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COMMENTARIES



Toward a Multiple Memory Systems Model of Attitudes and Social Cognition

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March, Gaertner, and Olson (this issue) highlight a critical weakness of most contemporary models of attitudes, whereby a valence-based account of attitude associations often fails to map onto patterns of behavior. This disconnect—between valence-based models of the mind and actual behavior—has long been recognized in domains of psychology outside of social cognition. For example, Harmon-Jones and colleagues have shown that neural, physiological, and behavioral responses to attitude objects are better explained in terms of their approach-avoidance associations than by valence (Gable & Harmon-Jones, 2010; Harmon-Jones & Allen, 1998). Harmon-Jones's action-based model of cognitive dissonance applied this thinking directly to the issue of attitude change and behavior (Harmon-Jones, Amodio, & Harmon-Jones, 2009; 2010). Similarly, neuropsychology studies have revealed that, in classical fear conditioning tasks, patients with bilateral amygdala damage can form accurate judgments of rewarding/aversive stimuli yet fail to exhibit physiological arousal or behavioral responses that characterize an adaptive response to threat (whereas hippocampal patients show the opposite pattern; e.g., Bechara et al., 1995). Circumplex models of emotion have been noted for likening particular emotions, such as anger and fear, based on their similar negative valence/high arousal profile, despite their nearly opposite effects in behavior (e.g., Carver & Harmon-Jones, 2009). These are just a few well-known programs of research that previously addressed this crucial disconnect between valence and behavior.

Given the precedence for distinguishing valence ascriptions from behavioral responses—especially with regard to threat—we were always surprised that the issue has not received more attention in social psychological models of attitudes. And so, not surprisingly, we were excited to read about March et al.'s (this issue) dual implicit process model of evaluation (DIPM), as it reflects an important shift in thinking among attitude theorists in the field of social cognition. In their article, the authors make a compelling case for the limitations of existing attitude models for explaining the threat response and support their view with evidence from neuroscience on how amygdala function can support threat responses in a way that does not align with valence-based attitude models.

Although the authors did not cover our own work on this issue, we (i.e., the first author) have been arguing this same basic point for the past 15 years, invoking contemporary cognitive neuroscience models of learning and memory while providing data showing dissociations between semantic associations and

threat-relevant evaluative associations in the brain and behavior (e.g., Amodio & Devine, 2006; Amodio & Hamilton, 2012; Amodio, Harmon-Jones, & Devine, 2003; Gilbert, Swencionis, & Amodio, 2012). This work has led us to develop the memory systems model (MSM) of attitudes and social cognition (Amodio, 2008; Amodio & Ratner, 2011b), which goes beyond the dual-implicit process model posited by March et al. (this issue) to incorporate several additional modes of learning, memory, and behavioral expression that have been established in the cognitive neuroscience literature.

Given the relevance of our work on the MSM to the present article, and in light of its omission, we take the opportunity here to describe the general framework and several of our findings. We then comment on a few specific points of March et al. (this issue) to offer the authors and readers some ideas for further development and theoretical refinement.

A Memory Systems Model of Attitudes and Social Cognition

We (i.e., the first author) first sought to distinguish implicit systems associated with valence from those linked to threat and behavior when investigating the affective underpinnings of implicit prejudice (Amodio et al., 2003). At the time (and still today, with few exceptions), researchers described implicit attitudes, including implicit prejudice, in terms of affective associations. This always struck us as odd, as the implicit tasks used to assess implicit attitudes relied entirely on associations between attitude objects and words—a kind of association that could be purely semantic and have nothing to do with affect. Affect, as emotion researchers understand it, usually involves some degree of arousal at minimum, and there is little indication that the rapidly paced trials of an evaluative priming task elicit anything akin to “affect” (e.g., Blaison, Imhoff, Hühnel, Hess, & Banse, 2012; cf. Breckler, 1984). In response, Amodio et al. (2003) noted that the amygdala is known to support negative affect and threat processing but not semantic associations. Thus, if we could show differential amygdala responses to Black compared with White or Asian faces, this would provide evidence for a truly affective basis of implicit prejudice. This is indeed what we found. Moreover, by using the emotion-modulated startle-eyeblink index of amygdala response, we could specifically assess threat-specific activity in the amygdala's central nucleus, linking the prejudiced response to implicit threat processing as opposed to other forms of arousal

or salience associated with amygdala response (Holland & Gallagher, 1999).

