Examining the Mapping Problem in Multi-mode Models

Agnes Moors

Department of Psychology

Ghent University

Multi-mode models have proposed dividing the realm of cognitive processes into two (e.g., Sloman, 1996; Strack & Deutsch, 2004), three (Leventhal & Scherer, 1987), or four categories or modes (Conrey, Sherman, Gavronski, Hugenberg, & Groom, 2005). As with all forms of categorization in daily life and science, the number and nature of the categories one chooses is context-dependent. Examples of categories of cognitive processes are heuristic and systematic; automatic and nonautomatic; associative and rule-based; sensory, analog, and conceptual; and neocortical and subcortical. It is perfectly legitimate to construe categories on the basis of one or another criterion. Most multi-mode models, however, take things one step further. They choose two or more criteria and make a priori assumptions of overlap among the categories obtained with these criteria. For example, the category of associative is often mapped onto the category of automatic and the category of rule-based onto the category of nonautomatic (e.g., E. R. Smith & DeCoster, 2000). For another example, associative processes are often said to operate on analog or perceptual codes and rule-based processes on conceptual codes (e.g., Leventhal & Scherer, 1987). For a final example, 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). The question one may ask is whether the mappings of categories obtained with different dividing lines are justified. I propose to investigate the mapping problem in a step-wise manner. A first step is to engage in the conceptual analysis of a pair of criteria and see whether they can be defined in non-overlapping terms. If it turns out that theoretical overlap is not mandatory, a second step is to investigate whether there is actual overlap among both categories in the real world. In the present paper I concentrate on the mapping of associative onto automatic and rule-based onto nonautomatic processing, and investigate it in the step-wise manner described above.

Step 1

Definitions of concepts often involve an element of choice. My choice will be explicitly guided by the desire to avoid overlap among criteria. The main argument for this is that when criteria are kept apart theoretically, more options are created for empirical research. For example, when the criteria of automatic vs. nonautomatic and associative vs. 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 investigating any combination. To the question why it matters to be able to investigate combinations, I would answer that definitions are never only a matter of semantics. Definitions do not come out of the blue. They are almost always fueled by empirical observations. There is always some sort of interaction between theory and empiricism. The purpose of the present section is therefore to examine whether there is a satisfactory way to define each distinction without having to make an appeal to the other. If this is possible, an opening is created for empirical research to influence theory.

I propose to consider the criterion of associative vs. rule-based (Sloman, 1996) as a matter of mechanisms and the criterion of automatic vs. nonautomatic as a matter of operating conditions (Bargh, 1992). These characterizations are best understood within a levels-of-analysis framework, in which processes are described at different levels of analysis (e.g., Anderson, 1987; Marr, 1982; Pylyshyn, 1980). At the first level, a process is described as a functional relation between input and output (i.e., what the process does). This level includes the content of inputs and outputs (e.g., heuristic vs. systematic information) as well as the conditions in which the process operates (e.g., automatic vs. nonautomatic). The second level articulates the formal properties of the process (i.e., what is in the black box) such as the mechanisms involved in transforming input into output (e.g., associative vs. rule-based) and the representational format (or codes) of inputs and outputs. The third level is concerned with the physical implementation of processes in the brain (i.e., the hardware level; e.g., neocortical vs. subcortical routes). The levels-of-analysis framework makes it easy to see that there are no a priori reasons to assume overlap among the categories obtained with different criteria. This is because the levels in the framework are only loosely related to each other. For example, one functional process can be accounted for by more than one formal mechanism. Also, the framework allows both functional and formal processes to operate under different types of conditions. In the remainder of this section I amplify on the conceptualization of the automatic vs. nonautomatic contrast in terms of conditions and the conceptualization of the associative vs. rule-based contrast in terms of formally different mechanisms.

Automatic vs. Nonautomatic

Contemporary feature-based views of automaticity define it as an umbrella term for a number of individual features such as uncontrolled, unintentional, unconscious, efficient, and fast (Bargh, 1992; Moors & De Houwer, in press-a). These features can be roughly defined as follows. An uncontrolled process is one that is not influenced by a person's goals about the process. Process-related goals can either be promoting (e.g., the goal to engage in the process) or counteracting (e.g., the goals to 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. Another word for uncontrolled in the promoting sense is *unintentional*. A process is uncontrolled in the counteracting sense when it is not counteracted (altered or stopped) by the goal to do so (alter or stop). A process is unconscious when the person has no awareness of it. Note that awareness is plausible for processes described at the functional level (i.e., the relation between input and output) but not for processes described at the formal level or the hardware level. 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 given above can be reformulated in terms of operating conditions. 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, automatic processes are ones that operate under suboptimal conditions; nonautomatic processes are ones that operate under optimal conditions. Although there have been alternative proposals to define automaticity in terms of one mechanism (associative processing, e.g., Logan, 1988) the above shows that there is a way to define automaticity independent of mechanisms. I now turn to the distinction between associative and rule-based processing.

