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On Building a Better Process Model: It's Not Only How Many, but Which Ones and By Which Means?

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The Quad Model proposes that four cognitive processes are pervasive across social behavior. I describe the model and compare it to dual- and uniprocess models. Distinguishing among the four processes can provide a more nuanced and accurate depiction of social behavior than can other models. It also allows the model to be applied to a much broader range of domains. A key problem for many dual-process models is that they confound processing style with either type of content (e.g., category vs. individuating information) or type of task (implicit vs. explicit tasks). As a result, these models have trouble assessing the joint influences of multiple processes. In contrast, the Quad Model provides estimates of the independent and simultaneous contributions of 4 key processes to social behavior.

My assignment in this symposium is to make the argument that multiprocess models (i.e., more than two) of automaticity and control in social psychology are superior to dual-process or single-process models. I accept this assignment with a little reluctance. It's not that I don't believe there are significant benefits to multiprocess models. Indeed, we are particularly fond of the number four, and I am eager to make the case that our Quad Model (e.g., Conrey, Sherman, Gawronski, Hugenberg, & Groom, 2005) has many advantages over other models. I am reluctant because there is no one, final answer to the How Many question that applies for all purposes across all domains and contexts. Rather, the answer to the How Many question will often be It Depends. I also am reluctant because it is important to not let the How Many question obscure the more important questions of Which Ones (which processes, in particular?) and By Which Means (how are the processes measured?). My discussion of the Quad Model addresses each of these issues.

A Brief Disclaimer

Before describing the Quad Model and its virtues, it is necessary to make one brief disclaimer. Although we believe that the Quad Model has much to offer, the question of How Many is a tricky one. The fundamental problem is that the designation of any particular number of processes as the real or important ones is bound to be somewhat arbitrary. Consider the key distinction between automatic and controlled processes that is central to virtually all dual-process models. In fact, there are a practically limitless number of different controlled processes that can be dissociated from one another both behaviorally and neurobiologically, including stimulus

detection processes, conflict detection processes, resistance to interference processes, cognitive regulation processes, emotional regulation processes, processes for maintaining attention, and processes for switching attention (e.g., Beer, Shimamura, & Knight, 2004; Botvinick, Braver, Barch, Carter, & Cohen, 2001; Friedman & Miyake, 2004; Jonides et al., 2003; Miyake et al., 2000; Rushworth, Paus, & Sipila, 2001). The same is true of automatic processes. For example, priming processes, familiarity processes, and perceptual fluency effects all can be dissociated both behaviorally and neurobiologically (e.g., Grison & Strayer, 2001; Wagner & Gabrieli, 1998; Wagner, Stebbins, Masciari, Fleischman, & Gabrieli, 1998).

Given the seemingly endless possibilities of dividing processes into ever finer distinctions, the goal of obtaining a count of the "real" number of processes is futile. Rather, at some point, the task must become one of choosing the appropriate "basic level" of process breadth (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). That is, one must settle on some balance of breadth and specificity when enumerating different categories or types of processes, and this balance may be context dependent. For example, in the Quad Model, we make a rough distinction between two different types of automatic process and two different types of controlled process, and we argue that it is useful to assess all four processes within a given study. However, in some cases, the simple distinction found in dual-process models between automatic and controlled processes may well suffice. In other cases, ambitious researchers may wish to further divide automatic and controlled processes into six or eight key components. Ultimately, researchers will need to decide on the level of process specificity that best serves their needs.

Multiple Automatic and Controlled Processes: How Many? Which Ones?

Having made the necessary disclaimer, I now argue that four is a particularly useful number of processes to consider when investigating the automatic and controlled components of behavior. The number four is not arbitrary. Rather, the four processes proposed by the Quad Model represent the four processes that are most commonly found among different dual-process models. Though the fundamental aim of most dual-process models is to assess the extent to which a given judgment reflects relatively automatic or controlled processing, the particular types of automaticity and control of interest vary across models.

Two Types of Control

Dual-process models have generally been concerned with one of two different types of control. In some models, control is represented as a stimulus detection process that attempts to provide an accurate representation of the environment. For example, in dual-process models of attitudes and persuasion, the controlled process discriminates between strong and weak arguments (e.g., Chaiken, 1980; Fazio, 1990; Petty & Cacioppo, 1981). In models of impression formation, the controlled process attends to target behaviors, presumably providing a more accurate impression than category-based deduction (e.g., Brewer, 1988; Fiske & Neuberg, 1990).

