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CHAPTER 2

Examining the Mapping Problem in Dual-Process Models

Agnes Moors

Multiprocess models divide the realm of mental processes into two (e.g., Gawronski & Bodenhausen, 2006, 2011; Lieberman, 2003; Sloman, 1996; Smith & DeCoster, 2000; Strack & Deutsch, 2004), three (Leventhal & Scherer, 1987), or four sets of processes (e.g., Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005; Sherman, 2006). The sets of processes in dual-process models often correspond to dichotomies such as affective versus nonaffective, heuristic versus systematic, automatic versus nonautomatic, associative versus rule-based, perceptual versus conceptual, associative versus propositional, and subcortical versus neocortical. It is perfectly legitimate to create sets on the basis of one or another dichotomy. Most dual-process models, however, take things one step further. They choose two or more dichotomies and make a priori assumptions of overlap among them (Keren & Schul, 2009; Moors & De Houwer, 2006b). A few examples: Associative processes are often said to be automatic, and rule-based processes nonautomatic (e.g., Smith & DeCoster, 2000). Associative processes are often said to operate on perceptual codes, and rule-based processes on conceptual codes (e.g., Leventhal & Scherer, 1987). Heuristic information (e.g., attractiveness of the speaker) is said to exert an automatic influence on decision making, and systematic information (e.g., persuasive arguments of the speaker) a nonautomatic influence (e.g., Chaiken, Liberman, & Eagly, 1989). By mapping various dichotomies onto each other, dual-process models may grow into dual systems models (e.g., Deutsch & Strack, 2006).

The question one may ask is whether it is justified to map dichotomies onto each other. I propose investigating the mapping problem in a stepwise manner. A first step is to engage in the conceptual analysis of various dichotomies to see whether they can be defined independent of each other. If it turns out that they can be so defined, a second step is to investigate empirically whether there is overlap among dichotomies in the real world. To be able to go from the first to the second step, however, an intermediate step is required, in which the definitions proposed in the first step should be translated into methods for diagnosing occurrent processes as belonging to one or the other term of the dichotomy. In this chapter, I engage in a conceptual analysis of the following dichotomies: automatic versus nonautomatic, associative versus rule-based, perceptual versus conceptual, and associative versus propositional (cf. the first step discussed earlier). After that, I examine whether the definitions

obtained in the first step lead to criteria for the diagnosis of processes (cf. the intermediate step discussed earlier).

CONCEPTUAL ANALYSIS

Definitions of sets are often of the intensional kind, specifying the necessary and sufficient conditions for something to be an exemplar of a set (i.e., one necessary and sufficient condition, or a collection of necessary conditions that are jointly sufficient). Intensional definitions can be descriptive or prescriptive. Descriptive definitions describe the rules that laypersons (implicitly or explicitly) follow (or seem to follow) when using concepts. Prescriptive definitions stipulate the rules that scientists prescribe for using concepts. The development of prescriptive definitions is often guided by two principles: A first principle is to stay close to natural language or the way in which laypersons use the term (descriptive definitions). As such, it should cover a sufficient number of intuitively clear exemplars (Green, 1992). A second principle stems from the desire to cut nature at its joints or to provide a useful heuristic for future research. These joints are not absolute but context dependent and in this sense involve an element of choice (i.e., they are stipulative). My choice of definitions is explicitly guided by the desire to avoid overlap among dichotomies. The main argument for this is that empirical research can only be carried out with concepts that are logically independent (e.g., Smedslund, 1992). For example, when the dichotomies of automatic versus nonautomatic and associative versus rule-based are defined independently, four combinations are open to investigation: associative and automatic, associative and nonautomatic, rule-based and automatic, and rule-based and nonautomatic. When, by contrast, automatic processes are defined as associative ones, and rule-based processes are defined in terms of nonautomatic features (e.g., conscious), there is no point in empirically investigating any combination. Investigating whether associative processes are automatic, for instance, would be equally absurd as investigating whether bachelors are indeed single and male. By excluding certain combinations from empirical research, we might miss out on relevant findings. Thus, my aim in this section is to examine whether there is a satisfactory way to define each dichotomy without having to make appeal to another dichotomy.

My proposal is to situate the various dichotomies within a levels-of-analysis framework. This framework proposes that any process can be described at (minimally) three levels of analysis (e.g., Anderson, 1987; Marr, 1982; Pylyshyn, 1980). At the functional level, a process is described as the relation between an input and an output. This level includes the content of inputs and outputs, as well as the conditions under which the process operates. For example, affective processing or evaluation can be described as the relation between a stimulus and affective properties (e.g., positive or negative valence). The processing of heuristic information can be described as the relation between a stimulus and heuristic properties (e.g., the attractiveness of the speaker). Conditions include those related to automaticity versus nonautomaticity (e.g., uncontrolled–controlled; unconscious–conscious, efficient–nonefficient, fast–slow). The algorithmic level articulates the mechanisms involved in transforming input into output, as well as the formats of the representations or codes that the mechanisms operate on or produce. For example, evaluation can proceed with an associative mechanism (retrieving stored valence) or a rule-based one (e.g., weighing the implications for various concerns), and both might operate on various types of codes (e.g., conceptual versus perceptual, associative versus propositional). The hardware level is concerned with the physical implementation of processes in the brain. At this level, a process is described in terms of its neurophysiological substrates (e.g., neocortical versus subcortical areas or circuits). For example, evaluation is often linked to circuits involving the amygdala.

The levels-of-analysis framework makes it easy to conceive of the various dichotomies as nonoverlapping. This is because the levels in the framework are only loosely related to each other. For instance, one functional process (e.g., evaluation) can be accounted for by more than one mechanism (e.g., by a rule-based or associative process). Also, presenting automaticity as a matter of con-

ditions provides a natural way to decouple it from processes (described at any level). The next sections include detailed definitions of dichotomies and compare them with alternative definitions, specifically with regard to how successful they are in avoiding overlap with other dichotomies.

Automatic versus Nonautomatic

Contemporary feature-based views of automaticity define it as an umbrella term for a number of features, such as uncontrolled, unintentional, unconscious, efficient, and fast (Bargh, 1992; Moors & De Houwer, 2006a). These features roughly can be defined as follows. An *uncontrolled* process is one that is not influenced by a person's goals about the process. Goals about processes can be either of the promoting kind (e.g., the goal to engage in the process, which can be split into goals to start, continue, and complete the process) or of the counteracting kind (e.g., the goals to avoid, alter, or stop the process). A process is uncontrolled in the promoting sense when it is not caused by the goal to engage in it (or to start, continue, or complete it). Another word for uncontrolled in the promoting sense is *unintentional*. A process is uncontrolled in the counteracting sense when it is not counteracted (avoided, altered, or stopped) by the goal to do so (avoid, alter, or stop). A process is *unconscious* when the person has no awareness of it. I think awareness is possible for processes described at the functional level (i.e., the relation between input and output) but not likely for processes described at the algorithmic or hardware level (Moors & De Houwer, 2006a). People may be aware that they evaluate a person as good or bad, but they probably lack insight into the mechanisms, codes, and brain circuits involved. An *efficient* process is one that makes minimal use of attentional capacity. A *fast* process is one that is completed within a short time interval.