Associative vs. Rule-based

As stated above, the distinction between associative and rule-based bears on the mechanisms or formal properties of the process. In a rule-based process, a mental rule is applied to an input (or a representation thereof) and computation of the rule produces an output. In an associative process an input activates stored representations of similar past inputs. This activation, in turn, spreads to associated stored representations, which determine the output. As an illustration consider the behavior of two persons paying 4 euros at the counter after having ordered 2 beers that cost 2 euros each. One person’s behavior is caused by the calculation of the rule “2 x 2 = 4”. 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.

An important next step is to formulate the distinction between associative and rule-based processes in abstract terms so that empirical tests can be developed to assess the presence of each process. I discuss several formal properties that have been proposed as essential for this distinction. First, it has often been suggested that rule-based processes are ones that can be described by an IF-THEN clause. For example, IF N x M = p THEN pay p euros, with N standing for the number of beers and M standing for the price of one beer. However, several authors have correctly noted that associative processes can be described by an IF-THEN clause as well. For example, IF ordering 2 beers in café THEN pay 4 euros. In fact, any process that connects an input to an output can be expressed in an IF-THEN format. The IF-part specifies the input whereas the THEN-part specifies the output. This has led some authors to conclude that associative and rule-based processes are not qualitatively different and that an associative process is just a simple type of rule-based process (Kruglanski, Erb, Pierro, Mannetti, & Chun, in press). Other authors have searched for other criteria to distinguish both types of processes. A second criterion proposed by these authors is that rule-based processes but not associative ones can be described by *abstract* rules (e.g., Sloman, 1996; E. E. Smith, Langston, & Nisbett, 1992) in which the premise (the IF-part) contains variables. Variables are abstract representations that can be instantiated in more than one way (i.e., with more than one constant). In the abstract rule of the beer example, the variables N and M can be instantiated with an infinite range of numbers. Associations fit the format of nonabstract rules in which the premise consists of only constants. Constants are representations of concrete or even unique instances. In the beer example, the nonabstract IF-THEN rule cannot be applied to novel situations (e.g., ordering 5 coffees), unless they resemble the situation in the premise. A third property that has been proposed is that rule-based processes can only operate when there is a perfect match between the input and the premise, whereas associative processes can also operate when there is a partial match between input and premise or stored representation (Hahn & Chater, 1998). In the beer example, the abstract rule N x M cannot be computed unless a value for N and M is available. The nonabstract rule to pay 4 euros when ordering 2 beers in a café can be applied to any situation that is similar to this one (the more similarity, the stronger activation of the memory trace will be). Due to the complementary forces of abstraction and partial matching both rule-based processes and associative ones can account for generalization. In the case of rule-based processes generalization is obtained by virtue of abstract variables; in the case of associative processes generalization is obtained by virtue of partial matching (partial matching compensates for the lack of variables). Non-abstract rules can thus be applied to new input, but only by virtue of similarity among the input and the constants specified in the premise. As a fourth property of rule-based processes, some theorists have mentioned that rule-based processes must *follow* rules, whereas associations merely (or at most) *conform* to rules. Rule *following* requires that a mental rule sits between the input and the output of a process and *causally affects* the output; rule *conforming* merely requires that the relation between input and output can be described or summarized according to a rule (Hahn & Chater, 1998; Pylyshyn, 1980; Searle, 1980; Sloman, 1996; E. E. Smith, Langston, & Nisbett, 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 associations. However, unlike with planets or bees, associations are internal to the organism (mental) and they do mediate between input and output. It may be noted that some connectionist theorists have insisted that associations or patterns of associations are in fact subsymbolic representations of rules. Especially members of the implementationalist wing of connectionism have argued that all symbolic rules are represented or implemented in a subsymbolic manner. This view again suggests no fundamental distinction between associative and rule-based processing. Processes can be described as rule-based on a functional level, but they are in fact associative on a formal level. Several classic theorists, however, have argued that the rules in rule-based processes must not only be internally represented and causal, but that the representations must also be symbolic (e.g., Hahn & Chater, 1998). A symbolic representation of a rule has the rule as its (Intentional) content (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 classic theorists (Clark, 1990; Fodor & Pylyshyn, 1988; Pinker & Prince, 1988; E. E. Smith, Langston, & Nisbett, 1992) have argued against the view that the rules in rule-based processes must be symbolically represented. These theorists allow rules to be built into the system. Fodor and Pylyshyn (1988) maintained that the only thing that must be symbolically represented in a classic computational system are the data on which the rules operate. The rules themselves may be hard-wired in the system. Patterns of associations are typically not built-in, but 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) or not. In summary, several formal properties have been proposed to mark off rule-based processes from associative ones: abstract vs. specific, perfect vs. partial matching of the premise, and rule following vs. rule conforming. Some authors consider the ingredients of internal representation and causality as sufficient for rule following whereas others also include the ingredient symbolic.