However, in other dual-process models, control is represented as a self-regulatory process that attempts to inhibit unwanted or inappropriate information. For example, in Devine's (1989) model of stereotyping, control must be exerted to overcome the automatic influence of stereotypes. In Wegner's (1994) model of thought suppression, control must be exerted to inhibit unwanted thoughts that have been activated by an automatic search process.

Both detection and regulation processes are controlled processes in that they require intention and cognitive resources and can be initiated and terminated at will (e.g., Bargh, 1994). However, they are very different types of control, and it is clear that, on many occasions, they operate simultaneously. For example, a police officer's decision whether to shoot a Black man who may or may not have a gun may depend both on his ability to discriminate whether the man has a gun and, when there is no gun, his ability to overcome an automatic bias to associate Blacks with guns and to shoot. Also, as I describe next, the two types of control may be affected in opposite ways by the same context or manipulation. Thus, we believe that there is much to be gained by distinguishing between these types of control and measuring their contributions to behavior independently.

Two Types of Automaticity

Dual-process models also have generally been concerned with one of two different types of automaticity. Most commonly, automaticity is represented as simple associations or habitual responses that are triggered by the environment. This is the kind of automaticity found in most dual-process models of attitudes, stereotyping, and prejudice, in which some target activates without awareness or intention associated content and/or evaluations (e.g., Brewer, 1988; Devine, 1989; Fazio, 1990; Fiske & Neuberg, 1990). The use of heuristics described in models of persuasion (e.g., Chaiken, 1980; Petty & Cacioppo, 1981) and judgment (e.g., Epstein, 1991; Sloman, 1996) operates in much the same way. This is the type of automaticity that implicit measures of attitudes are meant to assess (Correll, Park, Judd, & Wittenbrink, 2002; Fazio, Jackson, Dunton, & Williams, 1995; Greenwald, McGhee, & Schwartz, 1998; Wittenbrink, Judd, & Park, 1997).

In other dual-process models, however, automatic processes do not influence behavior from the outset but come into play only when control fails. Such processes have been most prevalent in dual-process models of memory, which posit that when controlled attempts at recollection fail, people may instead rely on automatically generated feelings of familiarity to identify a stimulus as old (Jacoby, 1991; Mandler, 1980). In recent years, Payne and his colleagues have produced an impressive array of findings applying this model toward understanding the influence of implicit stereotypes in (mis)identifying weapons (e.g., Lambert et al., 2003; Payne, 2001; Payne, Lambert, & Jacoby, 2002). Another example is Americans' implicit preference for items placed on the right side of a display when conscious introspection provides no rational basis for preference (Nisbett & Wilson, 1977).

Although both "early" and "late" (e.g., Jacoby, Kelley, & McElree, 1999) automatic processes operate without intention, awareness, or the use of cognitive resources, clearly they are different kinds of processes. It also is clear that they frequently operate simultaneously. For example, a police officer's decision to fire his weapon might be influenced by automatically activated associations between Black men and aggression. In the absence of such associations, however, the officer's decision still might be influenced by a secondary, automatic bias to presume danger in the absence of clear evidence to the contrary and guess that the person is holding a gun. Such a guessing bias may well occur even if the officer does not know the racial identity of the suspect. We believe that there is much to be gained by distinguishing between these types of automatic process and measuring their contributions to behavior independently.

The Quad Model

The Quad Model was developed with the goal of assessing simultaneously and independently the contributions of each of the controlled and automatic processes just described (Conrey et al., 2005). In this way, the model attempts to combine the most important features of different dual-process models into a single model. As such, the model proposes that many behaviors depend jointly on the automatic activation of an association (*association activation* [AC]), the ability to determine an accurate response (*discriminability* [D]), the ability to overcome automatically activated associations when necessary (*overcoming bias* [OB]), and the influence of response bias in the absence of other available guides to response (*guessing* [G]). These four processes correspond roughly to the two controlled and two automatic processes just described.

Model Structure

The Quad Model is a multinomial model (Batchelder & Riefer, 1999; Riefer & Batchelder, 1988) designed to assess the independent contributions of these four processes to a given behavior. The structure of the Quad Model is depicted as a processing tree in Figure 1. In the tree, each path represents a likelihood. Processing parameters with lines leading to them are conditional upon all preceding parameters. For instance, OB is conditional upon both AC and D. Similarly, G is conditional upon the lack of AC (1-AC) and

the lack of D (1-D). Note that these conditional relationships do not imply a serial order in the onset and conclusion of the different processes. Rather, these relationships are mathematical descriptions of the manner in which the parameters interact to produce behavior. Thus, attempts to discriminate a correct response (D) and attempts to overcome automatic biases (OB) may occur simultaneously. However, in determining a response on a trial of a given task, the influence of attempts to overcome bias will be seen only in cases in which discrimination is successful.

