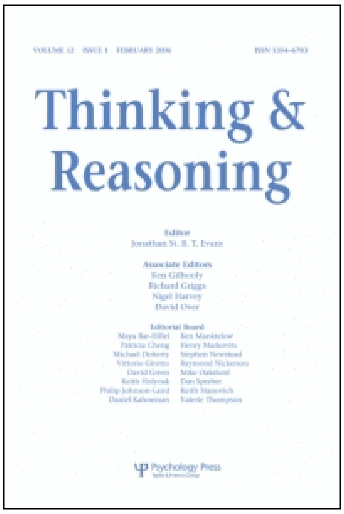


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# Beyond dual-process models: A categorisation of processes underlying intuitive judgement and decision making

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# Beyond dual-process models: A categorisation of processes underlying intuitive judgement and decision making

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Intuitive-automatic processes are crucial for making judgements and decisions. The fascinating complexity of these processes has attracted many decision researchers, prompting them to start investigating intuition empirically and to develop numerous models. Dual-process models assume a clear distinction between intuitive and deliberate processes but provide no further differentiation within both categories. We go beyond these models and argue that intuition is not a homogeneous concept, but a label used for different cognitive mechanisms. We suggest that these mechanisms have to be distinguished to allow for fruitful investigations of intuition. Specifically, we argue that researchers should concentrate on investigating the processes underlying intuition before making strong claims about its performance. We summarise current models for intuition and propose a categorisation according to the underlying cognitive processes: (a) associative intuition based on simple learning–retrieval processes, (b) matching intuition based on comparisons with prototypes/exemplars, (c) accumulative intuition based on automatic evidence accumulation, and (d) constructive intuition based on construction of mental representations. We discuss how this differentiation might help to clarify the relationship between affect and intuition and we derive a very general hypothesis as to when intuition will lead to good decisions and when it will go astray.

***Keywords:*** Automaticity; Decision making; Evidence accumulation; Intuition; Learning; Parallel constraint satisfaction.

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Every day people make a multitude of judgements and decisions of different complexity and importance. The question of how people make these decisions has attracted research interest over many years. In early work on decision making, researchers proposed very general theories that did not aim to describe processes but merely aimed to predict outcomes (i.e., input–output models instead of process models). One important example is the classic expected utility model, which assumes that people choose the option with the highest expected utility—which is the sum of the utilities of all outcomes multiplied by the probability that these outcomes occur (Savage, 1954; von Neumann & Morgenstern, 1944). Expected utility models did not claim that people indeed calculate weighted sums, but only that their choices can be predicted by such a model (Luce, 2000; Luce & Raiffa, 1957). The Nobel-prize winner Herbert A. Simon (1955) drew attention to the decision process. He questioned the assumption that people maximise utility, and argued that people might not rely on deliberate calculations of weighted sums in their decisions, because the limitations of cognitive capacity and the multitude of decision options do not allow them to do so. Essentially two alternative process model approaches have been suggested.

The first approach is based on the idea of adaptive strategy selection. People might use effortful weighted sum calculations in a few important situations only (Beach & Mitchell, 1978; Payne, Bettman, & Johnson, 1988). In other situations, for instance under time pressure, they might rely on short-cut strategies, so called heuristics. Heuristics were conceptualised as simple strategies that consist of stepwise cognitive operations and are (usually) carried out deliberately (cf. Payne et al., 1988; although they also consider a possible implementation as production rules). An example would be lexicographic strategies (Fishburn, 1974), which assume that people compare options by considering attributes in a stepwise manner and selecting the option that is best on the first differentiating attribute without considering the remaining attributes.

The second approach suggests that people might utilise partially automatic processes, which means that they use the huge computational and storage power of the brain to overcome the obvious limitations of their conscious cognitive capacity. Automatic-intuitive processes are, for instance, activated in visual perception (McClelland & Rumelhart, 1981; Wertheimer, 1938a, 1938b) and social perception (Bruner & Goodman, 1947; Read & Miller, 1998; Read, Vanman, & Miller, 1997) to structure information in our environment and to quickly form reasonable interpretations (Gestalten), which can constitute the basis for judgements and decisions (Glöckner & Betsch, 2008c). Automatic (unconscious) processes also play a crucial role in learning and memory retrieval (see Hintzman, 1990, for a critical overview) and generate information that might be directly utilised in judgements and decisions (Dougherty, Gettys, & Ogden, 1999;

Thomas, Dougherty, Sprenger, & Harbison, 2008). Furthermore, it could be shown that reliance on automatic-intuitive processes often leads to surprisingly good judgements and choices (e.g., Glöckner, 2008; Glöckner & Betsch, 2008a, 2008b; Hammond, Hamm, Grassia, & Pearson, 1987), but under certain circumstances also causes systematic biases (e.g., Kahneman, Slovic, & Tversky, 1982). In their intriguing work on heuristics and biases Daniel Kahneman and his colleagues (e.g., Kahneman et al., 1982) showed, among other things, that in automatic probability judgements people often rely on feelings of representativeness and availability, and anchor their judgements on (sometimes irrelevant) information. The distinction between deliberate rule-based processes and intuitive-automatic processes is reflected in many dual-process models.

