records shaped by reward, punishment, and the emotional state that attends them" (p. 1294).

In a similar vein, Bierman et al. (2005) interpret significantly increased SCRs before incorrect decisions as warning signals. In their task, participants worked on an artificial grammar learning task. Results revealed significantly increased SCRs before incorrect decisions (choosing the word that was not in accordance with the rules of the artificial grammar) compared to SCRs before correct decisions. Thus far, anticipatory increased SCRs have been found specifically before individuals make disadvantageous or incorrect decisions, and so increased arousal levels have been interpreted as an alerting signal implicitly inducing avoidance behavior. In other words, participants are non-consciously warned of a decision that might not be optimal (in the sense that it is incorrect or disadvantageous), and the SCR is taken to be the psychophysiological reflection of this intuitive somatic signal that draws on implicit experience.

However, the structure of our task was different: First, the triads task is *not* a task with advantageous/correct or disadvantageous/incorrect options as such. Rather, participants were encouraged to judge the semantic coherence of word triads, a judgment that is at least *in part subjective*. It could very well occur that an individual would conceive of an objectively incoherent triad as coherent because it just so happens that those three words form a highly individual associative network. The individual would then rate this triad as coherent, which would be "correct" given her specific background. Second, contrary to the Iowa Gambling Task or to artificial grammar learning tasks, participants in our semantic coherence task cannot—and are not encouraged or instructed to—develop an advantageous strategy in order to detect correct alternatives. That is why semantic coherence judgments are performed without feedback; participants *cannot learn specific contingencies or rules*. Rather, the only "strategy" given to participants in the intuitive condition is to "emotionally" read out the strength of the semantic association between the three words (cf., Volz & Zander, 2014). In contrast, the strategy instructed in the deliberate condition is to "analytically" assess each and every word for semantic relatedness to the other two words and then to come up with an overall assessment. Thus, in our view, a SCR, in the sense of a warning signal, was very unlikely to occur given these task requirements.

We also checked, in a post-hoc analysis, whether SCRs of correct and incorrect coherence judgments did indeed not differ, and those results do in fact support our initial hypothesis —namely, (i) that SCRs of hits and misses did not significantly differ (main effect of correctness); and (ii) that the intuitive and deliberate conditions were not differentially affected by this factor (interaction effect condition by correctness). But what then do significantly decreased SCRs in intuitive judgments reflect?

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Decreased SCRs = reflection of relaxation processes

Given that the EDA is used as an unspecific indicator of general arousal, with higher levels of arousal accompanied by and correlated with increased SCRs (Dawson et al., 2007; Figner & Murphy, 2011; Boucsein, 2012), we suggest that participants became much more aroused in the deliberate decision conditions (which could be related to the increased cognitive effort invested when solving the triads during this condition), and conversely, much more relaxed in the intuitive decision conditions. When separating solved from unsolved coherent triads, this arousal pattern can be further specified: Results revealed that only in intuition blocks SCRs of solved coherent triads differ from unsolved coherent triads insofar as arousal was lower for solved triads. These results are in line with the data from our between-block questionnaires (see SuppInf_1), where participants indicated deliberation blocks to be more exhausting than intuition blocks. This idea also concurs with research on the psychophysiological signature of relaxation: Decreased EDA signals were reported for *subjective relaxation processes*, when participants had to engage in specific relaxation and/or meditation techniques (Mathews & Gelder, 1969; Mohan et al., 2011; Steptoe & Greer, 1980), while increased EDA signals have been reported for more effortful cognitive processes (Kahneman, 1973). Thus, we interpret our results as indicating that participants in the intuitive conditions were more relaxed than in deliberation conditions, which required more cognitive effort. This was reflected in the significantly decreased SCRs during the intuition blocks.