The conditional relationships described by the model form a system of equations that predict the number of correct and incorrect responses in different conditions. The model's predictions are then compared to the actual data to determine the model's ability to account for the data. A chi-square estimate is computed for the difference between the predicted and observed errors. To best approximate the model to the data, the four parameter values are changed through maximum likelihood estimation until they produce a minimum possible value of the chi-square. The final parameter values that result from this process are interpreted as relative levels of the four processes. For a complete description of data analysis within the Quad Model, see Conrey et al. (2005).

An Example

As an example of how the model works, consider performance on a standard Black-White/positive-negative Implicit Association Test (IAT; Greenwald et al.,

Figure 1. The Quadruple Process Model (Quad Model). Each path represents a likelihood. Parameters with lines leading to them are conditional upon all preceding parameters. The table on the right side of the figure depicts correct (+) and incorrect (-) responses as a function of process pattern and trial type.

1998). The presentation of a Black face may automatically activate negative associations (AC), producing a tendency to respond by pressing the "negative" button. Depending on whether the trial is part of a compatible (pairing Black/bad and White/good) or incompatible (pairing Black/good and White/bad) block, this automatic tendency will be either congruent or incongruent with the correct answer "Black" achieved through discrimination (D). If the block pairs compatible responses, then there is no conflict between what is automatically activated and what is discriminated. In this case, there is no need to overcome the bias (OB) to produce the correct response. However, in an incompatible block, automatic activation and discrimination push the response tendency in opposite directions. Which of these two processes ultimately drives the response is determined by whether the participant succeeds in overcoming his or her bias. Finally, if no association is activated and the correct response cannot be determined, then participants must guess (G). Guessing need not be random and may, for example, reflect a bias to respond with the positive key (Conrey et al., 2005).

The model can be applied to any task that varies the compatibility between a response that is automatically activated by a stimulus and a response that is determined through controlled discrimination of the nature of the stimulus (De Houwer, 2003; Kornblum, Hasbroucq, & Osman, 1990). Although I have used the IAT as an example, the logic is exactly the same with any implicit measure that compares compatible and incompatible trials, including the Stroop task (Stroop, 1935), evaluative priming tasks (e.g., Fazio et al., 1995), the Weapons Identification Task (e.g., Payne, 2001), the Shooter Task (e.g., Correll et al., 2002), and the Go/No Go Association Task (Nosek & Banaji, 2001).

Although the model also may be applied to explicit tasks, we have focused on applying it to implicit tasks for two reasons. First, whereas most everyone agrees that explicit tasks reflect both automatic and controlled processes, many implicit measures have been presented as "process-pure" measures of automatic activation alone (e.g., Fazio et al., 1995; Greenwald et al., 1998; for reviews, see Conrey et al., 2005; Fazio & Olson, 2003). As such, implicit tasks are particularly interesting contexts in which to investigate the interaction of multiple automatic and controlled processes.

The second, and related, reason is that responses on implicit measures cannot separate the strength of automatic activation from the ability to overcome that activation. Consider the Stroop task. A young child who knows colors but does not know how to read will likely perform very well on the task, making few errors. An adult with full reading ability may achieve the same level of success. However, these performances would be based on very different underlying processes. In the

case of the adult, to perform the task accurately, the automatic habit to read the word must be overcome to report the color of the word accurately. In contrast, the child has no automatic habit to overcome on incompatible trials (e.g., the word *Blue* written in red ink). The same logic applies to implicit measures of attitudes. The identical responses of two individuals on an IAT, for example, may reflect moderate bias in one case but strong bias that is successfully overcome in the other. The measure itself cannot distinguish between these two cases. One consequence is that a strong ability to overcome bias may mask the true extent of that bias (e.g., Conrey et al., 2005).

Research Findings

To date, we have applied the model to the IAT and to the Weapons Identification Task (WIT; Conrey et al., 2005). The model fit the data from each of these tasks well, suggesting that all four components of the Quad Model contribute to performance on these implicit measures. We also found that response time bias on the IAT was positively correlated with model estimates of AC and negatively correlated with OB. Thus, to the extent that people have strong implicit associations, they show stronger bias, and to the extent that they are able to overcome their associations, they show weaker bias. This shows that IAT performance is influenced by controlled processes.

Other important findings have shown that the model parameters can be dissociated with meaningful manipulations. For example, forcing participants to respond quickly reduced D and OB but did not affect AC or G. This attests to the relatively controlled nature of D and OB and the relatively automatic nature of AC and G. Manipulating the base rate of correct left and right hand responses on the IAT caused G to shift in the direction of the base rate but did not affect any of the other parameters.