The definitions of automaticity features just given can be reformulated in terms of operating conditions (Bargh, 1992; Moors & De Houwer, 2007; Moors, Spruyt, & De Houwer, 2010). For example, a process is uncontrolled in the promoting sense (unintentional) when the goal to engage in it is not part (or only a redundant part) of the set of conditions that is sufficient for the process to operate. A process is uncontrolled in the counteracting sense when it operates regardless of the presence or absence of a counteracting goal within the set of conditions. A process is unconscious when it operates under the condition of a lack of awareness. A process is efficient when it operates under the condition of minimal available attentional capacity. A process is fast when it can be completed under the condition of minimal available time. In summary, a process is automatic when it operates under suboptimal conditions; a process is nonautomatic when it operates only under optimal conditions.

Logan (1988) proposed to replace feature-based definitions of automaticity with a mechanism-based definition. Specifically, he proposed to define automatic processes as ones that are based on single-step memory retrieval. Single-step memory retrieval is very much akin to what others have called an associative mechanism, that is, the activation of a memory trace leading to previously computed outputs. Such a definition of automaticity is obviously not successful in avoiding conceptual overlap with the associative versus rule-based dichotomy.

Associative versus Rule-Based

The associative versus rule-based dichotomy has a central role in research domains such as problem solving (Anderson, 2005; Mayer, 1992), categorization (Rouder & Ratcliff, 2006; Smith & Sloman, 1994), reasoning (Sloman, 1996), memory (Smith & DeCoster, 2000), and grammar learning (Reber, 1967). It refers to the mechanisms situated at the algorithmic level of analysis. A rule-based mechanism consists of the application of a rule to an input (or a representation of it). Computation of the rule produces an output. An associative mechanism consists of the activation of stored representations of similar past inputs. This activation, in turn, spreads to associated stored representations that determine the output. As an illustration from the domain of problem solving, consider the behavior of two persons paying 4 euros at the counter after having ordered two beers that cost 2 euros each. One person's behavior is caused by the calculation of the rule "$N \times M = 4$," in

which N is the number of beers ordered and M is the price of one beer. The other person's behavior is caused by the activation of a memory that she paid 4 euros last time when she ordered the same. As an example from categorization, consider that dolphins are (correctly) categorized as mamals based on the rule that mamals nurse their offspring. Based on similarity with fish exemplars, they can also be (incorrectly) classified as fish. It may be noted that some researchers speak of the similarity-based mechanism instead of the associative mechanism, because the initial activation of stored representations is based on similarity (Hahn & Chater, 1998; Pothos, 2005).

To arrive ultimately at a way to diagnose processes as either rule-based or associative, the previous definitions need to be formalized. What is computation? And in what sense is it different from activation of stored knowledge?[2] I discuss several criteria that have been proposed as capturing the essence of the rule-based versus associative dichotomy. First, it has been suggested that rule-based mechanisms are ones that can be described by an if–then clause. For example, "if $N \times M = p$, then pay p euros." However, several authors have correctly noted that the associative mechanism can be described by an if–then clause as well. For example, "if two beers, then pay 4 euros." In fact, any mechanism that connects an input to an output can be expressed in an if–then format. The if-part specifies the input, and the then-part specifies the output. This has led some authors to conclude that associative and rule-based mechanisms are not qualitatively different, and that an associative mechanism is just a simple type of rule-based mechanism (Kruglanski, Erb, Pierro, Mannetti, & Chun, 2006). Other authors have searched for other criteria to distinguish both types of mechanisms.

A second criterion is that rule-based, but not associative, mechanisms can be described by *abstract* rules (e.g., Sloman, 1996; Smith, Langston, & Nisbett, 1992) in which the premise (the if-part) contains variables. Variables are abstract representations that can be instantiated with more than one constant. In the abstract rule of the beer example (if $N \times M$, then p), the variables N and M can be instantiated with an infinite range of numbers. By contrast, associations can be described with *nonabstract* rules, in which the premise consists of only constants. Constants are representations of concrete instances. The nonabstract rule of the beer example (if two beers, then 4 euros) cannot be applied to novel situations (e.g., ordering five coffees) unless they resemble the situation in the premise (e.g., ordering two soft drinks).

A third criterion is that rule-based mechanisms can operate only if there is a perfect match between the input and the premise, whereas associative mechanisms can also operate if there is a partial match between the input and the premise (or stored representation; Hahn & Chater, 1998). In the beer example, the abstract rule $N \times M$ cannot be computed unless values for N and M are available. The nonabstract rule to pay 4 euros when ordering two beers can be applied to any situation that is similar to this one (the more similarity, the stronger will be the activation of the memory trace). Because of the complementary forces of abstraction and partial matching, both rule-based and associative mechanisms can account for generalization toward new exemplars. Rule-based mechanisms can produce generalization by virtue of abstract variables; the associative mechanism can produce generalization by virtue of partial matching (partial matching compensates for the lack of variables). Nonabstract rules can thus be applied to new input, but only by virtue of similarity among the input and the constants specified in the premise.

A fourth criterion spelled out by some theorists is that rule-based mechanisms are ones that *follow* rules, whereas the associative mechanism merely *conforms* to rules. Rule *following* means that a mental rule sits between the input and the output of a process and causes the output; rule *conforming* means that the relation between input and output merely can be described or summarized according to a rule (Hahn & Chater, 1998; Pylyshyn, 1980; Searle, 1980; Sloman, 1996; Smith et al., 1992). Numerous phenomena can be described with rules without there being actual rule following. Examples are the planetary motions and the dances of honeybees. Planets and bees are unlikely to have internal representations of the rules that describe their behavior. Something similar is assumed to occur with the asso-

ciative mechanism. However, unlike with planets or bees, associations are internal to the organism (mental) and they do mediate between input and output. Moreover, it has been argued that rules can be implemented by patterns of associations (like the ones proposed in connectionist models; Fodor & Phylyshyn, 1988), or that rules are approximations of such patterns (Smolensky, 1986). These views again suggest no fundamental distinction between associative and rule-based mechanisms: They are the same thing described on different levels of analysis.