These initial findings led us to consider the broader roles of different memory systems in attitudes and social cognition. The modern memory systems perspective was galvanized by Milner's (1962) seminal case study of the patient "HM." To treat an extreme form of epilepsy, doctors surgically removed substantial portions of temporal lobe from HM's brain, including the hippocampus, amygdala, and parahippocampal gyrus. HM recovered, but with a striking impairment: He could no longer form long-term episodic memories and was severely impaired in recalling prior experiences (Scoville & Milner, 1957). Nevertheless, he retained several other learning and memory capacities, such as motor skills and habits (Corkin, 1968). Later research on amnesics revealed that, despite their declarative memory loss, they retained implicit semantic associations (e.g., quicker identification of words following semantically related primes, such as "butter" following "bread"; Warrington & Weiskrantz, 1970), as well as classical fear conditioning (Bechara et al., 1995; LaBar & Phelps, 2005). These findings revealed dissociations, not just between declarative and nondeclarative memory but among several different forms of memory that can function implicitly (Zola-Morgan, Cohen, & Squire, 1983). (The reader might note that this basic theoretical perspective is nearly half a century old, yet somehow it has escaped mainstream social psychological theories.)

It is now known that implicit learning and memory encompasses multiple capacities, such as semantic priming, classical fear conditioning, Pavlovian reward conditioning, instrumental (goal-directed) conditioning, and the learning of skills and habits—each of which may reflect a component of an "attitude," but which are acquired, stored, and expressed in different ways (e.g., Henke, 2010; Squire & Zola, 1996). Dissociations between these processes have been illuminated through studies of neurological patients, selective animal lesions, neuroimaging, and careful behavioral experimentation. That is, damage to a brain region linked to one form of memory can cause the specific impairment of that form of memory without affecting other capacities (e.g., McDonald & White, 1993; Packard, Hirsh, & White, 1989). In the healthy brain, these different memory systems may function independently, in concert, or in competition (Foerde, Knowlton, & Poldrack, 2006; Poldrack & Packard, 2003), and a single task is often supported by multiple memory systems (Foerde & Shohamy, 2011). Yet, to understand behavior, and to predict how it will be expressed under different conditions, it is necessary to know the precise memory systems that underlie it.

Figure 1 shows a classic, albeit dated, version of the MSM presented by Squire and colleagues (Squire & Zola, 1996), which lays out a set of known memory systems and their unique neural substrates. What is striking, for the present purposes, is that this 20-year-old model distinguishes between at least four uniquely different forms of implicit learning and memory (excluding nonassociative learning). All of these relate to aspects of what we would call an "attitude"—conceptual associations with liking/disliking, affective responses to threat, instrumental choice preferences, and freezing-related behavioral responses. And all have implicit effects—that is, the mechanisms through which these systems learn, react, and influence

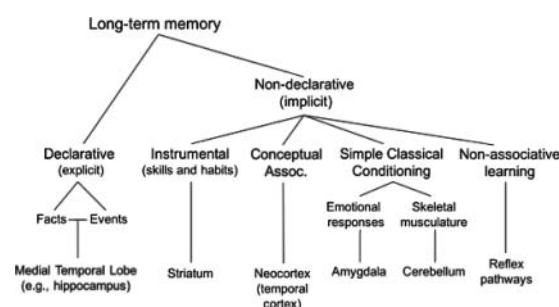


Figure 1. Taxonomy of long-term memory systems, and their neural substrates, adapted from Squire and Knowlton (1994).

