

## Letter

## Applying Interdisciplinary Innovations to Advance Theories of Social Behavior: Response to Van Dessel and Colleagues

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I thank Van Dessel, Gawronski, and De Houwer [1] for their thoughtful response to my opinion article [2]. However, their core objection, regarding the validity of the multiple systems account of learning and memory, appears misplaced. The contribution of my article was not to propose this broad framework for learning and memory; the memory systems framework was already firmly established as a mainstream view in cognitive psychology and neuroscience [3,4].

Van Dessel *et al.*'s main argument is that evidence for multiple memory systems from behavioral tasks alone is ambiguous. On this, I agree. If one considered only the kinds of behavioral tasks used in conventional social cognition research, it would be difficult to discern single-system and multiple-system models. However, my article presented findings from an extensive body of behavioral, neuroimaging, and lesion research in human and non-human animals, which, taken together, overwhelmingly supports a multiple memory systems model. Outside of social psychology, there is relatively little debate on this [5]; the focus now is on refining the specific computations and functions of memory systems, their precise neural substrates, and their interactive roles in learning, decision-making, and behavior [6,7].

Van Dessel *et al.* also cast doubt on evidence for memory system dissociations from lesion patient studies (e.g., comparing hippocampal and Parkinson's disease patients). However, this doubt is not supported

well by the articles they referenced; these offer only speculation about a single-system account [8], or broadly support a multiple memory systems account [6]. Although single-system computational models can be constructed to explain behavior ascribed to two different memory systems, they rarely, if ever, explain more than this. When computational and predictive coding models incorporate architecture of multiple memory systems, they explain a broader range of behavior than single-system models [9,10].

What is gained by maintaining a single-system view of social cognition? This is less clear from Van Dessel *et al.*'s response. Although single-system models offer a stimulating counterpoint to multiple system theories, they rarely generate predictions for how learning and memory interact with other psychological processes (e.g., of emotion, perception, motivation), or how knowledge is expressed through particular channels of behavior. Moreover, as hypothetical cognitive accounts, they are inherently disembodied and indifferent to biological plausibility. Indeed, such limitations led me to explore a memory systems model of social cognition in the first place.

Van Dessel *et al.* also highlighted an issue that was not central to my article and thus not a point of disagreement: the extents to which learning is propositional or associative and retrieval is implicit or explicit. However, many prominent theoretical frameworks now posit that learning and memory systems are not easily characterized in terms of their implicit or explicit operation [4]. Thus, rather than emphasize processing mode, the memory systems approach focuses on questions about computation, representation (i.e., algorithm), and implementation. Nevertheless, the memory systems model offers clarity on the conditions under which memory and behavior operate more or less implicitly.

But again, the point of my article was not to propose the memory systems model as if it were a new idea in learning and memory. What my article did do was present this model as an opportunity for social psychologists to update and advance their thinking on social cognition and attitudes. I described how this framework offers novel and testable predictions for the variety of ways impressions and attitudes are formed and represented, expressed in thought, emotion, perception, and behavior, and potentially changed. The goal was not to propose more systems, but to discuss how the operations of known memory systems can provide a better explanation of social cognition and behavior.

In doing so, my article encourages researchers to move beyond single-system models and the narrow set of behavioral methods that, being ambiguous about underlying mechanisms, may thwart theoretical advances. A case in point is my 2006 article [11], which Van Dessel *et al.* criticized as ambiguous evidence for the notion of memory systems in social cognition. The purpose of that work was not to propose a new multiple memory systems model, as that had already been established. Rather, the goal was to test new predictions from the model to clarify an enduring puzzle in prejudice research: why behavioral measures of implicit bias are so tenuously linked to social outcomes. We found that separate implicit association tests (IATs), constructed to reflect different underlying Pavlovian and semantic memory systems, did provide clearer predictions of racial discrimination.

Yet, as discussed in Amodio and Devine [11], our theoretical model did not translate well to the conventional tasks of social cognition and, indeed, the behavioral tasks we used (i.e., IATs) could not provide direct evidence for separate underlying memory systems on their own. Hence, a major takeaway was that new methods were needed to clarify the mechanisms

underlying implicit bias and its expression in behavior. For example, research using physiological and neuroimaging methods, in combination with behavior, has provided more direct evidence for when prejudices and stereotypes emerge from a single semantic associative system or different memory systems [12,13].

My hope is that the memory systems framework, and its broad body of evidence in learning psychology and neuroscience, will inspire new ideas about attitudes and social cognition, along with an expanded methodological approach. With the appropriate tools, we can begin to explore the many new predictions offered by the memory systems model. More broadly, by discussing and debating the merits of various perspectives, as in this exchange, we may integrate the best aspects of each approach to advance our shared goal of understanding social behavior.

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## Spotlight

### Gamma Oscillations Shape Pain in Animals and Humans

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**Recent studies (Hu and Iannetti *Proc. Natl. Acad. Sci. U. S. A.* 2019;116:1782–1791 and Tan et al. *Nat. Commun.* 2019;10:983) in animals and humans provide converging evidence that gamma oscillations in the primary somatosensory cortex are closely and causally related to pain behavior and pain perception. These findings could help to identify brain-based markers of pain, as well as urgently needed novel targets for pain therapeutics.**

Pain is a complex phenomenon that serves to protect the body. To this end, the brain dynamically integrates sensory and contextual information to guide behavior that aims to limit and avoid harm. Thus, pain is essentially an integrative phenomenon. In the brain, integrative functions are served by neuronal oscillations and synchrony [1]. Therefore, understanding the role of oscillations in the processing

of pain can shed new light on how functionally diverse processes merge into the experience of pain. Moreover, understanding this role promises insights into the pathology of chronic pain. Chronic pain is a highly prevalent disease that is characterized by ongoing pain and by significant cognitive and affective deficits, which significantly impair the quality of life and make it a leading cause of disability worldwide [2]. The treatment of chronic pain often focuses on the modulation of sensory processes. However, since the experience of chronic pain can be largely decoupled from sensory processes, these treatment strategies often fail [2]. This decoupling of chronic pain from sensory processes suggests that integrative processes and their dysfunction have an important role in the disease.

In recent years, human fMRI, electroencephalography (EEG), magnetoencephalography (MEG), and intracranial recordings have revealed that pain is associated with neuronal oscillations at different frequencies, ranging from infra-slow oscillations (of <0.1 Hz) to gamma oscillations (of between 40 and 100 Hz) [3]. However, the functional significance and the causality of the relationship between oscillations and pain are not fully clear. Moreover, the remote effects of neuronal oscillations on brain networks are largely unknown. Two recent studies [4,5] make significant contributions to these questions by providing converging evidence from humans and animals that highlights the importance of gamma oscillations in the processing of pain. Hu and Iannetti performed EEG recordings in humans and in rats to investigate the brain mechanisms involved in intra- and interindividual variation in pain perception [4]. This study elicited pain by using laser stimulation to selectively excite cutaneous nociceptors. Around 100 human participants were asked to report pain intensity following laser stimulation of varying intensity, while their brain responses (evoked responses