We also have shown that D and OB may be affected in opposite ways by the same manipulation. To do so, we reanalyzed data reported by Lambert et al. (2003) showing that an anticipated public context ironically increased the extent of bias on the WIT. This finding is surprising, because one might expect that making people accountable to others would diminish the extent of such biases (e.g., Lerner & Tetlock, 1999). Based on their analysis of the data, Lambert et al. concluded that the increased bias in the public condition was due to diminished control in that condition rather than to increased influence of the automatic attitude as a habit or dominant response (e.g., Hull, 1943; Zajonc, 1965). However, their analysis did not separate the two types of control, D and OB. In fact, our reanalysis showed that, although D was diminished in the public condition, OB was enhanced in that condition. Thus, one type of controlled process was inhibited by an audi-

ence, and another was enhanced by the audience. Moreover, our analysis showed that the AC parameter did increase in the public condition. Because the analysis used by Lambert et al. was not able to separate strength of AC from ability to overcome that association (OB), this increase in AC in the public condition had been obscured in the original analysis by the simultaneous increase in OB that was not measured. This is a good illustration of the advantages that can be gained from measuring all four components of the Quad Model.

Comparisons to Other Models: What's So Good About These Four Processes?

Now, to the central question at hand: Why is four better than one or two? There are two fundamental advantages of the Quad Model over dual- and uni-process models.

Range of Application

First, including all four types of process in a single model increases the breadth of the domains for which the model is appropriate. Dual-process models are largely limited to explaining behavior within the specific content domains for which they were developed (e.g., persuasion, person perception, attribution, etc.). Even some generalized dual-process models that are meant to apply across domains are applicable only to questions pertaining to the single automatic and single controlled process described in the models (e.g., Chen & Chaiken, 1999; Smith & DeCoster, 2000). In particular, these models are concerned only with detection-oriented control and do not consider regulatory processes. The unimodel (e.g., Erb et al., 2003) is similarly limited in range, because it is focused exclusively on the ways in which different pieces of information (those presumed by other models to be used automatically and those presumed by other models to be under control) are combined to reach a subjectively accurate judgment. The unimodel does not concern itself with self-regulatory processes that seek to overcome unwanted biases.

Thus, one significant advantage of the Quad Model is that it represents a general approach to separating component processes of behavior that can be applied to all of the domains currently served by different dual-process models, the unimodel, and more. Indeed, the Quad Model may be applied to any domain in which an initial automatic response is compatible or incompatible with a more controlled determination of appropriate action. Broadly speaking, the model is a model of impulse, response conflict, and impulse control that is applicable to a wide array of research topics both within and beyond social psychology, including

research on phobias, addiction, aggression, affect and judgment, and social influence (Sherman, Gawronski, Hugenberg, & Groom, 2006).

Accuracy/Detail

The second major advantage of the Quad Model is that it can provide a more accurate, detailed, and nuanced depiction of psychological processes than dual- or uni-process models. All four components of the model will play a role in most of the kinds of behaviors that psychologists want to explain. Distinguishing among the different processes permits one to ask important questions that cannot be asked with other models. For instance, the Quad Model can separate strength of bias from ability to overcome bias. Some automatic associations or impulses will drive behavior because they are very strong. In other cases, the automatic components will drive behavior because the ability to control them is weak. The implications of the two situations are very different. For example, the causes, consequences, and cures for implicit prejudice stemming from strong automatic biases and weak self-regulatory processes are going to be very different. In some contexts, it may be that training someone to overcome their biases is far more simple than eliminating those biases. Indeed, among the recent spate of research showing the apparent ease of changing implicit attitudes (e.g., Blair, Ma, & Lenton, 2001; Dasgupta & Greenwald, 2001; Kawakami, Dovidio, Moll, Hermsen, & Russin, 2000; Rudman, Ashmore, & Gary, 2001), we suspect that, in many cases, it has been a matter of training people to overcome their biases rather than eliminating them. The important point here is that the Quad Model allows researchers to separate these possibilities and to study, in depth, the factors that lead to each outcome. The model also is able to provide estimates of the extent to which each process influences behavior.