We argue that further progress in investigating intuitive-automatic processes necessitates a more sophisticated perspective than the one provided by dual-process models. In particular, we propose that theorising and empirical testing should differentiate the many different cognitive processes that are often subsumed in the category "intuition", in order to allow for specific predictions and for a better understanding of often contradicting findings. Most importantly, this should be done when trying to investigate whether and under which circumstances intuition or deliberation leads to better decisions. We argue that researchers should concentrate on investigating the processes underlying intuition first before making strong claims about its performance. In this paper we advance a more differentiated theoretical perspective in intuition research by developing a classification of existing models for automatic-intuitive processes. We highly recommend that researchers investigating intuition always clarify which specific kind of processes they are studying. We further think that there is a dire need to develop and further improve well-specified process models that instantiate the principles of intuition (see also Hintzman, 1990) to avoid the danger of loose theorising. Our classification of existing models aims to strengthen the connection between intuition research and cognitive psychology, and also to help identify the best-specified models for a specific kind of processes.

We will proceed as follows: First, we describe the relation between intuition and deliberation in different kinds of dual-process models. Then the various meanings ascribed to intuition will be discussed and the common ground from several definitions will be extracted. Third, our differentiated classification of automatic-intuitive processes is introduced and existing models are assigned to the respective categories. Subsequently we discuss how the more differentiated perspective on intuition can help to clarify the relation between intuition and affect, and we discuss three common factors that should contribute to high-quality intuitive decisions. Finally we derive some hypotheses that allow testing our assumption of distinct processes.

## DUAL-PROCESS MODELS

Dual-process models come in different flavours. Most models postulate that people rely either on deliberate (conscious, controlled) or intuitive (automatic, unconscious) reasoning, or on certain combinations of both (for overviews, see Evans, 2007, 2008; Weber & Johnson, 2009). Classical models were proposed in cognitive psychology (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). Later they were introduced into social psychology as the elaboration likelihood model (Petty & Cacioppo, 1986) or the heuristic systematic model (Chen & Chaiken, 1999), which describe phenomena such as persuasion and attitude change. Since then the influence of automatic processes on social cognition has been highlighted repeatedly (Bargh, 1996; Bargh & Chartrand, 1999; Kruglanski et al., 2003; Strack & Deutsch, 2004). In judgement and decision-making research, dual-processing theories were sometimes referred to, but for a long time they received surprisingly little attention. This changed with several influential publications by Kahneman and colleagues (Gilovich, Griffin, & Kahneman, 2002; Kahneman, 2003; Kahneman & Frederick, 2002) who, among other things, summarised properties of the two processes based on a set of other dual-processing theories (e.g., Epstein, 1990; Sloman, 2002).

In a recent review Evans (2008) suggested a classification of dual-processing models into (a) models that assume a clear distinction between the two kinds of processes and an initial selection between them based on certain variables (e.g., Petty & Cacioppo, 1986), (b) models that assume a parallel activation of both kinds of processes (Sloman, 2002), and (c) default-interventionist models which assume that automatic processes are always activated first and that additional deliberate processes are activated only if it is necessary to intervene, correct, or support reasoning of automatic-intuitive processes (Evans, 2007; Glöckner & Betsch, 2008c; Guthrie, Rachlinski, & Wistrich, 2007; Haidt, 2001; Hogarth, 2001; Kahneman & Frederick, 2002). The latter view is theoretically more in line with uni-model approaches (Kruglanski & Orehek, 2007; Kruglanski & Thompson, 1999) and cognitive continuum theory (Hammond et al., 1987) in that the clear distinction between the two kinds of processes is somewhat qualified (see also Horstmann, Ahlgrimm, & Glöckner, 2009).

Despite these different assumptions, most models agree on very general properties of the two kinds of processes. Deliberate processes are supposed to consist of conscious, controlled application of rules and computations. The core property of the intuitive processes is that they operate (at least partially) automatically and without conscious control. Apart from this basic agreement, there is major divergence concerning the nature and functioning of intuitive processes. Predictions concerning the underlying information integration processes are often vague. Evans (2008, p. 255) concluded:

> [I]t emerges that (a) there are multiple kinds of implicit processes described by different theorists and (b) not all of the proposed attributes of the two kinds of processing can be sensibly mapped on to two systems as currently conceived. It is suggested that while some dual-process theories are concerned with parallel competing processes involving explicit and implicit knowledge systems, others are concerned with the influence of preconscious processes that contextualize and shape deliberative reasoning and decision-making.

We agree with the general point that there are multiple kinds of intuition, as discussed in the next section. Later we will suggest a more specific classification of the underlying processes.



