ASSOCIATION FOR PSYCHOLOGICAL SCIENCE

Perspectives on Psychological Science
1–19

DOI: 10.1177/1745691620904972
www.psychologicalscience.org/PPS
SAGE

Putting the Nonsocial Into Social Neuroscience: A Role for Domain-General Priority Maps During Social Interactions

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Abstract

Whether on a first date or during a team briefing at work, people's daily lives are inundated with social information, and in recent years, researchers have begun studying the neural mechanisms that support social-information processing. We argue that the focus of social neuroscience research to date has been skewed toward specialized processes at the expense of general processing mechanisms with a consequence that unrealistic expectations have been set for what specialized processes alone can achieve. We propose that for social neuroscience to develop into a more mature research program, it needs to embrace hybrid models that integrate specialized person representations with domain-general solutions, such as prioritization and selection, which operate across all classes of information (both social and nonsocial). To illustrate our central arguments, we first describe and then evaluate a hybrid model of information processing during social interactions that (a) generates novel and falsifiable predictions compared with existing models; (b) is predicated on a wealth of neurobiological evidence spanning many decades, methods, and species; (c) requires a superior standard of evidence to substantiate domain-specific mechanisms of social behavior; and (d) transforms expectations of what types of neural mechanisms may contribute to social-information processing in both typical and atypical populations.

Keywords

social neuroscience, social cognition, person perception, domain specificity, priority maps, biased competition

Human social interactions tend to occur easily, a fact that disguises the complexity of the mental processes involved. Attempts to understand the biological bases of human social interaction have been hampered by a relative lack of neuroscience research. Indeed, the history of human neuroscience has been dominated by the study of domain-general mechanisms that apply to all contexts; the study of systems supporting social interactions has been left relatively neglected or ignored completely. Over the past 25 years, however, the cognitive and brain mechanisms that underpin social interactions have begun to receive considerable attention (Adolphs, 2009; Cacioppo & Berntson, 1992; C. D. Frith & Frith, 2012; Lieberman, 2007). An initial picture of social-information processing has emerged that spans perceptual, cognitive, emotional, and regulatory functions and their associated neural substrates, which has informed both basic research in psychology and neuroscience as well as research in clinical and applied settings (Adolphs, 2010a).

A central thrust of social-neuroscience research has been to delineate processes that are specific to social interactions, so-called domain-specific processes (i.e., processes that are tailored to particular stimulus or task features; H. C. Barrett, 2012). This makes sense as a starting point for any emerging field of research because it is important to differentiate the research program from prior work, which in this case, had primarily focused on domain-general processes (i.e., processes that operate across different stimulus or task features; H. C. Barrett, 2012). It is clear that valuable insight has been generated through this general approach (Adolphs, 2010a; U. Frith & Frith, 2010; Kanwisher, 2010). At the same time, we argue that the focus on specialized mechanisms has been overextended and that a correction is needed at

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this point for social neuroscience to develop into a more mature research program. Such a developmental shift for the field holds the potential to drive substantive theoretical and empirical advances in the domain of social as well as cognitive neuroscience.

We argue here that an overreliance on specialized, domain-specific explanations has produced a misleading characterization of the mechanisms involved in supporting social interactions and skewed the focus of the literature onto relatively specialized processes at the expense of general processing mechanisms. Indeed, several recent suggestions have argued that mechanisms underpinning social-information processing are likely to be a combination of domain-general and domain-specific processes as well as the links between the two types of information processing (H. C. Barrett, 2012; Binney & Ramsey, 2020; Ramsey, 2018b; Spunt & Adolphs, 2017; van Elk, van Schie, & Bekkering, 2014). In other words, domain-general and domain-specific systems may play complementary roles in social cognition (Michael & D'Ausilio, 2015), and understanding how these systems interact is likely to be a challenging but ultimately revealing line of future research.