A fifth criterion proposed by some theorists is that the rules in rule-based processes must be not only internally represented and causal but also symbolic (e.g., Hahn & Chater, 1998; Smith & DeCoster, 2000). A symbolic representation of a rule has the rule as its content or object (but see Searle, 1980). Because patterns of associations do not represent rules symbolically (they are subsymbolic representations of rules at best), activation of them does not count as rule-based processing. Other theorists (Clark, 1990; Fodor & Pylyshyn, 1988; Pinker & Prince, 1988; Smith et al., 1992) have argued against the view that the rules in rule-based processes must be symbolically represented. They allow rules to be hardwired in the system. Fodor and Pylyshyn (1988, p. 61) maintained that the only things that must be symbolically represented in a computational system are the data on which the rules operate. Patterns of associations are typically not built in but are shaped by the environment. Yet one may wonder why the distinction between innate and learned would be crucial in determining whether something counts as a real rule (i.e., a generator of rule-based processing). In summary, several criteria have been proposed to demarcate rule-based from associative mechanisms: abstract versus nonabstract, perfect versus partial matching of the premise, and rule following versus rule conforming. With regard to the latter criterion, some authors consider internal representations and causal influence as sufficient ingredients for rule following, whereas others also include the ingredient symbolic representation.

An alternative proposal is to define rule-based processes as ones that are conscious, or at least conscious during application (Cleeremans & Destrebecqz, 2004; Zhong, Dijksterhuis, & Galinsky, 2008). Given that consciousness is a feature of nonautomaticity, such a definition is not successful in avoiding overlap with the automatic–nonautomatic dichotomy. As such, it precludes empirical research concerned with whether rule-based mechanisms can be automatic (e.g., Hélie, Roeder, & Asch, 2010; Hélie, Waldschmidt, & Asch, 2010; Van Opstal, Gevers, Osman, & Verguts, 2010).

The next dichotomies to be discussed, perceptual versus conceptual and associative versus propositional, characterize the format of the representations or codes on which mechanisms operate. The terms *conceptual* and *propositional* indicate a resemblance, respectively, with words and sentences in natural language. The resemblance is not physical, but structural or functional (what can be done with it), and various bases for this resemblance have been highlighted.

Perceptual versus Conceptual

The dichotomy of perceptual versus conceptual codes is central in the domain of imagery and has often been referred to as picture-like versus verbal-like (Barsalou, 1999).[3] Conceptual codes are thought to be abstract[4] (e.g., the word *dog* applies to many instances of dogs), context-independent (e.g., the same code for *dog* is activated in all contexts), and amodal (i.e., the same code is activated by a picture of a dog, and the word *dog* in writing or pronounced out loud; Barsalou, 1999). Perceptual (or sensory) codes have perceptual (or sensory) features and are therefore concrete (e.g., an image of a dog cannot be applied to all dogs), context-dependent (e.g., a different *dog* code is activated in the context of a dark alley than in the context of a dog house), and modal (an image of a dog activates a code other than that produced by the word *dog* pronounced out loud). Some authors add motor features to these perceptual codes and call them *embodied* (Barsalou, 1999). Activation of embodied codes leads to partial reenactment or mental simulation of the perceptions and actions that typically occur in the presence of the represented object, which makes them dynamic. This is a further difference with conceptual codes, which are considered static.

Associative versus Propositional

Propositional codes are often said to be *compositional*, which means that they comprise meaningful parts that can be recombined with other parts to form new representations (i.e., productivity; Fodor & Phylyshyn, 1988).[5] In that sense, they are just like sentences in natural language, which also comprise words that can be recombined with other words to form different sentences. An organism that is capable of responding differently to the same stimulus in different contexts must have the capacity to form propositions in the sense that it can isolate parts and reuse them in new combinations.

In addition to being compositional, several authors have proposed that the content of propositional codes also must be truth evaluable (Anderson, 1978). Thus, in addition to comprising (recombinable) parts (e.g., cat–roof), propositional codes also must specify a relation between these parts that can be evaluated as true or false (e.g., the cat is on the roof). In order for a relation to be truth evaluable, it must have a certain quality. These so-called "qualified" relations (e.g., *A* is *B*, *A* is bigger than *B*, *A* is under *B*) are contrasted with unqualified relations, also termed (pure) associations, in which the nature of the relation between the parts is unspecified (e.g., *A–B*; De Houwer, Chapter 35, this volume). This aligns with the idea that to hold a proposition (e.g., "the apple is red") is not to hold a list of concepts (apple, is, and red) but to predicate something (redness) onto something (the apple; Soames, 2012). To sum up, *propositional codes* are defined here as complex representations that comprise a qualified relation between elementary representations. *Associations* are defined as complex representations that comprise unqualified relations between elementary representations.

Theorists in the domain of learning (e.g., Gawronski & Bodenhausen, 2011) have used the contrast between associations and propositions as the basis for distinguishing between two types of mechanisms: associative ones and propositional ones.[6] The *associative mechanism* is often defined as the activation of an association in memory, and the *propositional mechanism,* as the validation of a proposition, that is, the evaluation of it as true or false. It may be noted that these definitions comprise two parts: one part is a verb (activation, validation), and the other is a type of representation (association, proposition). Thus, in these definitions, mechanisms are partly defined in terms of formats of representations. Other authors (e.g., De Houwer, Chapter 35, this volume) also define the associative mechanism as the activation of an association, but the propositional mechanism as anything that happens (validation or activation) with a proposition. According to this view, the pure activation of a proposition is also called a *propositional mechanism.* Here too, mechanisms are defined in terms of formats of representations.

One might ask whether it is possible to avoid such overlap between mechanisms and representations. Can associative and propositional mechanisms be defined in such a way that they are allowed to operate on any type of representation? I think this is indeed possible for the associative mechanism but not for the propositional mechanism. The *associative mechanism* can be minimally defined as the activation of a representation in memory, without specifying the format of the representation that is activated. The *propositional mechanism,* on the other hand, if it is defined as validation or the evaluation of something as true or false, can only operate on representations that are truth evaluable. As discussed earlier, only propositions, defined as complex representations comprising a qualified relation between two elementary representations, can be evaluated as true or false. This is not possible for elementary representations (e.g., the concept *cat*), or for associations, defined as complex representations of unqualified relations between two elementary representations (e.g., cat–roof). This being said, some theorists (e.g., Gawronski & Bodenhausen, 2011) seem to suggest that associations give rise to the spontaneous formation of propositions, and that the latter can be validated. For instance, the association "banana–good" gives rise to the proposition "banana is good," which can be evaluated as true or false. But how does the organism know which quality to attribute to an unqualified relation? The banana–good example suggests that the organism follows a default rule, according to which associations suggest a positive or even identity relation (i.e., an "is a" relation). But

such a default rule cannot be applied to the cat–roof example. A better solution might be to argue that associations tend to be interpreted in a way that is consistent with existing propositions. But even then, given that people may endorse multiple propositions about the same pair of concepts (the banana is good when I am in a fruit mood, otherwise it is bad; the cat may be under the roof), the question of which proposition is most likely to be chosen as a frame for a given association remains unanswered. In any case, the transition from associations to propositional codes is something that is left largely unspecified.