## WHAT IS INTUITION?

Controversy about what intuition is starts with its definition and further concerns its properties, the scope and the homogeneity of the phenomenon, its working mechanism, its distinction from deliberation, its relatedness to affect, and its dependence on experience. To illustrate that there is partial agreement but also controversy about the definition of intuition, we cite four examples):

> "The outcomes [of intuition] are typically approximate (not precise) and often experienced in the form of feelings (not words)" (p. 9). "The correlates are speed, and confidence" (p. 10). "Intuition or intuitive responses are reached with little apparent effort, and typically without conscious awareness; they involve little or no conscious deliberation" (p. 14) "[but are reached] in a largely tacit, unintentional, automatic, passive process" (p. 21). "We know, but we do not know why" (p. 29) (all from Hogarth, 2001).
>
> "Intuition is an involuntary, difficult-to-articulate, affect-laden recognition or judgment, based upon prior learning and experiences, which is arrived at rapidly, through holistic associations and without deliberative or conscious rational thought" (Sadler-Smith, 2008, p. 31).
>
> "Intuition is the way we translate our experiences into judgments and decisions. It's the ability to make decisions using patterns to recognize what's going on in a situation and to recognize the typical action scripts with which to react. Once experienced intuitive decision makers see a pattern, any decision they have to make is usually obvious." (Klein, 2003, p. 13).
>
> "Intuition is a process of thinking. The input to this process is mostly provided by knowledge stored in long-term memory that has been primarily acquired via associative learning. The input is processed automatically and without conscious awareness. The output of the process is a feeling that can serve as a basis for judgments and decisions" (Betsch, 2008, p. 4).

From the above definitions we derive the common ground: Intuition is based on automatic processes that rely on knowledge structures that are acquired by (different kinds of) learning. They operate at least partially without people's awareness and result in feelings, signals, or interpretations. Assumptions concerning the underlying processes and consequently also concerning further properties of these processes diverge. We refrain from trying to unify these perspectives. On the contrary, we suggest that intuition is used as a label for different kinds of automatic processes, which we will categorise into four general types.

We are not the first researchers to propose a decomposition of intuition. Evans (2008, 2009) has argued that the intuitive system (or System 1) is really a multiplicity of systems that take in a wide variety of implicit processing. These multiple systems are of two kinds: *autonomous* systems that control behaviour directly without the need of controlled attention, and *pre-attentive* systems that supply content into working memory (e.g., perception, attention) and thus determine what information enters analytic processes, which in turn control behaviour.

De Neys and colleagues (e.g., De Neys, Schaeken, & d'Ydewalle, 2005), in their studies of causal conditional reasoning, had made a similar distinction. Their studies showed that (in Evans' terms) both *autonomous* and *pre-attentive* systems seemed to be at work when people respond to questions about category membership. Responses are sometimes based on autonomous processes, in cases of automatic and associative retrieval of background knowledge about common categories from memory. Also, assessing the empirical falsity of conclusions in some cases involves a direct category mismatch detection. In other cases responding involves pre-attentive System 1 processes, when background knowledge about counter-examples is activated through strategic memory retrieval. This processing supplies information to working memory, and subsequent responses are not automatic and effortless. Such responses are indeed found to depend on cognitive ability and working memory capacity.

Stanovich (2004; see also Stanovich, 2009, and Evans, 2008, 2009) labels this multiplicity of type I systems The Autonomous Set of Systems (TASS): a set of multiple processes that function automatically in response to triggering stimuli. Their shared aspects are that they are fast, automatic, and mandatory; their operations yield no conscious experience although their products might; they require no analytic system input. TASS includes domain-general processes of unconscious learning and conditioning; automatic processes of action regulation via emotions; and rules, discriminators, and decision-making principles practised to automaticity.

According to Dienes (2008; Dienes & Scott, 2005; Scott & Dienes, 2008), intuition in implicit learning uses unconscious structural knowledge. Structural knowledge is knowledge that enables a judgement, and is distinguished from judgement knowledge, which is knowledge of whether an item has that structure. Both types of knowledge may be conscious and unconscious. People have no idea what that unconscious knowledge is, or that it exists. This distinction between two types of knowledge is useful to explain implicit learning, and in our view supports an argument by Evans (2009) that consciousness is not a safe basis for defining the difference between System 1 and 2 processing, since it is not sharply limited.

The framework that we propose, in which we describe four types of intuition (see Table 1), builds on and goes beyond these decompositions. Our associative intuition and matching intuition relate to the conditioning and unconscious learning processes proposed by TASS. Parts of these mechanisms might be considered autonomous types in Evans' terms. Our accumulative and constructive intuition are pre-attentive types. Hence, to a certain degree we further detail the two types suggested by Evans. We furthermore try to relate our categories more closely to the different existing computational models. The mechanisms of consistency maximising proposed by constructive intuition and implemented by parallel constraint satisfaction models (see below) might additionally be understood as computational implementations of conflict detection mechanisms described by De Neys and colleagues (De Neys & Glumicic, 2008; De Neys, Vartanian, & Goel, 2008; Franssens & De Neys, 2009).