Another example of this advantage of the Quad Model is its ability to separate the two controlled processes, D and OB. Our reanalysis of Lambert et al.'s (2003) data showed that sometimes these two types of control will be influenced in opposite ways by the same context. Another illustration of the importance of this distinction concerns the factors that may account for individual differences in implicit prejudice. Devine and her colleagues have identified a group of people that seem better able to respond without bias on such measures (see Devine, Plant, Amodio, Harmon-Jones, & Vance, 2002). These "good regulators" have been distinguished from "bad regulators" (who wish to be nonprejudiced but fail to achieve that goal) and "nonregulators" (who are not concerned about responding in prejudiced ways). What accounts for the differences among these groups? One possibility is that they differ in the strength of their automatic associa-

tions, with good regulators possessing weaker associations than the other groups. Another possibility is that good regulators are better at discriminating the appropriate behavior in relevant contexts. Finally, a third possibility is that good regulators, as their name would suggest, are better at overcoming their biases than the other groups. In this case, they would not necessarily have weaker biases or stronger detection skills but would simply have more success in overcoming bias when its influence is felt. The Quad Model provides a means for distinguishing among these accounts.

In a recent article, Amodio, Devine, and Harmon-Jones (2006) reported data suggesting that good regulators demonstrated greater control than the other groups. However, from the behavioral data, it was not possible to distinguish between controlled detection processes and controlled self-regulatory processes. A reanalysis of the data with the Quad Model showed that the difference between the groups resided in detection and not in self-regulation (Sherman & Amodio, 2006). This conclusion is supported by the fact that good regulators demonstrated particularly strong electrophysiological responses corresponding to conflict detection (Amodio et al., 2005; Sherman & Amodio, 2006). Thus, good regulators may not be especially good at regulating. Rather, it appears that they are particularly able to detect conflict between competing automatic and controlled responses. Greater sensitivity to such conflict may provide an advantage in implementing an egalitarian mindset that facilitates nonbiased responding (e.g., Monteith, Ashburn-Nardo, Voils, & Czopp, 2002). Our reanalysis of Amodio et al.'s data also revealed that good and bad regulators possessed weaker automatic associations than nonregulators, an effect that had been obscured in the original analysis. Thus, good and bad regulators have weaker automatic biases than nonregulators, but good regulators show greater conflict detection (a kind of discriminability) than bad regulators.

Comparisons to Other Models: By Which Means?

Beyond How Many and Which Ones, another important question in comparing process models is By Which Means. That is, by which means are the relevant processes in a model measured? In my view, this is a greater source of difficulty for most dual-process models than the fact that they demarcate only two processes. Almost all dual-process models fall into one of three categories of measurement model: content dissociation models, task dissociation models, or process dissociation (PD) models. More recently, a number of generalized dual-process models have taken a more abstract approach, focusing less on the particulars of

measurement, and arguing that automatic and controlled processes represent specialized, discrete processing systems (Lieberman, 2003; Smith & DeCoster, 2000; Strack & Deutsch, 2004). In this section, I compare the methods and assumptions of the Quad Model to these different approaches.

Content Dissociation Models

Content confounds. The first wave of dual-process models can be mostly characterized as content dissociation models that were designed to account for relatively automatic and controlled processes within particular domains of inquiry, such as persuasion (Chaiken, 1980; Petty & Cacioppo, 1981), attitudes and behavior (Fazio, 1990), person perception (Brewer, 1988; Fiske & Neuberg, 1990), dispositional attribution (Gilbert, 1989; Trope, 1986), and so on. In these models, the contributions of automatic and controlled processes often are tied to the relative weights given to particular types of information in judgment tasks. For example, in dual-process models of persuasion, relatively automatic processing is associated with the use of persuasion heuristics (e.g., Chaiken, 1980; Petty & Cacioppo, 1981) or accessible attitudes (e.g., Fazio, 1990), whereas controlled processing is associated with the use of message arguments. Dual-process models of person perception (e.g., Brewer, 1988; Fiske & Neuberg, 1990) associate the use of social category information (e.g., stereotypes) with relatively automatic processing and the use of individuating target information (e.g., traits, behaviors) with controlled processing.

One significant drawback to this approach is that it incorporates a confound between content and process. Although it is certainly the case that some kinds of information (e.g., heuristic cues, attitudes, stereotypes) are typically applied with more ease and less intent than other kinds of information (e.g., persuasive arguments, individuating information), it is not difficult to find or induce exceptions to this state of affairs, depending on the task, context, and perceivers' motivations (e.g., Erb et al., 2003; Krull & Dill, 1996; Kunda & Thagard, 1996; Trope & Alfieri, 1997). Thus, equating specific types of content with specific types of processes is problematic.

More recent versions of these models typically dissociate content and process (Brewer & Feinstein, 1999; Fiske, Lin, & Neuberg, 1999; Petty & Wegener, 1999), permitting all types of content to be processed in either way. However, this solution raises a difficult question for these models. Namely, absent the distinction between "automatic" and "controlled" content, it is not clear why a dual-process model is necessary. One could simply postulate that there is a single quantitative dimension along which the extent of automatic and

controlled processing varies for all types of information (e.g., Erb et al., 2003; Petty & Wegener, 1999).