Theorists have defined the distinction between associative and propositional mechanisms not only in terms of types of representations but also in terms of features of nonautomaticity, in particular the feature *conscious* (e.g., De Houwer, Chapter 35, this volume; Mitchell, De Houwer, & Lovibond, 2009). For example, it has been proposed that the formation of a proposition must be conscious, or at least that the output of this formation process, the proposition itself, must be conscious at some point. In addition, it has been proposed that evaluation of the proposition as true (i.e., belief of the proposition) must be conscious at some point. These theorists accept that once a proposition is stored in memory,[7] it may be retrieved in an unconscious way, and that conscious and unconscious propositions may exert an unconscious (and otherwise automatic) influence on subsequent behavior and thought. Even so, the fact that consciousness of the proposition is put forward as a necessary element in the definition of the propositional mechanism creates overlap with the automatic–nonautomatic dichotomy. Such overlap can be avoided by adopting a minimal definition of the propositional mechanism as validation or truth evaluation irrespective of consciousness.

DIAGNOSIS

The conceptual exercise in the previous section shows that it is possible to define most dichotomies in nonoverlapping ways. A closer look at these nonoverlapping definitions reveals that several of them do not allow one to draw an all-or-none distinction between the two terms of a dichotomy. This has implications for the diagnosis of the mental processes underlying some performance as belonging to either term of a dichotomy.

Automatic versus Nonautomatic

In the former section I defined *automaticity* as an umbrella term for a collection of features. In addition, I favor a gradual approach to automaticity (Logan, 1985; Moors & De Houwer, 2006a; Shiffrin, 1988). This gradualness is manifested in two ways. First, I suggest that a process can be automatic with regard to some but not other features. For example, it seems that some processes are fast and efficient but can be counteracted (Uleman & Moskowitz, 1994). Second, each automaticity feature can itself be considered as gradual. A process more or less can be uncontrolled, unconscious, efficient and/or fast. Although I believe the gradual approach to automaticity is theoretically the most cautious approach, it does not provide an objective criterion for the diagnosis of a process as automatic or nonautomatic. This problem can be dealt with by specifying the sense in which (i.e., the feature according to which) one considers a process to be automatic or nonautomatic, and by making relative conclusions or choosing an intersubjective criterion (i.e., convention) for calling some process controlled or uncontrolled, conscious or unconscious, efficient or nonefficient, and fast or slow (Moors & De Houwer, 2006a).

Researchers have proposed to examine (1) the uncontrolled nature of a process by removing aspects of the procedure (e.g., instructions or other cues) that might induce a processing goal (to engage in or counteract a process), or by blocking implementation of such a goal (e.g., Klauer & Teige-Mocigemba, 2007; Moors, De Houwer, Hermans, & Eelen, 2005; Spruyt, De Houwer, & Hermans, 2009); (2) the unconscious nature of a process by presenting stimuli subliminally (Greenwald, Klinger, & Schuh, 1995); (3) the efficient nature of a process by increasing the load of a secondary task in dual-task studies (e.g., Hermans, Crombez, & Eelen, 2000); and (4) the fast nature of a process by using short stimulus onset asynchronies combined with short response

deadlines (Draine & Greenwald, 1998; for a detailed review, see Moors, Spruyt, & De Houwer, 2010).

Associative versus Rule-Based

Assessment of rule-based mechanisms separate from or in addition to the associative mechanism also suffers from the problem that the criteria adduced to distinguish between the two mechanisms not always lead to unequivocal ways to diagnose performance as based on one or the other mechanism. First, as explained earlier, both rule-based and associative mechanisms are able to account for generalization toward new stimuli (abstract rules by virtue of variables, associations by virtue of partial matching).

Second, abstraction is a gradual notion (Hahn & Chater, 1998). The variables in abstract rules and the constants in nonabstract rules occupy two points on a continuum. Variables can be instantiated with a larger set of things than can constants, but the variables in abstract rules often cannot be instatiated by just anything (e.g., in the abstract rule, "if $N \times M = p$, then pay p euros," N and M must be instantiated by the number of beers ordered and the price of one beer, not by the number of words spoken and the color of the curtains). At the extreme abstract end of the continuum are logical rules in which the variables can be substituted by anything (e.g., if [X and Y], then X). Conversely, constants often hold some level of abstraction (e.g., in the nonabstract rule "if two beers, then pay 4 euros" the representation of two beers can itself be instantiated by more than two unique instances of beer). At the extreme nonabstract end of the continuum are constants that represent a unique instance. Given the relative nature of abstraction, no objective line can be drawn between variables and constants. This is reflected in the idea that activation of stored knowledge can be based on concrete as well as abstract similarities (e.g., similar function). Similarity even may pertain to abstract relations among variables (cf. Goldstone, 1994; Redington & Chater, 1996; Hummel & Holyoak, 2003). For instance, dolphins are perceptually similar to fish but they are similar to other mammals in the abstract sense that they nurse their offspring, and the latter type of similarity is indistinguishable from applying the rule that mammals are animals that nurse their offspring. Thus, evidence for generalization toward stimuli that share only abstract features with previously encountered ones (Reber, 1989; Marcus, Vijayan, Bandi Rao, & Vishton, 1999) is equally compatible with rule-based and with associative mechanisms (Redington & Chater, 1996; but see Sloman & Rips, 1998; Smith et al., 1992).

Third, advocates of the idea that rules in rule-based mechanisms must be symbolically represented have proposed to use verbal reports to investigate the content of representations. If a person has a symbolic representation of a rule, there is a possibility that he or she can verbally report the rule. Unfortunately, the criterion of verbal reportability is unsuitable for research concerned with automatic (in the sense of *unconscious*) rule-based processing. It is also not suited for studying nonsymbolic rules, such as subsymbolic patterns of associations or built-in rules.

The research literature contains several other proposals for how to register the operation of rule-based mechanisms independent of the operation of the associative mechanism, but none of the proposed methods seems unequivocal (cf. reviews by Hahn & Chater, 1998; Rouder & Ratcliff, 2006; Sloman, 1996; Smith et al., 1992). One option is to continue searching for a distinction between rule-based and assocative mechanisms that *does* lead to an undisputable empirical test. Another option is to abide by a gradual view of this distinction (e.g., Pothos, 2005) or to specify an intersubjective criterion (i.e., convention) for calling a mechanism rule-based or associative.