In the subsequent sections of the article, we unpack how a relatively narrow focus on domain-specific systems has led to a situation in which researchers interested in social-information processing expect too much explanatory power from the operation of domain-specific systems alone and the role of domain-general processes in social interactions has been neglected. Furthermore, our understanding of domain-general processes reflects the outputs of mature research programs. For instance, domain-general processes associated with orienting of attention and sequencing of complex behavior have been studied in depth across thousands of studies employing a diverse set of methodological approaches and spanning multiple species, which has produced a substantial body of supporting evidence (Corbetta, Patel, & Shulman, 2008; Duncan, 2010; Petersen & Posner, 2012). Consequently, rather than largely ignoring or downplaying the role of domain-general processes, we suggest that there is considerable value in generating and testing alternative models of cognitive and brain function where the contribution of domain-general systems to social-information processing is explicitly modeled.

In the current article, therefore, we emphasize the relatively untapped value of hybrid accounts of social-information processing that place greater parity on domain-general as well as domain-specific processes. We outline substantive implications for taking such an approach in terms of understanding the cognitive and brain mechanisms that underpin social behavior. Indeed, these models generate novel predictions compared with existing models of social-information processing, and they are simpler in the sense that they rely on fewer specialized components and processes. In other words, we argue (a) that there exist ready-made solutions to questions surrounding social-information processing that take a domain-general form and (b) that these solutions should be investigated alongside specialized processing components.

To illustrate the key advantages of hybrid accounts of cognitive and brain function, we outline an example hybrid model of information processing during social interactions. Note, however, that this is not to suggest that there is one hybrid account of social-information processing; rather, a productive research program is likely to generate many different hybrid accounts. By outlining one hybrid model, we aimed to use it as a vehicle to highlight the value of hybrid accounts more generally as well as to link it in with other recent hybrid accounts of mental function (Amodio, 2019; Binney & Ramsey, 2020; Cabeza & Moscovitch, 2013; Jefferies, 2013; Lambon Ralph, Jefferies, Patterson, & Rogers, 2017; Ramsey, 2018b; Spunt & Adolphs, 2017). Hybrid accounts make it clear that a higher bar of attainment needs to be set for what counts as convincing evidence for domain-specific explanations of social behavior. Therefore, hybrid models provide an important call to action for researchers interested in social-information processing by requiring a deeper evaluation of the evidence used to support domain-specific information-processing claims.

Our example hybrid model integrated two independent lines of research that, to date, have seen little cross-talk between them. The first is work on person perception in social and cognitive neuroscience, which has primarily focused on domain-specific systems (Adolphs, 2010a; U. Frith & Frith, 2010; Kanwisher, 2010). *Person perception* is used in a broad sense here as it relates to sensory, cognitive, and affective processes that are tied to social interactions. The second line of research was based on domain-general processes associated with orienting of attention, which involves selecting between competing stimuli in the environment as well as competing internal states, such as task goals (Corbetta et al., 2008; Duncan, 2010; Petersen & Posner, 2012). More specifically, a large and growing literature has established the concept of *priority maps*. Identified in a neural circuit spanning dorsal frontoparietal cortex, priority maps integrate bottom-up cues to stimulus salience, with top-down behavioral relevance regarding such things as task goals, in order to guide subsequent behavior (Bisley & Goldberg, 2003, 2010; Fecteau & Munoz, 2006; Ptak, 2012; Serences & Yantis, 2006).

The two systems of representation and control have distinct attributes. The person-representation system is largely modality- and content-specific. In contrast, the priority mapping system is largely generalized in its function. Nonetheless, a crucial third piece of the proposed model is that these two systems are reciprocally connected. Indeed, social signals from the environment as well as stored person representations and current goals are in constant flux and exchange, which is partly mediated by integration across multiple distributed circuits. Therefore, as with the models of biased competition that were outlined more than two decades ago (Desimone & Duncan, 1995; Duncan, Humphreys, & Ward, 1997), a core feature of the model is a continually updating level of functional integration and interaction between signals associated with person representations and priority maps.