Joint contributions of automaticity and control.

Content dissociation models also have difficulties in accounting for the joint contributions of automatic and controlled processes to behavior. Some models suggest that automatic and controlled processes represent distinct alternatives, and that the processes do not co-occur (e.g., Brewer, 1988; Fazio, 1990; Petty & Cacioppo, 1981). Obviously, these kinds of models are not meant to assess the joint contributions of these processes. Other content models propose that automatic and controlled processing represent two ends of a continuum (e.g., Fiske et al., 1999; Fiske & Neuberg, 1990). In this case, it is impossible to determine the extent of contribution of each process. Movement in one direction along the continuum may reflect increased automatic processing, diminished control, or both. Movement in the other direction may reflect increased control, diminished automaticity, or both. Indeed, continuum models logically require that, as automatic processes are enhanced, controlled processes are diminished, and vice versa. However, given that automatic and controlled processing frequently are independent of one another (e.g., Jacoby, Toth, & Yonelinas, 1993) or even positively correlated (e.g., Jacoby, Begg, & Toth, 1997), this is an important drawback. These considerations all point to the significant advantage of assessing the contributions of automatic and controlled processes simultaneously and independently, as does the Quad Model and PD models (e.g., Jacoby, 1991; Lindsay & Jacoby, 1994).

A related matter concerns the temporal relationship between automatic and controlled processing. A number of models assume sequential processing, with automatic processing occurring first, sometimes followed by controlled processing (e.g., Devine, 1989; Fiske & Neuberg, 1990; Fiske et al., 1999; Gilbert, 1989; Kahneman, 2003; Martin, 1986; Trope, 1986; Wegener & Petty, 1997). One drawback with this type of model is that it cannot account for cases in which an automatic process operates only in the wake of failed control (e.g., Jacoby et al., 1999). More generally, these models suggest that the primary purpose of controlled processes is to edit the products of automatic processes that have already occurred. In contrast, the Quad Model and PD models assume that each of the processes operates simultaneously and independently from the outset. Although the ultimate influence of any of the different processes depends on the outcome of other processes, the processes themselves operate independently and in parallel. Moreover, automatic and controlled processes do not begin and end in the Quad Model but rather continue to exert influence until a behavioral response is enacted.

More recent versions of some content models have incorporated the idea that automatic and controlled processes occur simultaneously and interact with one another (e.g., Brewer & Feinstein, 1999; Fazio & Towles-Schwen, 1999; Petty & Wegener, 1999). However, these models remain ill-equipped to account for the full subtlety of such interactions. In particular, in these models, joint influences of automaticity and control are expressed only through the simultaneous influence of two different pieces of information (e.g., one item used automatically and one used in a controlled fashion). Although any given content (e.g., a heuristic or persuasive message) may reflect either automatic or controlled processing, it may not represent a combination of the processes. That is, a given piece of information (e.g., a heuristic) may be used in either an automatic or controlled fashion but may not reflect both influences simultaneously. This represents a fundamental difference in the conceptual approach of content models and the Quad Model. Namely, the Quad Model (and PD models) holds that the application of any type of information always reflects a combination of automatic and controlled processes and that these processes can be estimated simultaneously from a single response, independently of particular content.

Task Dissociation Models

The second major class of dual-process model assesses automatic and controlled processes by administering two separate measures, one aimed at tapping an automatic process and one aimed at tapping a controlled process. For example, research on prejudice often assesses automatic prejudicial responses with an implicit measure (e.g., a priming task or IAT), and conscious, controlled tendencies with an explicit measure (e.g., a questionnaire or Likert scale; e.g., Devine, 1989; Fazio et al., 1995; Greenwald et al., 1998; Wittenbrink et al., 1997). One significant drawback to this approach is that it confounds processing style (automatic vs. controlled) with the particular measurement task (e.g., IAT vs. questionnaire). This is a problem because the chosen tasks may differ in a number of ways beyond the extent to which they tap automatic versus controlled processes. As an example, a generation of research depicting differences between implicit and explicit memory was wholly reinterpreted when Roediger and his colleagues discovered that, whereas implicit measures tapped perceptual encoding processes, explicit measures tapped conceptual encoding processes (e.g., Roediger, 1990). Thus, the distinction between implicit and explicit memory may instead reflect a distinction between perceptual and conceptual processing. This should serve as an important cautionary tale for social psychologists.