Perceptual versus Conceptual

Diagnosing representations as perceptual (picture-like, concrete, modal, dynamic) versus conceptual (verbal-like, abstract, amodal, static) has met with similar difficulties. Various authors (Anderson, 1978; McDowell, 1994; but see Dretske, 1981; Peacocke, 1992) have suggested that the two are informationally equivalent. Any detail of a picture-like representation can be described verbally. Furthermore, activation can spread from amodal and disembodied representations to the sensory and motor systems, and

in this way account for modal and embodied effects (Garcia-Marques & Ferreira, 2011; Mahon & Caramazza, 2008). As emphasized by several authors (Anderson, 1978; De Houwer, 2011; Thomas, 1999), it is a fallacy to take the properties of effects as reflecting the properties of the underlying representations. Because of these considerations, it may be difficult, if not impossible, to distinguish empirically between perceptual and conceptual representations (Anderson, 1978; Barsalou, 1992; Garcia-Marques & Ferreira, 2011).

Associative versus Propositional

As argued earlier, it is possible and desirable to (conceptually) distinguish between codes and mechanisms. Propositional codes are different from the propositional mechanism that validates them, and associations are different from the associative mechanism that activates them, and that can also activate propositional codes. According to the definitions presented here, diagnosing whether propositional codes versus associations are involved requires determining whether the information involved is qualified versus unqualified. Diagnosing whether an associative or propositional mechanism is operating on a proposition requires determining whether the proposition was merely activated or also validated. An association can only be activated.

Associations versus Propositional Codes

Dual-process models based on the associative versus propositional dichotomy have assumptions about not only the deployment of associations versus propositional codes but also their formation (cf. Note 6). Associations form gradually by repeated presentation of two elements paired in time and space, whereas propositional codes can form after a single verbal instruction containing the proposition (e.g., Gawronski & Bodenhausen, 2006, 2011; Rydell & McConnell, 2006; Sternberg & McClelland, 2012). To examine associations versus propositional codes, researchers have tried to install them by manipulating the information provided to the participants (two elements related in time and space vs. bound up in a qualified relation) and the way in which the information is presented (repeated pairings vs. a single verbal instruction). There is an important caveat, however. Associations can lead to the spontaneous formation of propositions (cf. supra). For instance, the association banana–good can give rise to the proposition "the banana is good" or even "the banana has a temporospatial relation with good." Propositions, from their part, can also lead to the formation of associations. A qualified relation can be stored partially, without the quality of the relation. Moreover, propositions that were entirely stored can be retrieved partially, leaving the quality of the relation unretrieved (De Houwer, Chapter 35, this volume). These considerations cast doubt on the methods of repeated pairings versus verbally instructing propositions as reliable methods for installing associations versus propositional codes.

Associative versus Propositional Mechanisms

Several researchers (e.g., Gawronski & Bodenhausen, 2006; Rydell & McConnell, 2006; Strack & Deutsch, 2004; Wilson, Lindsey, & Schooler, 2000) have proposed diagnosing the propositional mechanism with direct subjective (i.e., self-report) measures, and the associative mechanism with indirect objective measures such as stimulus–response compatibility (SRC) tasks (e.g., priming task: Fazio, Jackson, Dunton, & Williams, 1995; Implicit Association Test [IAT]: Greenwald, McGhee, & Schwartz, 1998). For instance, the validation of the proposition "the banana is good" can be measured by asking a participant to rate the goodness of the banana on a scale. Activation of the association "banana–good" can be measured by administering a priming task in which it is verified whether *banana* as a prime facilitates responding to positive rather than negative target stimuli. The proposal to measure *propositional mechanisms* (defined here as the validation of a proposition) with self-report is based on the idea that people only report that something is good when they have evaluated this proposition as true. This assumption could be questioned, however. Participants can fill out questionnaires in a mindless manner, that is, without validation or assent, or they may lie. Adding a confidence measure

might reduce mindless responding but not lying. The proposal to measure the *associative mechanism* (minimally defined here as the activation of any type of representation) with SRC tasks is based on the assumption that effects on these tasks circumvent validation. This assumption has been challenged by a study of Peters and Gawronski (2001) in which validation information influenced both self-reports and outcomes of indirect measures (the affect misattribution task and the evaluative priming task) and research showing that effects on the IAT can be faked (e.g., De Houwer, Beckers, & Moors, 2007; Steffens, 2004). The mapping of processes onto measurement procedures or outcomes can be considered a different kind of mapping problem, one that should also receive independent empirical testing. As various authors have argued, however, measurement procedures are rarely process pure, and it is therefore problematic to use a measurement outcome as a proxy for a mental process (e.g., De Houwer, Gawronski, & Barnes-Holmes, in press; De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009; Gawronski, Deutsch, LeBel, & Peters, 2008; Jacoby, 1991; Sherman, 2006).

The use of self-report methods versus SRC tasks for diagnosing propositional versus associative mechanisms is further inspired by the mapping of this dichotomy on the nonautomatic versus automatic dichotomy, as well as the assumption that self-report methods versus SRC tasks uniquely and confidently measure nonautomatic versus automatic processes. Researchers have argued that this assumption, rather than being taken for granted, should be submitted to empirical testing (De Houwer, 2006; De Houwer & Moors, 2007). In addition, as already mentioned, the mapping of dichotomies (propositional vs. associative mechanism onto nonautomatic vs. automatic) does not fit in my plan to avoid overlap between dichotomies.

CONCLUSION

As dual (and multi) process models divide the realm of mental processes, they tend to assume conceptual and/or actual overlap among dichotomies. I argued that such assumptions of overlap may be premature. In fact, they should be investigated empirically. As a preparation to such empirical research, I first examined whether dichotomies can be defined independent of each other and concluded that this is indeed possible for most dichotomies. I then considered whether the definitions resulting from this exercise allow researchers to distinguish empirically between the two terms in each dichotomy. In this respect, I pointed out the difficulty in finding unequivocal empirical criteria to classify processes as automatic versus nonautomatic, associative versus rule-based, associative versus propositional, and as operating on perceptual versus conceptual codes and associations versus propositional codes.

In particular, the gradual views proposed for the dichotomy of automatic versus nonautomatic (Moors & De Houwer, 2006a; Shiffrin, 1988) and associative versus rule-based (Pothos, 2005) obstructs the creation of sharply delineated sets. This is not problematic for research concerned with automaticity and mechanisms as such; it remains valuable to examine the degree to which a process is rule-based, and the degree to which it possesses individual features of automaticity. But it is problematic for dual-process models that rely on a sharp, principled, distinction between sets of automatic and sets of nonautomatic processes and between sets of associative and sets of rule-based processes (cf. Moors & De Houwer, 2006b).

One solution might be to revert to a reformulation of dual-process models in gradual terms, including their assumptions of overlap among dichotomies. For instance, a dual-process model might distinguish between more associative versus more rule-based processes (e.g., defined as more concrete vs. more abstract) and might assume that more associative processes are more automatic than more rule-based ones. The latter assumption could be put to an empirical test. One could, for instance, examine whether a process applied to a set of stimuli generalizes to untrained stimuli that are similar in a more or less abstract sense, and whether this generalization takes place under less or more optimal conditions (e.g., Van Opstal et al., 2010).