behavior can function without awareness or understanding of their processes (even if some aspects of their functions are subject to awareness). Hence, rather than two forms of implicit attitude, as proposed by March et al. (this issue), the literature suggests there are multiple established processes that can support implicit attitudes (e.g., semantic/conceptual memory, classical fear conditioning, Pavlovian reward conditioning, goal-directed instrumental conditioning, and habit-based instrumental conditioning). Important to note, we know that these learning and memory systems cannot be strictly described as either implicit or explicit—this is the dated aspect of Figure 1—because although they can influence behavior implicitly, aspects of their operations may be subject to awareness to varying extents (see below for more on this point).

In MSM parlance, March et al. (this issue) appear to posit a dissociation between implicit semantic memory (i.e., conceptual associations with valence or other kinds of information) and fear conditioning. This was also our starting point (e.g., Amodio & Devine, 2006). Amodio and Devine (2006) and Amodio et al. (2003) tested and found evidence for this dissociation in the domain of intergroup bias, showing that Implicit Association Test measures of stereotyping (semantic memory) and prejudicial evaluation (fear conditioning, as we thought at the time) were uncorrelated and had unique predictive effects on intergroup judgments and behaviors. Amodio and Hamilton (2012) further showed that intergroup anxiety selectively amplified implicit prejudice—as predicted, given the hypothesized roots of both threat and implicit prejudice in the amygdala—but did not affect implicit stereotyping. Gilbert, Swencionis, and Amodio (2012) further dissociated the effects of affective bias and stereotyping in the decision process. Although these publications focused on the comparison between stereotyping and prejudice as examples of semantic and threat-related processes, these same memory systems support the distinction between conceptual valence and threat response described by the DIPM (e.g., Amodio, 2014b).

More recently, we have observed that although the distinction between semantic memory and fear conditioning maps onto many interesting phenomena in social psychology, neither directly guides active decision making and behavior. Instead, a third system—instrumental learning, which governs feedback-based reinforcement learning and is subserved by dopaminergic activity in the striatum—more directly supports implicit goal-directed actions (Alexander, DeLong, & Strick, 1986; Samejima, Ueda, Doya, & Kimura, 2005). We recently demonstrated the role of this learning system in the formation of social attitudes,

dissociating it in the brain and in behavior from the encoding of conceptual trait information (Hackel, Doll, & Amodio, 2015). We expect that the instrumental learning system will prove critical for understanding implicit attitudes and their effects on decisions (Berg & Amodio, 2017).

How Does the MSM Explain Existing Dual-Process Accounts of Attitudes?

The MSM stands in stark contrast to the current dual-process models that assume only a single associative network—that is, only one kind of memory in the mind. This single-model of implicit associations is rooted in 1970s-era information-processing theory (Shiffrin & Schneider, 1977), and it corresponds to what we would today refer to as semantic memory—a form of relatively high-level associations between concepts, often organized in categorical structures. This kind of learning may explain how associations are learned via passive exposure to concept pairings encountered in the environment (in the case of implicit associations) or through instructed learning and reasoning (in the case of propositional processes)—the two major processes proposed in many current dual-process models of attitudes and evaluation (e.g., Gawronski & Bodenhausen, 2006).

Cognitive neuroscience research on semantic memory has primarily associated it with the temporal lobe, with social knowledge in particular in the anterior temporal lobe (Gilbert et al., 2012; Olson, McCoy, Klobusicky, & Ross, 2013; Ralph, Jefferies, Patterson, & Rogers, 2017). Via direct anatomical connections (de Schotten, Dell'Acqua, Valabregue, & Catani, 2012), semantic information stored in the anterior temporal lobe may be selected into working memory in lateral frontal cortex and invoked to inform impression formation and decision processes in medial prefrontal cortex (also, orbital frontal cortex)—effects consistent with evidence from social cognition on how such associations can influence relatively high-level thoughts and decisions. However, the anterior temporal lobe does not have clear direct connections with neural regions that guide physiological states, such as arousal, or behaviors, such as freezing, approach, or avoidance (de Schotten et al., 2012). Thus, in both their theoretical conceptualizations and in their likely neural underpinnings, the dominant dual-process models of today are useful in explaining conceptual associations but do not provide adequate accounts of behavioral or physiological responses.