The more general point is that no task is "process pure." Any task that requires an observable response

cannot be entirely automatic, and no task is immune from the influence of automatic processes (e.g., Jacoby et al., 1993). Rather, all tasks reflect some combination of simultaneously occurring automatic and controlled processes. Thus, in the same ways that it is a problem to assign automatic and controlled processes to different types of content, it also is a problem to assign automatic and controlled processes to different tasks. Process estimation is confounded, and there is no way to examine the automatic and controlled components of behavior within a given type of content or task.

PD Models

These concerns about task dissociation approaches led Jacoby (1991; Lindsay & Jacoby, 1994) to develop PD techniques for estimating the automatic and controlled components of behavior simultaneously within a single task. Significantly, this approach avoids both the content/process confounds of content dissociation approaches and the task/process confounds of task dissociation approaches. The Quad Model relies on the underlying logic of the PD approach and owes a substantial intellectual debt to Jacoby and his colleagues. However, the Quad Model also differs in important ways from other PD models.

Jacoby and his colleagues have developed two different models of PD. Both models rely on the logic of opposition, contrasting compatible trials, on which a controlled process and an automatic process should lead to the same response, and incompatible trials, on which the two processes should lead to different responses. Estimates of automatic and controlled processing are derived by subtracting performance on the incompatible trials from performance on the compatible trials. The primary difference between the two models is whether automatic or controlled processes are assumed to be primary. One model (the recollection-accessibility-bias model) is designed for tasks in which automatic processes are thought to operate only in the wake of failed control (e.g., recognition memory tasks; Jacoby, 1991). This is the "late" type of automaticity previously described. The primary limitation of this model is that it permits no role for automatic processes that grab attention and influence behavior even though the correct response can be determined. Thus, this model is not applicable to implicit measures of attitude, such as the IAT, or the Stroop task, in which most people can determine the correct response easily, but an automatic association or habit drives behavior away from that response (for a more thorough discussion, see Conrey et al., 2005).

The other PD model (the inhibition-deficit model) is designed for tasks like the IAT or Stroop, in which automatic associations may capture behavior from the outset, regardless of whether control succeeds (e.g., Lindsay & Jacoby, 1994). The primary limitation of

this model is that it does not distinguish between cases in which an automatic association is not activated at all from cases in which the association is activated but is overcome. If an association or habit is activated, it will drive behavior; there is no possibility of successfully overcoming an activated bias in this model. One consequence is that this model cannot distinguish strength of automatic association from ability to overcome that association. Another limitation of this model is that it offers no role for "late" automatic processes, such as G processes (for a more thorough discussion, see Conrey et al., 2005).

In summary, the Quad Model and PD models share many important fundamental assumptions about the nature of automatic and controlled processing. The models agree that the use of any content or task will invoke some combination of automatic and controlled processing. The models also agree that the different processes operate simultaneously and independently but influence behavior in an interactive manner. Finally, the models concur that the way to quantify these components is through opposition tasks that vary the compatibility between automatic and controlled processes. The primary difference between the models is that the Quad Model seeks to provide a more detailed discrimination of automatic and controlled processes than do PD models. Each PD model assesses a single automatic process.¹ Neither PD model permits a role for the type of self-regulatory process captured in the OB parameter of the Quad Model. By including all four components in a single model, the Quad Model is able to address important questions that PD models cannot (e.g., separating strength of bias from ability to overcome bias). Moreover, because it includes all the components of both PD models, the Quad Model may be applied to both types of tasks addressed by the models. Thus, the range of application of the Quad Model is broader than either of the PD models.

System Models

Recently, researchers have proposed a number of generalized dual-process models that aim to provide comprehensive integrations of the many domain-specific dual-process models (e.g., Lieberman, 2003; Smith & DeCoster, 2000; Strack & Deutsch, 2004). These general models are not concerned with the particular means by which automatic and controlled processes are measured but rather seek to provide a conceptual framework that can account for the basic distinction, regardless of content domain or measure-

¹Recently, Jacoby and his colleagues (e.g., Jacoby, Bishara, Hessels, & Toth, 2005) proposed a new PD model that incorporates both early and late types of automatic process. However, this model does not provide a role for self-regulatory processes that might overcome an automatic bias and cannot separate strength of activation from ability to regulate activation.

ment task. The integrative nature of these models is their greatest strength. Another strength is that they each tie their respective automatic and controlled systems to particular neural structures. In so doing, the models establish important links to broader research on functional neuroanatomy that can provide valuable insights into the nature of automaticity and control within social psychology.