Not all dichotomies seem amenable to a gradual definition, however. The dichotomy

of associations versus propositional codes seems to be of a matter of all or nothing: A relation is either qualified or unqualified. Once a relation is *somewhat* qualified, it is already qualified. The same can be said of the dichotomy of associative versus propositional mechanisms: A person either does or does not evaluate a proposition as true or false. On closer scrutiny, however, it may not be mandatory to consider truth ascription as a discrete mental act. As Hume (1739–1740, Part 3, Book 1) suggested, people do not decide about the truth of a statement; a statement imposes itself as more or less true, based on features such as salience and the degree of coherence with other propositions (cf. Gawronski & Bodenhausen, 2011). Or consider the scenario that the truth value of a proposition is stored together with the proposition and is activated to varying degrees (Petty et al., 2007). Such a scenario depicts the dichotomy of associative versus propositional mechanisms as gradual. Thus, one could investigate whether propositions that receive a higher truth value operate under more or less optimal conditions than propositions that receive a lower truth value. The dichotomy of perceptual versus conceptual also can be framed in categorical terms (when the features modal–amodal, and embodied–disembodied are emphasized), as well as gradual terms (when the features abstraction and context dependence are emphasized). It may be noted that dual-process models relying on a gradual definition of mechanisms actually are unimodels, unless they also rely on other distinctions (e.g., associations vs. propositional codes) that are of a categorical nature.

A related solution for dichotomies that are of a gradual nature is to install intersubjective dividing lines between the two terms of the dichotomy. Rather than calling a process more or less automatic, more or less rule-based, or more or less propositional, the community of researchers may come to an agreement about a set of operational criteria that determines when they consider a process as automatic, rule-based, or propositional.[8]

Dichotomies that resist a gradual definition (associations vs. propositional codes) or that researchers do not accept as being gradual (e.g., some researchers insist on a categorical distinction between associative and rule-based mechanisms) may not escape a gradual treatment. A dichotomy may be categorical on a conceptual level, but conclusions about the presence of the terms often can be only gradual: One often cannot identify with certainty which code or mechanism is at stake, at least not with behavioral methods (although I do not exclude that corroborating evidence can be obtained with neurophysiological methods). To conclude, the fate of dual-process models may be gradual and/or a matter of convention.

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NOTES

1. Full-blown dual-systems models assume not only that various dichotomies map onto each other but also that the two systems thus created are isolatable (i.e., that each system can operate without the other; Keren & Schul, 2009). In addition, systems often comprise several correlated processes (e.g., the slow vs. fast learning systems each comprise processes for learning and deployment).
2. Rule-based mechanisms often operate on stored representations that themselves are activated with the associative mechanism (although they may also operate on newly formed ones). So the associative mechanism is often embedded in the rule-based mechanism (e.g., Smith & DeCoster, 2000).
3. The dichotomy of perceptual versus conceptual *codes* discussed here differs from the dichotomy of perceptual versus conceptual *processing* in the memory literature, which refers to encoding and retrieval of semantic versus physical information (e.g., Weldon, Roediger, Beitel, & Johnston, 1995). The former dichotomy is situated at the algorithmic level, the latter at the functional level.
4. At first sight, the abstract nature of propositional codes evoked in this definition overlaps with the abstract nature of rule-based mechanisms in one of the definitions discussed earlier. On second thought, however, abstract rules contain variables that can be instantiated with both concrete and abstract codes.
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REFERENCES

Anderson, J. R. (1
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Anderson, J. R. (19
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Sciences, *10*, 467
Anderson, J. R. (2
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Barsalou, L. W. (19
tems. *Behavioral*
577–660.
Chaiken, S., Liber
(1989). Heuristic
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5. It may be noted that if formats of representations are defined in terms of aspects of their content, then the previously drawn distinction between formats and contents of representations is somewhat blurred.
6. It is important to keep in mind the distinctions between mechanisms involved in learning or encoding (i.e., the formation of propositions and associations) and mechanisms involved in deployment. Here I discuss the mechanisms involved in deployment.
7. An issue of debate is whether in addition to the content of the proposition, the person's evaluation of the proposition as true is itself stored in memory (e.g., Petty, Briñol, & DeMarree, 2007) or not (e.g., Gawronski & Bodenhausen, 2007).
8. This is already the case in some research domains. For instance, in search tasks, a process is called efficient if slope ß of the linear function $y = ßx + \alpha$ (where y is the reaction time, x is the set size, and α is a constant) is smaller than 10 milliseconds (Hansen & Hansen, 1988).

REFERENCES

Anderson, J. R. (1978). Arguments concerning representations for mental imagery. *Psychological Review, 85*, 249–277.

Anderson, J. R. (1987). Methodologies for studying human knowledge. *Behavioral and Brain Sciences, 10*, 467–505.

Anderson, J. R. (2005). *Cognitive psychology and its implications* (6th ed.). New York: Worth.

Bargh, J. A. (1992). The ecology of automaticity. Toward establishing the conditions needed to produce automatic processing effects. *American Journal of Psychology, 105*, 181–199.

Barsalou, L. W. (1990). On the indistinguishability of exemplar memory and abstraction in category representation. In T. K. Wyer & S. R. Srull (Eds.), *Advances in social cognition III: Content and process specificity in the effects of prior experiences* (pp. 61–88). Hillsdale, NJ: Erlbaum.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577–660.

Chaiken, S., Liberman, A., & Eagly, A. H. (1989). Heuristic and systematic information processing within and beyond the persuasion context. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended thought* (pp. 212–252). New York: Guilford Press.

Clark, A. (1990). Connectionism, competence, and explanation. *British Journal for the Philosophy of Science, 41*, 195–222.

Cleeremans, A., & Destrebecqz, A. (2004). Real rules are conscious. *Behavioral and Brain Sciences, 28*, 19–20.

Conrey, F. R., Sherman, J. W., Gawronski, B., Hugenberg, K., & Groom, C. (2005). Separating multiple processes in implicit social cognition: The quad model of implicit task performance. *Journal of Personality and Social Psychology, 89*, 469–487.

De Houwer, J. (2006). What are implicit measures and why are we using them? In R. W. Wiers & A. W. Stacy (Eds.), *The handbook of implicit cognition and addiction* (pp. 11–28). Thousand Oaks, CA: Sage.

De Houwer, J. (2011). Why the cognitive approach in psychology would profit from a functional approach and vice versa. *Perspectives on Psychological Science, 6*, 202–209.

De Houwer, J., Beckers, T., & Moors, A. (2007). Novel attitudes can be faked on the Implicit Association Test. *Journal of Experimental Social Psychology, 43*, 972–978.