Implicit Versus Explicit: Does it Really Matter?

Although much research in the field of attitudes and social cognition remains focused on the implicit/explicit nature of an attitude, current thinking in the learning and memory literature has moved away from the strong implicit/explicit distinction displayed in the Squire model (Henke, 2010) and instead focuses much more on the specific functions of these systems in supporting learning, memory, and adaptive behavior. This is partly because a given memory system may not always be categorized as implicit or explicit, and more crucially because the implicitness of a process is not nearly as important as understanding its function in the mind and in behavior (Amodio, 2014a).

The field of social cognition has also been coming to terms with the meaning of “implicit,” and several commentators have observed that “implicit” may refer to different aspects of a response (e.g., Amodio & Mendoza, 2010; Gawronski, Hofmann, & Wilbur, 2006). Gawronski et al. (2006) cogently noted that one could lack awareness of the source of an attitude, the content of the attitude, or the way in which an attitude influences a response (or any combination of these). Unfortunately, the tasks used by social psychologists to measure implicit associations are often imprecise in determining exactly what aspects of an association are implicit (e.g., Hahn, Judd, Hirsh, & Blair, 2014; Monteith, Voils, & Ashburn-Nardo, 2001; see also De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). By contrast, the MSM offers a more refined analysis of how different types of associations are acquired, stored, and expressed, with detailed pathways to behavior informed by neuroanatomy. This analysis therefore offers a much more precise account of which aspect of an association is implicit.

But does implicitness matter? We think so. Even if a person is entirely aware of the content of her attitude, the attitude may still affect her behavior without explicit awareness of its influence or one's intention. Indeed, this is a reason why egalitarians nevertheless often respond with prejudice (e.g., Monteith et al., 2001). Thus, we believe that a theoretical account of implicit influence is crucial to our understanding of judgments, decisions, and behaviors (e.g., in the realm of prejudice, addictions, and consumer behaviors).

Questions and Suggestions Regarding the DIPM

In general, we agree with the positions presented by March et al. (this issue), but in this section we address a few specific aspects of the DIPM that we suggest may benefit from further development or considerations of existing research.

1. March et al. (this issue) posit that implicit 1(i1) and implicit 2 (i2) are “serially linked.” This means that i1 always precedes and potentially influences i2. If i1 is the amygdala, and we presume that i2 is temporal cortex, it is unclear exactly how or why they are serially linked. According to memory systems research, different memory systems can learn and respond independently and simultaneously, yet interactively (Foerde et al., 2006; Poldrack & Packard, 2003). And so although activity in one system could influence another, there is no assumption that one *must* precede another. Thus, we wonder if the assumption of serial linkage is necessary to support the kinds of attitudes and behaviors that March et al. (this issue) seek to explain. And, if it is, we would want to know more about the putative neural circuitry, and also the implications for psychology and behavior.
2. Amygdala activity described by March et al. corresponds most directly with a freezing response—a form of passive avoidance—but does not relate as well to the kind of active avoidance that is described in many of their examples. It may help to be more specific about the amygdala subnuclei (e.g., central vs. basolateral) and relevant circuits (e.g., as in Amodio & Ratner, 2011a), given the authors' interest in these patterns of behavior in response to threat.