In the following sections, we first outline the basic structure of the proposed model before evaluating it in a range of ways. First, we compare it with alternative models that make opposing claims, such as the claim that control processes rely on specialized systems (e.g., Brass, Ruby, & Spengler, 2009). We also compare it with other models that pay limited attention to domain-general processes (e.g., Lieberman, 2007). In both cases, we show how an emphasis on domain-general processing can result in important new predictions. Another important feature of this approach is that it leads to a cumulative science that relies on well-studied and well-established domain-general cognitive and brain systems, and we ask how far these general systems can take researchers in their understanding of a specific domain. We go on to consider other implications of the model by showing how it can reveal substantial new insight into the basic systems that support social-information processing as well as clinical conditions whose pathologies are typified by disruption to social-information processing. Finally, we place constraints on the generality of the findings proposed in order to explain when and where the model is and is not relevant before considering the merits and weaknesses of the model as well as ways that it can take the field forward in novel directions.

A Hybrid Account of Information Processing During Social Interactions

The proposed model of social-information processing is a hybrid account in the sense that it relies in equal measure on domain-specific mechanisms that are tied specifically to social-information processing as well as domain-general processes. The basic structure of the model is based on three primary sources. The first source is Jerry Fodor's conception of mind, which distinguished between a set of specialized input modules and a central processor[1] (Fodor, 1983). The second source is work in the semantic-cognition literature, which has demonstrated that the extraction of meaning from the environment is based on two primary systems of representation and control that rely on distinct cognitive and neural architectures (Binney & Ramsey, 2020; Jefferies, 2013; Lambon Ralph et al., 2017). The third source is the overarching principle of brain organization proposed in models of biased competition (Desimone & Duncan, 1995; Duncan et al., 1997). In the following section, we outline the basic structure of the model and how it relates to these prior accounts of cognition and brain function.

Overall structure of the model: representation, control, and biased competition

Similar to models developed in the semantic-cognition literature, the current model comprises domain-specific social representations and domain-general systems for computation of behavioral priorities and guidance of behavior (Jefferies, 2013; Lambon Ralph et al., 2017; Fig. 1a). The representational system supports the acquisition and long-term storage of information related to other people (Fig. 1b, left). Domain-general systems make up what we refer to as "control" processes (i.e., neural processes that guide and direct behavior so that it is coherent and effective). Guidance of behavior in this way is achieved through the impact of control processes on proximate mechanisms of perception and cognition. Thus, the control mechanisms that we discuss below have the effect of coordinating a broad range of specialized processors for perception, cognition, affect, and memory in order to produce effective responses to relevant objects and persons in the environment.

In our model, control processes are composed of priority maps and a process of biased competition. To be absolutely clear, we are not claiming that these two control systems comprise the entirety of control systems in human brains and behaviors. We see these as powerful examples of well-studied potential control mechanisms. Furthermore, these two examples reflect an interesting distinction for us, illustrating both a localizable and a distributed process for control. Priority maps guide behavior to spatial locations of high behavioral relevance and have been associated with neural activity in dorsolateral frontoparietal cortex (Fig. 1b, right). Biased competition operates in ubiquitous fashion across the entire brain and therefore integrates neural activity within and between the neural networks associated with person representation and priority maps, in line with task- and context-specific constraints (Fig. 1c).