De Houwer, J., Gawronski, B., & Barnes-Holmes, D. (in press). A functional-cognitive framework for attitude research. *European Review of Social Psychology.*

De Houwer, J., & Moors, A. (2007). How to define and examine the implicitness of implicit measures. In B. Wittenbrink & N. Schwarz (Eds.), Implicit measures of attitudes: Procedures and controversies (pp. 179–194). New York: Guilford Press.

De Houwer, J., Teige-Mocigemba, S., Spruyt, A., & Moors, A. (2009). Implicit measures: A normative analysis and review. *Psychological Bulletin, 135*, 347–368.

Deutsch, R., & Strack, F. (2006). Duality-models in social psychology: From opposing processes to interacting systems. *Psychological Inquiry, 17*, 166–172.

Draine, S. C., & Greenwald, A. G. (1998). Replicable unconscious semantic priming. *Journal of Experimental Psychology: General, 127*, 286–303.

Dretske, F. (1981). *Knowledge and the flow of information.* Cambridge, MA: MIT Press.

Fazio, R. H., Jackson, J. R., Dunton, B. C., & Williams, C. J. (1995). Variability in automatic activation as an unobtrusive measure

of racial attitudes: A bona fide pipeline? *Journal of Personality and Social Psychology, 69,* 1013–1027.

Fodor, J. A., & Pylyshyn, Z. (1988). Connectionism and cognitive architecture: A critical analysis. *Cognition, 28,* 3–71.

Garcia-Marques, L., & Ferreira, M. B. (2011). Friends and foes of theory construction in psychological science: Vague dichotomies, unified theories of cognition, and the next experimentalism. *Perspectives on Psychological Science, 6,* 192–201.

Gawronski, B., & Bodenhausen, G. V. (2006). Associative and propositional processes in evaluation: An integrative review of implicit and explicit attitude change. *Psychological Bulletin, 132,* 692–731.

Gawronski, B., & Bodenhausen, G. V. (2007). Unraveling the processes underlying evaluation: Attitudes from the perspective of the APE Model. *Social Cognition, 25,* 687–717.

Gawronski, B., & Bodenhausen, G. V. (2011). The associative–propositional evaluation model: Theory, evidence, and open questions. In (J. M. Olson & M. P. Zanna (Eds.), *Advances in experimental social psychology* (Vol. 44, pp. 59–127). Amsterdam: Elsevier.

Gawronski, B., Deutsch, R., LeBel, E. P., & Peters, K. R. (2008). Response interference as a mechanism underlying implicit measures: Some traps and gaps in the assessment of mental associations with experimental paradigms. *European Journal of Psychological Assessment,* 24, 218–225.

Goldstone, R. L. (1994). The role of similarity in categorization—Providing a groundwork. *Cognition, 52,* 125–157.

Green, O. H. (1992). *The emotions: A philosophical theory.* Dordrecht: Kluwer.

Greenwald, A. G., Klinger, M. R., & Schuh, E. S. (1995). Activation by marginally perceptible ("subliminal") stimuli: Dissociation of unconscious from conscious cognition. *Journal of Experimental Psychology: General, 124,* 22–42.

Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. K. (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology, 74,* 1464–1480.

Hahn, U., & Chater, N. (1998). Similarity and rules: Distinct? Exhaustive? Empirically distinguishable? *Cognition, 65,* 197–230.

Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology, 54,* 917–924.

Hélie, S., Roeder, J. L., & Ash, F. G. (2010). Evidence for cortical automaticity in rule-based categorization. *Journal of Neuroscience, 30,* 14225–14234.

Hélie, S., Waldschmidt, J. G., & Ash, F. G. (2010). Automaticity in rule-based and information-integration categorization. *Attention, Perception, and Psychophysics, 72,* 1013–1031.

Hermans, D., Crombez, G., & Eelen, P. (2000). Automatic attitude activation and efficiency: The fourth horseman of automaticity. *Psychologica Belgica, 40,* 3–22.

Hume, D. (1739–1740). *A treatise of human nature.* London, UK: John Noon.

Hummel, J. E., & Holyoak, K. J. (2003). A symbolic-connectionist theory of relational inference and generalization. *Psychological Review, 110,* 220–264.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Keren, G., & Schul, Y. (2009). Two is not always better than one: A critical evaluation of two-system theories. *Perspectives on Psychological Science, 4,* 533–550.

Klauer, K. C., & Teige-Mocigemba, S. (2007). Controllability and resource dependence in automatic evaluation. *Journal of Experimental Social Psychology, 43,* 648–655.

Kruglanski, A. W., Erb, H.-P., Pierro, A., Mannetti, L., & Chung, W. Y. (2006). On parametric continuities in the world of binary either ors. *Psychological Inquiry,* 17, 53–165.

Leventhal, H., & Scherer, K. R. (1987). The relationship of emotion to cognition: A functional approach to a semantic controversy. *Cognition and Emotion, 1,* 3–28.

Lieberman, M. D. (2003). Reflective and reflexive judgment processes: A social cognitive neuroscience approach. In J. P. Forgas, K. R. Williams, & W. von Hippel (Eds.), *Social judgments: Implicit and explicit processes* (pp. 44–67). New York: Cambridge University Press.

Logan, G. D. (1985). Skill and automaticity: Relations, implications, and future directions. *Canadian Journal of Psychology, 39,* 367–386.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review, 95,* 492–527.

Mahon, B. Z., & Caramazza, A. (2008). A criti-

cal look at the Em
esis and a new prop
tual content. *Jour*
102, 59–70.

Marcus, G. F., Vijay
Vishton, P. M. (19
month-old infants.

Marr, D. (1982). Visi
approach. In *Visio*
tigation into the
processing of visi
126). New York: F

Mayer, R. E. (1992).
cognition. New Yo

McDowell, J. (1994
bridge, MA: Harv

Mitchell, C. J., De H
F. (2009). The pro
associative learnin
ences, 32, 183–19

Moors, A., & De H
ticity: A theoretic
Psychological Bul

Moors, A., & De H
with dividing the
Psychological Inq

Moors, A., & De H
automaticity?: Ar
features and their
(Ed.), *Social psyc*
The automaticity
(pp. 11–50). New

Moors, A., De Ho
Eelen, P. (2005).
motivational val
Experimental Ps

Moors, A., Spruyt,
In search of a mea
Recommendation
view of automati
Payne (Eds.), *Ha*
nition: Measurer
(pp. 19–37). Nev

Peacocke, C. (1992
bridge, MA: MI

Peters, K. R., & C
puppets on a str
of contingency
explicit evaluati
Psychology Bull

Petty, R. E., Briñ
(2007). The mer
attitudes: Implic
ment, change, a
25, 657–686.

cal look at the Embodied Cognition Hypothesis and a new proposal for grounding conceptual content. *Journal of Physiology—Paris, 102,* 59–70.