The primary difference between general dual-process models and the Quad Model is that the Quad Model makes finer distinctions among automatic and controlled processes. Smith and DeCoster's (2000) model does not concern itself at all with self-regulatory control processes. The controlled system in the model is specified as a memory system residing in the hippocampal region of the brain (e.g., McClelland, McNaughton, & O'Reilly, 1995). This type of control may correspond roughly to stimulus detection and integration processes, and the model is well suited for domains in which this type of control combines with automatic, associative influences to direct behavior. However, self-regulatory control resides not in the hippocampus but primarily in the prefrontal cortex (e.g., Miller & Cohen, 2001). As such, this type of control is not represented in Smith and DeCoster's model. The system models proposed by Epstein (1991) and Sloman (1996) to account for automatic and controlled processes specifically within the domain of reasoning and judgment are similarly focused on controlled detection processes.

Both Lieberman's (2003) and Strack and Deutsch's (2004) models can accommodate each of the processes specified by the Quad Model. However, these models place the different automatic and controlled processes within a single automatic and a single controlled system that includes all types of automatic and controlled processes, respectively (see also the system model described by Kahneman, 2003). In contrast, the conceptual basis of the Quad Model is that these different automatic and controlled processes warrant distinction and that important questions can be addressed by assessing each of the different processes independently.

Lieberman's (2003) model provides a particularly thorough account of the different neural generators associated with different cognitive processes. However, one important limitation of this model is its stipulation that controlled processes are engaged only when automatic determination of behavior fails. Thus, the model cannot account for cases in which automatic influences operate in the wake of failed control (e.g., Jacoby et al., 1999). More generally, due to its serial nature, the model is not well suited for accounting for the simultaneous contributions of automatic and controlled processes.

Another important difference between the Quad Model and generalized models is that the Quad Model provides both a conceptual integration of dual-process

models and a specific means of assessing the independent and simultaneous contributions of distinct processes within a single task. Thus, the Quad Model provides two significant advantages over generalized dual-process models. First, it provides a theoretical basis for distinguishing among important different automatic and controlled processes, and second, it provides a practical application that can be used to decompose these components of behavior across a wide range of domains.

Automaticity and Control as Features Rather Than Categories

One common feature of all dual-process models is that they organize behavior around separate categories of automatic and controlled processes. As we have seen, depending on the type of model, these categories are associated with different content, different types of measurement tasks, or different systems. In PD approaches, the categories are associated with different processes. Thus, the process that attempts to recollect an item from memory is associated with the category of control, whereas the process that makes memory judgments on the basis of familiarity is associated with the category of automaticity. Indeed, my description of the Quad Model places two processes into the category of controlled processes (D, OB) and two processes into the category of automatic processes (AC, G).

I suggest here that an entirely different approach may be more productive. Specifically, rather than treating automatic and controlled processes as separate *categories* of processes, it would be more useful to treat automaticity and control as *features* of processes. In this case, the primary goal of the researcher is to identify the qualitative nature of key component processes of a given behavior. Subsequent research may then assess, among other things, the extent to which the process is relatively controlled or automatic as an empirical question. I am suggesting a process approach that does not treat automaticity/control as the central or defining distinction among processes. Instead, the particular nature of the process is the key question (i.e., What does the process do?) and the automatic versus controlled nature of the process is only one important feature of the process.

Consider the components of the Quad Model. As an organizational framework, it is useful to associate the four processes with either automaticity or control. However, there is no a priori reason, for example, why guessing must be an automatic process. Indeed, it is easy to imagine that there are cases in which people adopt conscious guessing strategies that are enacted when other sources of information fail to provide a response. For instance, if a participant fails to attend to a stimulus on the IAT and cannot determine what kind of item was presented, she or he may make

a conscious self-presentational decision to guess that the item belonged to the category containing positive words. Similarly, there is no a priori reason why overcoming bias must be a controlled process. Along these lines, several models of prejudice reduction suggest that, for some people, the process of inhibiting automatic associations itself becomes automatized (e.g., Monteith et al., 2002; Moskowitz, Gollwitzer, Wasel, & Schaal, 1999).

Conclusion

In summary, I have argued that there are important merits to the Quad Model of behavioral response. Namely, specifying processes beyond the broad distinction of automatic and controlled processes allows the Quad Model to present a more nuanced and even accurate portrayal of behavior than other models. Distinguishing among different automatic and controlled processes also opens up a range of important questions that cannot be addressed by other models. In integrating the four central processes of various dual-process models into one model, the Quad Model also is relevant to a much broader range of topics than are other models. Finally, the PD approach taken by the Quad Model avoids difficult confounds that hamper other models and approaches. This approach allows researchers to generate independent estimates of four simultaneously occurring processes as well as their interactive influences on behavior. The Quad Model provides both a conceptual framework for understanding the joint contributions of automatic and controlled processes to behavior and a means for measuring those processes.

Notes

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