## FOUR TYPES OF PROCESSES UNDERLYING INTUITION

Although the different theoretical approaches diverge about the question where intuition comes from, most agree that intuition does not just "fall from heaven" but that it is acquired through learning, and that there are some systematic processes of retrieval or integration of information that generate intuitions and unconscious influences on choice behaviour (see definitions above). Models can be categorised according to the format in which information is thought to be stored in memory and the specification of the retrieval or information integration processes. Without aiming to be exhaustive we discuss four partially complementary types of processes, which are summarised in Table 1.

Before describing the different processes in more detail we would like to make one important disclaimer. The proposed processes underlying intuition are not completely distinct from each other. There are particular overlaps between simple learning–retrieval and exemplar/prototype learning–retrieval processes. From the perspective of the latter, some of the described simple learning–retrieval processes could be seen as a special case or even just as a description of the same process on a higher level of abstraction. A similar argument might be made for the relation between evidence accumulation and construction of mental representations. Nevertheless, because each category has some special focus and since in our view not all of the simpler models can be completely subsumed

TABLE 1
Types of intuition

| *Category* | *Description* |
| --- | --- |
| Associative intuition: Simple learning–retrieval | *Learning:* Reinforcement and association learning (classical conditioning/evaluative conditioning/signal learning, operant/instrumental conditioning); social learning; implicit recording of frequencies and values<br>*Retrieval:* Intuition as mere feelings of liking and disliking; intuition as affective arousal; intuition as the activation of the previously successful behavioural option |
| Matching intuition: Exemplar/prototype learning–retrieval | *Learning:* Acquisition of exemplars, prototypes, images, schemas<br>*Retrieval:* Comparison with exemplars (prompting and echo); comparison with prototypes; comparison of images |
| Accumulative intuition: Evidence accumulation | *Source of information:* Memory traces (from both above perspectives) and/or currently perceived information<br>*Integration:* Accumulation of evidence based on quick automatic process; random sampling proportional to the importance of the information; overall (cognitive or affective) evaluation is compared with threshold |
| Constructive intuition: Construction of mental representations | *Source of information:* Memory traces (from both above perspectives) and/or currently perceived information<br>*Integration:* Activation of related information; automatic construction of consistent mental representations; accentuation of evidence (coherence shifts); the result (e.g., chose option A) or the whole automatically constructed interpretation of the problem enters awareness |

These proposed types of intuition are not completely distinct from each other, yet each category has some special focus, which warrants our differentiation. Particularly, simple learning–retrieval processes could be seen as a special case of exemplar/prototype learning–retrieval processes or even just as a description of the same process on a higher level of abstraction.



under the more complex ones, we argue that our classification has initial validity.

## Associative intuition: Simple learning–retrieval

In interaction with their environment people record a surprising amount of information both consciously and unconsciously. Even if they do not intend to do so, people automatically record frequencies of events (Hasher & Zacks, 1979; Zacks, Hasher, & Sanft, 1982), values of options (Betsch, Plessner, Schwieren, & Gütig, 2001b), and they even acquire complex artificial rules through implicit learning (Reber, 1993). Presenting neutral (i.e., a new brand name) with unconditioned stimuli (i.e., a beautiful face) leads to acquiring evaluative reactions (e.g., feelings of liking or disliking; cf. evaluative conditioning, Walther, 2002; Walther & Grigoriadis, 2004). A similar effect of increased liking of an object can be reached by merely presenting the object repeatedly (Zajonc, 1968, 1980). Similarly, according to classic findings in conditioning, the application of punishment (reward) after a certain choice behaviour reduces (increases) its prevalence rate (Skinner, 1938), of which people are not necessarily aware. Conditioning will also change the neural circuitry in the brain, and Damasio (1994) suggests that a punishment/reward schedule will create a "somatic marker" that shapes future decision making. It has been shown that such implicitly learned, unconscious, affective reactions towards decision options may indeed precede explicit understanding and determine decisions (Bechara, Damasio, Tranel, & Damasio, 1997), and that when people are in a positive mood they rely on these feelings more strongly (De Vries, Holland, & Witteman, 2008). However, these and similar demonstrations of the primacy of emotion-based reactions have been critically reviewed (Dunn, Dalgleish, & Lawrence, 2006), among other reasons because people have been found to have at least some conscious awareness of the punishment/reward contingencies of the decision task (Maia & McClelland, 2004). In a similar vein, findings indicate that some of the above-mentioned learning effects might not function completely unconsciously. The supposed unconscious status has been questioned for complex artificial rule learning (Perruchet & Pacteau, 1990), evaluative conditioning (Pleyers, Corneille, Luminet, & Yzerbyt, 2007), and unconscious instrumental learning (Shanks & St. John, 1994). We take a neutral stance in this controversial debate. We simply would not require the considered processes to be completely automatic and completely unconscious under all conditions.