Marcus, G. F., Vijayan, S., Bandi Rao, S., & Vishton, P. M. (1999). Rule learning by seven-month-old infants. *Science, 283,* 77–80.

Marr, D. (1982). Vision: The philosophy and the approach. In *Vision: A computational investigation into the human representation and processing of visual information* (pp. 103–126). New York: Freeman.

Mayer, R. E. (1992). *Thinking, problem solving, cognition.* New York: Freeman.

McDowell, J. (1994). *Mind and world.* Cambridge, MA: Harvard University Press.

Mitchell, C. J., De Houwer, J., & Lovibond, P. F. (2009). The propositional nature of human associative learning. *Behavioral and Brain Sciences, 32,* 183–198.

Moors, A., & De Houwer, J. (2006a). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin, 132,* 297–326.

Moors, A., & De Houwer, J. (2006b). Problems with dividing the realm of cognitive processes. *Psychological Inquiry, 17,* 199–204.

Moors, A., & De Houwer, J. (2007). What is automaticity?: An analysis of its component features and their interrelations. In J. A. Bargh (Ed.), *Social psychology and the unconscious: The automaticity of higher mental processes* (pp. 11–50). New York: Psychology Press.

Moors, A., De Houwer, J., Hermans, D., & Eelen, P. (2005). Unintentional processing of motivational valence. *Quarterly Journal of Experimental Psychology: A, 58,* 1043–1063.

Moors, A., Spruyt, A., & De Houwer, J. (2010). In search of a measure that qualifies as implicit: Recommendations based on a decompositional view of automaticity. In B. Gawronski & K. B. Payne (Eds.), *Handbook of implicit social cognition: Measurement, theory, and application* (pp. 19–37). New York: Guilford Press.

Peacocke, C. (1992). *A study of concepts.* Cambridge, MA: MIT Press.

Peters, K. R., & Gawronski, B. (2011). Are we puppets on a string?: Comparing the impact of contingency and validity on implicit and explicit evaluations. *Personality and Social Psychology Bulletin, 37,* 557–569.

Petty, R. E., Briñol, P., & DeMarree, K. G. (2007). The meta-cognitive model (MCM) of attitudes: Implications for attitude measurement, change, and strength. *Social Cognition, 25,* 657–686.

Pinker, S., & Prince, A. (1988). On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. *Cognition, 28,* 73–193.

Pothos, E. M. (2005). The rules versus similarity distinction. *Behavioral and Brain Sciences, 28,* 1–14.

Pylyshyn, Z. W. (1980). Computation and cognition: Issues in the foundations of cognitive science. *Behavioral and Brain Sciences, 3,* 111–132.

Reber, A. S. (1967). Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior, 6,* 855–863.

Reber, A. S. (1989). Implicit learning and tacit knowledge. *Journal of Experimental Psychology: General, 125,* 123–138.

Redington, M., & Chater, N. (1996). Transfer in artificial grammar learning: a re-evaluation. *Journal of Experimental Psychology: General, 125,* 123–138.

Rouder, J. N., & Ratcliff, R. (2006). Comparing exemplar- and rule-based theories of categorization. *Current Directions in Psychological Science, 15,* 9–13.

Rydell, R. J., & McConnell, A. R. (2006). Understanding implicit and explicit attitude change: A systems of reasoning analysis. *Journal of Personality and Social Psychology, 91,* 995–1008.

Searle, J. R. (1980). Minds, brains, and programs. *Behavioral and Brain Sciences, 3,* 93–94.

Sherman, J. W. (2006). On building a better process model: It's not only how many, but which ones and by which means? *Psychological Inquiry, 3,* 173–184.

Shiffrin, R. M. (1988). Attention. In R. C. Atkinson, R. J. Hernstein, G. Lindzey, & R. D. Luce (Eds.), *Stevens' handbook of experimental psychology* (Vol. 2, pp. 739–811). New York: Wiley.

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin, 119,* 3–22.

Sloman, S. A., & Rips, L. J. (1998). Similarity as an explanatory construct. *Cognition, 65,* 87–101.

Smedslund, J. (1992). Are Frijda's laws of emotion empirical? *Cognition and Emotion, 6,* 435–456.

Smith, E. E., Langston, C., & Nisbett, R. (1992). The case for rules in reasoning. *Cognitive Science, 16,* 1–40.

Smith, E. E., & Sloman, S. A. (1994). Similarity

versus rule-based categorization. *Memory and Cognition, 22,* 377–386.

Smith, E. R., & DeCoster, J. (2000). Dual-process models in social and cognitive psychology: Conceptual integration and links to underlying memory systems. *Personality and Social Psychology Review, 4,* 108–131.

Smolensky, P. (1986). Information processing in dynamical systems: Foundations of harmony theory. In D. E. Rumelhart, J. L. McClelland, & the PDP Research Group (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition. Vol. 2, Psychological and biological models* (pp. 194–281). Cambridge, MA: The MIT Press.

Soames, S. (2012). Propositions. In D. Graff Fara & G. Russell (Eds.), *The Routledge companion to the philosophy of language* (pp. 209–220). Abingdon, UK: Routledge.

Spruyt, A., De Houwer, J., & Hermans, D. (2009). Modulation of semantic priming by feature-specific attention allocation. *Journal of Memory and Language, 61,* 37–54.

Steffens, M. (2004). Is the Implicit Association Test immune to faking? *Experimental Psychology, 51,* 165–179.

Sternberg, D. A., & McClelland, J. L. (2012). Two mechanisms of human contingency learning. *Psychological Science, 23,* 59–68.

Strack, F., & Deutsch, R. (2004). Reflective and impulsive determinants of human behavior. *Personality and Social Psychology Review, 8,* 220–247.

Thomas, N. J. T. (1999). Are theories of imagery theories of imagination?: An active perception approach to conscious mental content. *Cognitive Science, 23,* 207–245.

Uleman, J. S., & Moskowitz, G. B. (1994). Unintended effects of goals on unintended inferences. *Journal of Personality and Social Psychology, 66,* 490–501.

Van Opstal, F., Gevers, W., Osman, M., & Verguts, T. (2010). Unconscious task application. *Consciousness and Cognition 19,* 999–1006.

Weldon, M. S., Roediger, H. L., Beitel, D. A., & Johnston, T. R. (1995). Perceptual and conceptual processes in implicit and explicit tests with picture fragment and word fragment cues. *Journal of Memory and Language, 34,* 268–285.

Wilson, T. D., Lindsey, S., & Schooler, T. Y. (2000). A model of dual attitudes. *Psychological Review, 107,* 101–126.

Zhong, C.-B., Dijksterhuis, A., & Galinsky, A. D. (2008). The merits of unconscious thought in creativity. *Psychological Science, 19,* 912–918.

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of the worl
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