Although some authors have proposed to define rule-based processes in terms of the nonautomaticity feature conscious (e.g., Cleeremans & Destrebecqz, 2005, have argue that real rules must be conscious when applied) the above shows that there are ways to define the mechanisms of rule-based and associative independent of the presence of consciousness or other operating conditions. I now turn to a discussion of the second step, the empirical investigation of combinations of mechanisms and operating conditions. I focus on the least obvious combination, that of rule-based and automatic.

Step 2

Empirical research aimed at investigating whether rule-based processes can occur in an automatic way faces the questions of how to assess automaticity and how to assess rule-based processes separate from, or in addition to, associative processes. Although the definitions discussed in the former section succesfully avoid overlap among the categories of automatic and associative and among the categories of nonautomatic and rule-based, they do not generate unequivocal empirical criteria to classify actual processes underlying some performance in one or the other category. I consider the automatic vs. nonautomatic distinction and the assocative vs. rule-based distinction in turn.

Automatic vs. Nonautomatic

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

Associative vs. Rule-based

Assessment of rule-based processes separate from or in addition to associative processes also suffers from the problem that formal distinctions between processes not always lead to different testable predictions. First, as explained above, both rule-based and associative processes 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 figuring in abstract rules and the constants figuring in non-abstract rules occupy two points on a continuum. Variables can be substituted by a larger class of instances than constants can, but the variables that figure in abstract rules can often not be substituted by just any constant (e.g., in the abstract rule of the beer example, 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 price of a coffee). At the extreme abstract end of the continuum are logical rules in which the variables can be substituted by any constant (e.g., IF [X and Y] THEN X). Conversely, concrete representations often hold some level of abstraction (e.g., in the nonabstract rule of the beer example, the representation of beer can itself be instantiated by more than one unique instance 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 may even pertain to abstract relations among variables (cf. Goldstone, 1994; Redington & Chater, 1996; Hummel & Holyoak, 2003). Thus, evidence for generalization toward stimuli that share abstract (but not concrete) features with previously acquired ones (Reber, 1989; Marcus, Vijayan, Bandi Rao, & Vishton, 1999) is equally compatible with rule-based as with associative accounts (Redington & Chater, 1996; but see E. E. Smith et al., 1996; Sloman & Rips, 1998). Third, advocates of the idea that rules in rule-based processes must be symbolically represented have proposed to use verbal protocols to investigate the content of representations. If a person has a symbolic representation of a rule, it is possible that she can verbally report the rule. Unfortunately, the criterion of verbal reportability is useless 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 processes independent of the operation of associative processes, but none of the proposed methods seems unequivocal (cf. reviews by Hahn & Chater, 1998; Sloman, 1996; E. E. Smith et al., 1992). One option is to continue the search for a formal distinction between rule-based and assocative processes that *does* lead to an unequivocal empirical test. Another option is to abide by a gradual view of this distinction (e.g., Pothos, 2005) and to specify a subjective criterion for calling some process associative or rule-based.

Conclusion

As dual (and other multi) mode models divide the realm of cognitive processes, they tend to assume overlap among the categories obtained with different criteria for division. I argued that such asumptions of overlap may be premature. In particular, equating automatic processes with associative ones and nonautomatic processes with rule-based ones is not a theoretical obligation (Step 1). It should be empirically examined whether these categories co-occur in the real world (Step 2). With regard to Step 2, I pointed at the difficulty to formulate unequivocal empirical criteria to classify a process as associative or rule-based. Moreover, gradual views of the automatic vs. nonautomatic distinction and of the associative vs. rule-based distinction obstruct the creation of sharply delineated categories. This is not problematic for research concerned with automaticity and/or mechanisms *as such.* (E.g., it remains valuable to consider individual features of automaticity and examine the degree to which they apply) But it is problematic for dual mode models that rely on a sharp, principled distinction between categories of cognitive processes (cf. Moors & De Houwer, in press-b).

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