Obviously, the learning mechanisms mentioned above provide a large number of sources for different kinds of "intuition": (a) intuition as mere feelings of liking and disliking, which we take into account in our choices, (b) intuition as affective arousal, which might influence our reaction to an option, or (c) intuition as the activation of the previously successful behavioural option when we are confronted with a similar task. The first possibility is elaborated in the affect heuristic (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic, Finucane, Peters, & MacGregor, 2002), which assumes that from experience people acquire so-called "affective tags" which are related to options. These tags are activated as soon as people are confronted with options, and the option with the more positive affective tag is selected. The idea that general affective arousal states are activated when confronted with specific options or situations is reflected in the second view: the somatic marker hypothesis (Damasio, 1994). Somatic markers or gut feelings are supposed to warn people away from bad outcomes and alert them to good outcomes. The third view is reflected in routine models of decision making according to which people's choices are heavily influenced by previous experience (Betsch, Brinkmann, Fiedler, & Breining, 1999; Betsch & Haberstroh, 2005; Betsch, Haberstroh, & Höhle, 2002). In many cases the routine option is instantly selected without consideration of other information and without conscious awareness. Repeatedly reinforced options (i.e., routines) are maintained even when there is clear information that it would be better to deviate from them (Betsch, Haberstroh, Glöckner, Haar, & Fiedler, 2001a). It has been shown that, particularly under time pressure, people fall back on their routines and decide against explicitly formed intentions (Betsch, Haberstroh, Molter, & Glöckner, 2004).



## Matching intuition: Exemplar or prototype learning–retrieval

A different class of theories describes associative processes in more detail and on a higher level of complexity. These theories suggest that intuition might rely on complex learning and retrieval processes that include storage of multiple exemplars in memory, matching of situations or objects to exemplars or prototypes, and retrieval from multiple-trace memory. The MINERVA-DM model (Dougherty et al., 1999; cf. Hintzman, 1988) explains likelihood judgements as resulting from such complex memory retrieval processes in multiple-trace memory systems. According to the model, each experience with an object is separately stored in memory as a single trace. Intuition, in the sense of a feeling towards an option, is an "echo" that results from automatically comparing the current object or situation to all similar experiences of objects and situations stored in memory. Along similar lines of thought, intuition might be understood as generating estimates based on the sampling of instances from memory (Fiedler, 2000, 2008; Unkelbach, Fiedler, & Freytag, 2007) or as responding based on recognising traces in memory (Klein, 1993). In Klein's recognition-primed decision model, complex pattern-recognition processes are postulated to underlie intuition: A situation generates cues that are compared to memory traces. This enables people to recognise patterns (which make sense of a situation); these patterns in turn activate action scripts (routines for responding). All this takes place in an instant, without conscious thought. Somewhat similar, image theory (Beach & Mitchell, 1987; Mitchell & Beach, 1990) postulates an automatic pattern-matching process of different images (e.g., trajectory image: What do I want to achieve? and projected image: Do I get there on the current track?) that direct decisions. Recently, MINERVA-DM has been extended to a model for the generation and evaluation of hypotheses called HyGene (Thomas et al., 2008). According to the model, hypotheses (i.e., possible mental representations of the problem) are evaluated against each other via a conditional global matching process as suggested by MINERVA-DM.

Both perspectives discussed so far highlight the importance of learning and retrieval processes for intuition. The models discussed in the following paragraphs focus more on automatic information *integration* processes, which could take into account information from memory but also currently perceived information.

## Accumulative intuition: The automatic accumulation of evidence

Evidence accumulation and diffusion models (Busemeyer & Townsend, 1993; Ratcliff, 1978; Ratcliff & McKoon, 2008) assume that people select options based on automatic information-sampling processes. Information is repeatedly inspected and added up, partially relying on automatic processes.[1] According to decision field theory (Busemeyer & Johnson, 2004; Busemeyer & Townsend, 1993), for instance, the inspection rate of each piece of information is proportional to its importance, which leads to an approximation of a weighted linear information integration without deliberately calculating weighted sums. As soon as the evidence for one option reaches a certain threshold, this option is selected. In recent formulations of the theory (Busemeyer & Johnson, 2004) it is argued that evidence is not accumulated in a deliberate manner but is integrated automatically into an overall affective valence measure. Decision field theory is a very general model. It is mathematically well specified and allows for very precise predictions. Information underlying a decision can be both currently available and sampled from memory. Hence, evidence accumulation models can account for decision processes that are akin to perception.

## Constructive intuition: The construction of mental representations

Taking an even more complex perspective, it has been argued that information is not only accumulated, retrieved from memory, and matched to exemplars, but that people construct mental representations based on information provided and further relevant information that is activated in memory. In contrast to evidence accumulation models, not only is evidence added up but constellations of information are preserved too. Information is also not only matched to existing exemplars but mental representations are constructed that go beyond existing information in forming new consistent interpretations and possibly also in combining elements creatively in new ways. Good shapes ("Gestalten") are formed by maximising consistency

[1]It should be noted that evidence accumulation does not always occur automatically. Most models would allow intentional process as well.

given the constellation of information (McClelland & Rumelhart, 1981; Read et al., 1997; Rumelhart & McClelland, 1982; cf. Wertheimer, 1938a). The underlying processes can be captured mathematically using parallel constraint satisfaction (PCS) network models, which have also been repeatedly applied to judgements and decisions (Glöckner & Betsch, 2008c; Glöckner & Herbold, in press; Holyoak & Simon, 1999; Thagard, 1989; Thagard & Millgram, 1995).