3. March et al. discuss the implications of their proposal for prejudice. We have written extensively on this topic (e.g., Amodio, 2008, 2014b; Amodio & Devine, 2008; Amodio & Mendoza, 2010). In particular, March et al. write that their analysis suggests a functional dissociation between threat-related and positive/negative aspects of implicit prejudice. Indeed, this was also our thinking in Amodio et al. (2003), described earlier, as well as our attempts to use this model to explain behavioral expression and prejudice reduction (e.g., Amodio & Devine, 2005, 2006). Similarly, the idea that implicit bias associated with societal views could be rooted in a semantic system, whereas more personally driven threat responses could be rooted in fear conditioning, was also raised in prior work on these issues (Amodio & Devine, 2008; Amodio, Devine, & Harmon-Jones, 2008; see also Devine, 1989). We see an exciting opportunity to integrate these findings from the intergroup domain with March et al.'s (this issue) ideas regarding attitudes, as they address the same fundamental questions about attitudes and social cognition.
4. Finally, we appreciate March et al.'s discussion of how an amygdala-based threat response may be regulated, particularly in the context of prejudice. Indeed, we have written rather extensively on this very issue, too (Amodio, 2008, 2011, 2014a, 2014b; Amodio & Devine, 2010; Amodio et al., 2003; Amodio & Ratner, 2011a). In our analysis and empirical work on the regulation of implicit bias, we have also focused on the role of anterior cingulate cortex (Amodio, Devine, & Harmon-Jones, 2008; Amodio et al., 2004; Amodio, Kubota, Harmon-Jones, & Devine, 2006) and prefrontal cortex (Amodio, 2010; Amodio, Devine, & Harmon-Jones, 2007). Whereas anterior cingulate cortex is thought to be involved in conflict monitoring (e.g., Kerns et al., 2004; Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004) and/or determining the expected value of control (Shenhav, Cohen, & Botvinick, 2016), studies with both humans and nonhuman primates show that regions of lateral prefrontal cortex guide the implementation of control (e.g., Kerns et al., 2004; Miller & Cohen, 2001). Critically, for the present discussion, these control regions in lateral prefrontal cortex have few if any direct anatomical connections to the amygdala (e.g., Ghashghaei, Hilgetag, & Barbas, 2007; Zald et al., 2012; see Barbas, 2015 and Ray & Zald, 2012, for reviews). By contrast, they have strong connections with the striatum and motor areas (Alexander et al., 1986; Miller & Cohen, 2001). These functional and anatomical patterns casts doubt on the neo-Freudian model of internal top-down regulation of threat, and instead support the idea that control-related lateral PFC activity targets the control of expressed behavior. For example, in a study of fear regulation that included eye-tracking, the effect of prefrontal cortical activity on amygdala activity was explained by subjects' eye movements away from aversive stimuli—evidence that the PFC regulates by modulating behavior rather than directly inhibiting amygdala activity (van Reekum et al., 2007). Furthermore, the threat response involves more than just the amygdala; for example, we proposed that social threat can impair control via norepinephrine modulation of anterior cingulate activity and demonstrated this process with cortisol reactivity effects

on stereotype control during an interracial interaction (Amodio, 2009). In terms of the DIPM, we suggest it is unlikely that i2 downregulates i1 directly, as proposed, and encourage the authors to consider alternative models that are consistent with anatomical and behavioral findings (e.g., Miller & Cohen, 2001; as discussed in Amodio & Devine, 2010; Amodio & Ratner, 2013; see also Cunningham, Zelazo, Packer, & Van Bavel, 2007).

Conclusions

We were very happy to read about the DIPM. It is a model that makes sense to us, especially given our own work, as a more intuitive explanation for real-life attitude function and behavior. It also signals to us that others in the field of social psychology are now ready to move beyond the traditional valence-based network model of attitudes—built on 1970s-era information-processing theories of concept knowledge—and toward models that incorporate modern research on learning and memory from the contemporary cognitive neuroscience literature. This is a good thing for attitude theory, and for social cognition in general, as it will bring us closer to a more plausible and useful model of human social behavior and decision making.

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