Moreover, this psychophysiological relaxation component that manifested itself in decreased SCRs during intuition blocks might in fact reflect a cognitive processing mode that is holistic by nature. Theories on the underlying cognitive mechanisms of semantic coherence judgments propose that the perception of word triads automatically elicits activation in semantic memory—a process known as the automatic spread of activation (cf. Bowers et al., 1990; Bolte et al., 2003; Collins & Loftus, 1975). According to Bowers et al. (1990), this kind of processing non-consciously and gradually activates pre-existing memory contents, and only if sufficient activation is prevalent, it can cross a threshold of awareness and explicate the common concept that links the semantic associations. Furthermore, automatic-spread-of-activation processing is assumed to proceed holistically, that is, each triad is processed in its entirety. Our results suggest that this holistic kind of processing is characterized by a psychophysiological relaxation process that correlates with the facilitated proliferation of semantic information relative to the more effortful process of deliberation that is characterized by psychophysiological activation.

This idea concurs with the *coarse semantic coding theory* put forward by Beeman et al. (1994) (for an overview of a recent specification see Kounios & Beeman, 2014). According to this approach, based on a hemispheric asymmetry account of human thought processes, when encountering semantic material, the left hemisphere strongly activates a small field of associated concepts. In contrast, the right hemisphere weakly activates a broad range of associated concepts including concepts that are only distantly related with the encountered concept. In semantic intuitive coherence judgments, this latter kind of activation may be particularly reflecting holistic automatic-spread-of-activation processing. Furthermore, on a neuronal level, it has been found that, when using similar word triads to ours, insight problem solving correlates with activation in the right hemisphere.

Our results nicely dovetail with this idea, because we also found different psychophysiological arousal levels for solved (lower arousal) and unsolved coherent triads (higher arousal), interestingly only in intuition blocks. That is, when the automatic-spread-of-activation was large enough for semantic activation to cross the threshold of awareness, participants could report the CA and were most relaxed. Importantly, this does not occur during deliberate blocks where solved and unsolved triads did not significantly differ in levels of arousal, suggesting that major engagement in finding solution words during the deliberative condition is not reflected in increased arousal. Hence, it seems that the factor that is mostly driving the observed difference in arousal is the holistic processing during intuition blocks and not the increased effort invested in solving the triads during the more cognitively demanding deliberation blocks. Based on these considerations, our data suggest, that, on a psychophysiological level, the semantic broadening process reflecting holistic automatic-spread-of-activation processing is revealed by a decrease in arousal. Thus, our results may indicate that relaxed mind states during intuitive blocks foster holistic automatic-spread-of-activation processing resulting in a proliferation of semantic associations relative to a more effortful process of deliberation.

Finally, it is important to highlight that the semantic coherence task we used is qualitatively different from tasks commonly used to investigate decision making strategies. As described above, the triad task is not linked with reward–punishment learning mechanisms. Thus, it would be difficult to generalize our findings to tasks such as the Iowa Gambling Task. Moreover, considering that tasks which have emotion-related signals involved in predicting future negative or positive outcomes are intrinsically emotional (regardless of the decision strategy), it seems challenging to disentangle emotional responses arising from reward-punishment learning mechanisms from those arising from different decision strategies. In this regard, our findings are probably more generalizable to other types of coherence tasks. For instance, investigating different decision strategies in judgments of perceptual visual (e.g., Volz & von Cramon, 2006) or auditory (e.g., Volz et al., 2008) coherence.

It might also be of potential interest to use a between-subject design instead of the within-subject design we employed to overcome possible difficulties participants might have had changing the two instructed decision strategies (intuition versus deliberation). Although we asked participants whether they have found the instructions plausible—and this was indeed the case, it may also be possible that participants underreported their difficulty in switching strategies because of demand characteristics of this question.

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CONCLUSION

To sum up, in this study we empirically tested the widely endorsed assumption that intuitive judgments are more emotional than deliberate judgments. Based on our results, we tentatively conclude that one has to distinguish between a valence and an arousal dimension. We found intuitive judgments of coherence to be indeed specific as to their psychophysiological signature in that arousal is the differentiating component between the two modes of processing. What was surprising about the results, however, was that the sympathetic activation during intuitive judgments of coherence was actually significantly lower than that of deliberate judgments, which may reflect that relaxed states prompt a holistic processing in which the spread of semantic associations can proliferate. Obviously, research on emotionality in intuitive judgments is still underexplored, and we are looking forward to learning much more from future studies on this topic using different kinds of task domains.

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