According to PCS models, as soon as people are confronted with decision tasks, mental representations are constructed (for a broad overview, see Holyoak & Spellman, 1993; for a somewhat different usage of the term "mental models" see Johnson-Laird, 1983; note also the similarity to the HyGene model described above). These can be conceptualised as networks which contain information that has been provided directly, as well as related information that has been activated in memory. Activation is spread through the network to find the best possible interpretation (mental representation of the task) in an automatic process in which contrary facts are devalued and supporting facts are highlighted (cf. Montgomery, 1989; Svenson, 1992). Often the process and the resulting mental representation are completely unconscious and only the result enters awareness. We feel that we should choose this option without knowing why. In other cases, only a part of the mental representation will be unconscious. However, unconscious nodes that are connected with the conscious ones might produce a feeling that although all facts speak for selecting option A, something is wrong with it—which according to PCS induces increased deliberation.

As mentioned above, the four perspectives do not exclude each other but are mainly complementary. Most obviously, the two learning perspectives provide the informational basis for the information integration accounts. In the two learning perspectives, complexity increases from simple mechanisms to more complex ones and the simpler models might be partially subsumed under the more complex ones. The same is true for the two information integration perspectives (Table 2).

We think that this more differentiated classification of intuition might help to overcome some controversies and misunderstandings in intuition research. We will exemplify this by discussing the relation of

TABLE 2
Relations between types of intuition

| | *Simple mechanisms* | *More complex mechanisms* |
|---|---|---|
| Learning perspectives | Associative intuition | Matching intuition |
| Information integration perspectives | Accumulative intuition | Constructive intuition |

affect and intuition from the suggested more differentiated process perspective.

## THE RELATION OF AFFECT AND INTUITION

Dual-process models often assume that intuitive processes are closely related to the processing of affective information. For instance Kahneman and Frederick (2002) summarise that the processes from the intuitive system act on affective stimuli. According to the different perspectives, this statement should be qualified (see Table 3). For associative intuition, affect plays an important role in that it is often used as a signal to approach or avoid a stimulus, which reflects (implicit) learning experiences (e.g., Clore, Gasper, & Garvin, 2001; Slovic et al., 2002; for an overview, see Pfister & Böhm, 2008). In routine models (also belonging to associative intuition), however, affect essentially plays no role and learning experiences just lead to the activation of an option that comes to mind when confronted with a decision task. For matching intuition, affect is often the result of an automatic memory prompting process. It therefore reflects learning experiences that are less direct and the resulting affect is based on processed memory traces. Note, however, that for such processes it does not hold that the intuitive system acts on affective information. The automatic process integrates memory traces (which might include affective and cognitive parts) and generates affect to transfer the result into awareness. In a similar vein, in both information integration perspectives intuition acts on affective as well as cognitive information. For accumulative intuition both are integrated in an overall affective evaluation, which determines the decision. Hence, affect is partially the input but also the product of information processing. For constructive intuition both kinds of information are taken into account too. They are processed to form consistent interpretations. The overall energy (or remaining inconsistency) in the interpretation determines the overall affective reaction towards the decision situation. Hence the affective reaction is determined by the importance of the decision for the individual (general

TABLE 3
The role of affect for the different types of intuition

| *Type* | *Role of affect* |
|---|---|
| Associative intuition | Often affect as output |
| Matching intuition | Affective and cognitive information as input; often affect as output |
| Accumulative intuition | Affective and cognitive information as input; often affect as output |
| Constructive intuition | Affective and cognitive information as input; affect and cognition as output |

activation level) and by the conflict between pieces of information. According to this perspective in many situations affect accompanies emerging cognitive interpretations that enter awareness.

## THE QUALITY OF DECISIONS BASED ON INTUITION

One of the assumptions of most economists and a prediction of some adaptive strategy selection models is that more thorough decision strategies will usually lead to better choices (e.g., Beach & Mitchell, 1978). Hence, following the instruction to deliberate instead of using spontaneous intuitive estimations should usually increase decision quality. Interestingly, it has been shown that in certain situations more deliberation leads to less adaptive judgements (Wilson, 2002; Wilson & Schooler, 1991), presumably because analysing reasons can focus people's attention on non-optimal criteria, which are then used as a basis for the subsequent choices. Even more provocatively it has been claimed that, especially in complex decision problems, people sometimes produce better choices if they are distracted from reflecting on a task (when they "think unconsciously") before making a choice compared to when they are not (Bos, Dijksterhuis, & van Baaren, 2008; Dijksterhuis, Bos, Nordgren, & van Baaren, 2006). However, this claim has been repeatedly questioned. Major criticisms are, first, that it cannot be shown that people do not reflect while they are distracted (Smith & Collins, 2009). Second, the claims of superiority of "unconscious thought" are undermined by theoretical and experimental deficiencies of the theory (Gonzalez-Vallejo, Lassiter, Bellezza, & Lindberg, 2008). Third, results of superior decisions after "unconscious thinking" are found not to be replicable (Acker, 2008; Thorsteinson & Withrow, 2009), while distracted thinking is more susceptible to random ordering effects (Newell, Wong, Cheung, & Rakow, 2009). Distraction has been found to be beneficial in consumer decisions, but this is contingent on the consumer's mind set: People who form overall representations of the products do benefit from distraction, but people who analyse strong and weak features of the products do not (Lerouge, 2009). Plessner and Czenna (2008) discuss a review of studies that show mixed findings concerning the quality of intuitive and deliberate decision making. In light of the different processes underlying intuition discussed so far, this is not very surprising. The automatic processes and particularly their interaction with deliberate processes are likely to be influenced differentially by certain task factors. In matching-intuition processes, increased deliberation might for instance lead to an increased influence of salient features. In constructive-intuition processes, in contrast, deliberation might be used to decrease the influence of salient features in a mental representation. Hence, the mixed findings provide indirect support for our different type of processes hypothesis.

Expert intuition is often discussed as a special kind of intuition, yet it is not fundamentally different from other types except in its being based on significant, often dedicated, explicit learning (Klein, 2003; Sadler-Smith, 2008). As a result, expert intuition is domain specific. It allows experts to assess situations quickly and correctly, spotting anomalies and recognising the viable options. It is sometimes mistrusted, since intuitive experts are not easily able to explain their decisions. However, and again similar to other types of intuition, if learning has taken place in representative situations and with adequate feedback, the decisions from expert intuition will be correct as well as efficiently fast. In a similar vein, MINERVA-DM (i.e., matching intuition) has been suggested as a model to account for differences in the accuracy of judgements with different levels of expertise. Specifically, simulations showed that overconfidence should increase when people lack experience with the judgement domain and when the target stimulus has been poorly encoded in memory (Dougherty et al., 1999). Furthermore, it has recently been suggested that the parallel constraint satisfaction approach to decision making can account for sometimes-inconsistent findings concerning expertise development and expert performance (Herbig & Glöckner, 2009) by assuming differences in mental representations that are caused by the different amount of experience. It would be beyond the scope of this paper to summarise the extensive literature on the relation between expertise and decision making (for overviews, see Camerer & Johnson, 1991; Shanteau, 1988; Shanteau & Stewart, 1992; Yates & Tschirhart, 2006).

To repeat two central points from the introduction: We think that researchers should concentrate much more on investigating the processes underlying intuition before making strong claims about its performance. The further development and testing of elaborated process models is necessary to allow stable predictions. The models and findings we described might be a starting point. The methodological tools to proceed are provided in Glöckner and Witteman (2009).

Interestingly, from all four perspectives discussed above—associative intuition, matching intuition, accumulative intuition, and constructive intuition—rather similar qualitative predictions can be derived concerning when intuition will lead to good choices:

1. Automatic mechanisms provide good choices as long as the information with which they are fed is unbiased, representative, and sufficient. The learning experiences should be representative and, if this is the case, the better option will be chosen (e.g., Dougherty et al., 1999; Hogarth, 2001); the evidence accumulation process should be proportional to the importance, and if so, choices will follow rational norms; the sampling of exemplars should be representative for the

problem, and if they are, then the estimation will be correct; and the constructed mental representation should correctly represent the underlying problem structure, and if it does, then the highlighted interpretation will be the correct one.

2. Unconscious and conscious processes can both bias the information input to the computational mechanisms. Both kinds of biases can be due to motivational or emotional factors or they could simply be induced by properties of the task (e.g., salience, availability).
3. Conscious mechanisms can in principle be used to correct for biased information, although it might be questioned whether people can detect biased information and whether they are able to compensate properly (instead of possible over- or under-shooting). Recent evidence indicates that people are often well able to handle the former issue. When solving classic judgement and decision-making tasks, people typically detect that they are biased when giving intuitive responses (De Neys & Glumicic, 2008; De Neys et al., 2008; Franssens & De Neys, 2009). In a similar vein, it has recently been shown that inconsistency between pieces of information leads to an increased physiological arousal, which might function as an alerting signal (Glöckner & Hochman, 2009).

Of course, the fact that these predictions may be similar does not mean that the discussed mechanisms cannot be differentiated empirically. Distinct process and outcome predictions can be derived and used to differentiate between mechanisms, as we will illustrate in the next section.

## TESTING THE APPROACH: SOME DISTINCT PREDICTIONS OF THE MECHANISMS

Most of the considered models predict that judgements or choices follow a weighted compensatory integration of information (Brunswik, 1955; Busemeyer & Townsend, 1993; Doherty & Kurz, 1996; Dougherty et al., 1999; Glöckner & Betsch, 2008c; Hammond et al., 1987). Due to the high overlap in choice predictions, and considering the fact that, due to free parameters, the models can often mimic each other, it is hard to differentiate between them based on choices only. Apart from of course manipulating the independent variables, we recommend simultaneously assessing multiple dependent variables such as decision time, confidence, information search, attention shifts, physiological arousal, or single fixation durations to differentiate between the mechanisms (e.g., Glöckner & Herbold, in press; Glöckner & Hochman, 2009; Horstmann et al., 2009; see Glöckner, 2009, for an extended statistical analysis method; see Glöckner & Witteman, 2009, for an overview).

Some qualitatively distinct predictions can be made about some of these dependent variables that allow testing the proposed classification. It should, however, be kept in mind that some of the considered models in each category might also make slightly different predictions.

With associative intuition there should be a relatively direct mechanistic link between previous learning experiences and decisions. Decision times should be roughly equal for options with similar frequencies of learning experiences, and time might decrease with increasing number of learning experiences. Confidence, feelings, and a related anticipatory arousal should also mainly reflect previous learning experiences and should be less influenced by additional (cognitive) information that is currently available. Overall, the influence of context information should be low.

Matching intuition should be much more influenced by context information and it should be even more sensitive to changes in the similarity of crucial features of the task. Assuming that there are time-costs related with memory prompting (comparing the situation with exemplars), decision times might increase with increasing numbers of learning experiences. Confidence should also be highly sensitive to manipulations of similarity but should increase with learning experiences. Attention should be equally distributed to all attributes or there might be a special focus on attributes that are most diagnostic for a match.

Accumulative intuition describes an automatic retrieval and accumulation process. Evidence should be added up in a linear manner. Attention, which can for instance be measured using eye tracking, should be distributed to the different outcomes or cues proportionally to their importance or probability. In contrast to associative and matching intuition, learned experiences and currently available information are blended into one overall evaluation. Accumulative intuition could therefore also be applied without any specific learning experiences. Decision time should increase with decreasing differences in evidence strength between the options.

Constructive intuition predicts that people construct consistent mental representations of a task in a process similar to perception. In a simultaneous top-down and bottom-up process, the valuation of information is changed to support the emerging interpretation. Consequently, many rather distinct predictions can be made. First, constructive intuition predicts systematic information distortions (e.g., Holyoak & Simon, 1999). Second, it predicts that minor changes in the evidence can lead to completely different interpretations and decisions. Hence, the mechanism predicts some discontinuities. As in classic ambiguous figures (*Kippfiguren*) from Gestalt psychology, a slight shift in attention can completely change the picture. Third, decision time and confidence should be dependent on the overall consistency in the evidence (whether and how quickly it allows the construction of a consistent interpretation or not). Fourth, arousal should increase with increasing inconsistency between the pieces of evidence. Fifth, attention should be shifted to the attributes that are highlighted in the decision process.

If the proposed predictions do not hold empirically, this might indicate that some of the suggested categories should be collapsed. Research might, on the other hand, also help to specify the conditions under which different mechanisms are applied. We strongly encourage researchers to test whether our distinction of four categories of mechanisms holds, or should be collapsed, or further differentiated. We also encourage theorists and proponents of the different models to add further and more specific hypotheses to the debate.



## DISCUSSION

Dual-process models highlight the difference between intuitive and deliberate processes in judgement and decision making, and describe general properties of the two classes of processes. However, they usually do not differentiate between different kinds of processes within each class. As demonstrated by listing some recent definitions of intuition, this leads to considerable disagreement among researchers about the question of what intuition really is. We argue that this disagreement can be overcome by accepting that the commonly used label "intuition" refers to a collection of very different processes. Based on existing process models for decision making that take automatic processes into account, we suggest that at least four different types of intuition can be differentiated: (a) Associative intuition based on simple learning and retrieval, (b) Matching intuition relying on complex prototype and exemplar storage and retrieval, (c) Accumulating intuition based on automatic linear integration of information from memory and currently perceived information, and (d) Constructive intuition based on the construction of consistent mental representations.

The suggested differentiation is a first step towards qualifying the assumptions of dual-process models about general properties of intuition. By way of example we demonstrated that the differentiation helps to shed light on the assumption often postulated by dual-process models that intuition operates on affective information. For some types of intuition this is true, but other types equally take into account cognitive information. Furthermore, the differentiated analysis reveals that affect is important as input to as well as output from the different processes.

Finally, we used the process perspectives to derive common ground predictions about the conditions under which intuition will—on average—lead to good judgements and decisions. This should be the case if the *input* to the processes is unbiased, representative and sufficient (cf. Hogarth, 2001). Although this prediction seems almost trivial, it differs markedly from predictions by multi-strategy models (e.g., Gigerenzer & Todd, 1999; Payne et al., 1988). The later models assume that an optimal selection of strategies and their flawless application leads to good decisions. Hence, according to multi-strategy models performance is optimised by learning on the levels of strategy selection and strategy application. According to the intuitive processes perspectives discussed in this paper, in contrast, learning mainly optimises the informational basis, which constitutes the input to the same (usually complex) information integration process (see also Newell, 2005).[2]

Overall, with this work we aim to highlight that intuition researchers should invest less effort in answering the questions of what intuition really is and whether it is generally better or worse than deliberation. We think that it is more fruitful to investigate more specific hypotheses concerning the different underlying processes, and we hope that the suggested differentiation of intuition into four kinds can be a starting point for this fascinating challenge.

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