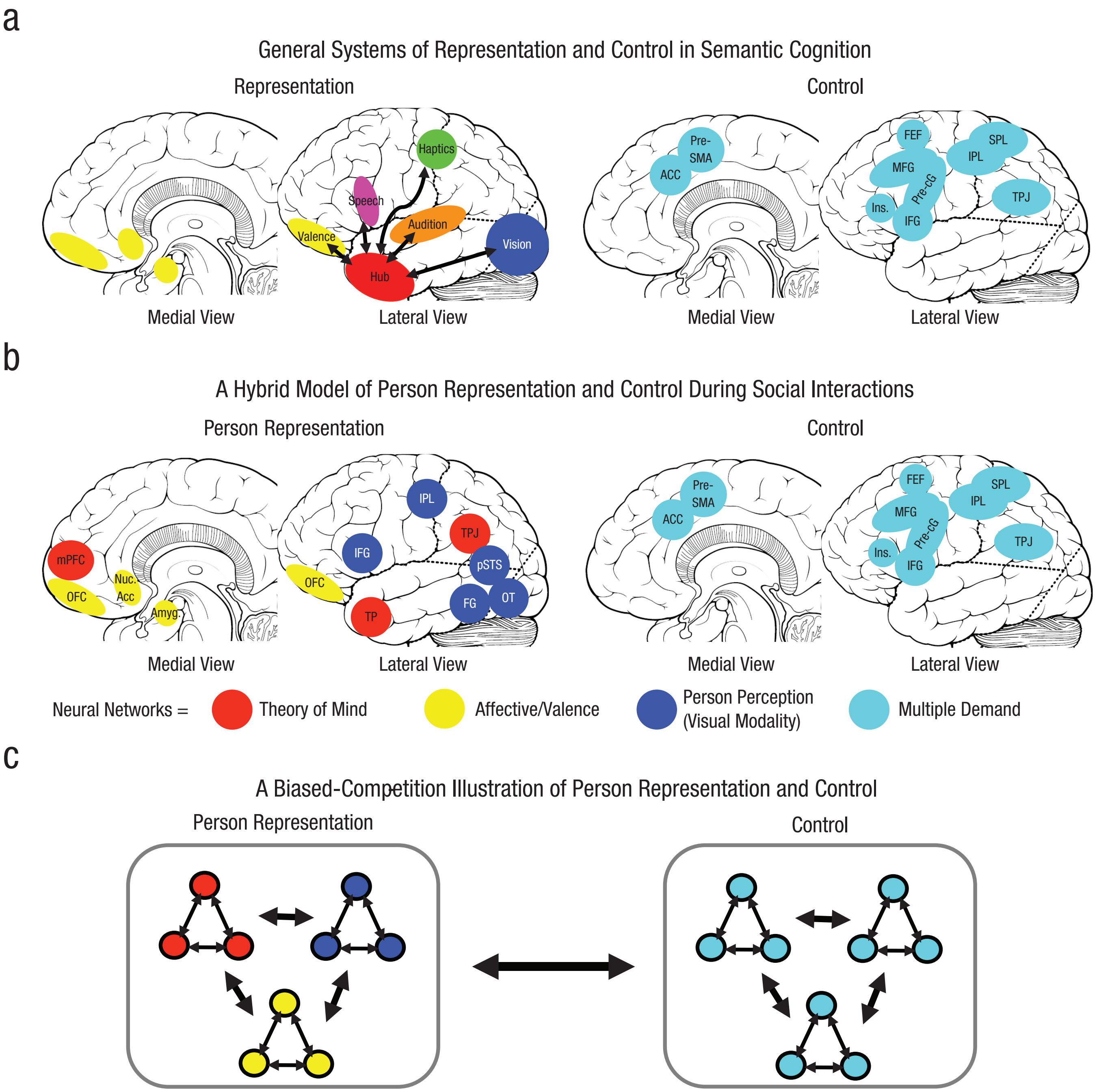

Fig. 1. Neural networks for representation and control in semantic cognition (a), social cognition (b), and as a function of biased competition (c). Illustrated in (a) is the basic division between representation and control and the associated neural structures, which has been developed in the domain of semantic cognition (see Jefferies, 2013; Lambon Ralph, Jefferies, Patterson, & Rogers, 2017). In (b), the division between representation and control is applied to mental processes that operate during ongoing social interactions. In (c), a model of biased competition is illustrated as it applies to representation and control. Under such a model, there is competition within and excitation between different forms of person representation (left) as well as different components of general cognitive control (right). Finally, there is excitation between person representations and control systems. Arrows denote competition and excitation within or between different information processing components. ACC = anterior cingulate cortex; Amyg. = amygdala; FEF = frontal eye field; FG = fusiform gyrus; IFG = inferior frontal gyrus; Ins. = insula; IPL = inferior parietal lobule; MFG = middle frontal gyrus; mPFC = medial prefrontal cortex; Nuc. Acc = nucleus accumbens; OFC = orbital frontal cortex; OT = occipitotemporal cortex; pre-cG = precentral gyrus; pre-SMA = presupplementary motor area; pSTS = posterior superior temporal sulcus; SPL = superior parietal lobule; TP = temporal pole; TPJ = temporoparietal junction.

The model also shares some similarities with older conceptions of mind that suggested inputs are largely specialized, whereas central processes are largely generalized (Fodor, 1983). Under a broad conceptualization of person perception, inputs for social cognition would include sensory, cognitive, and affective person representations that span the perception of faces and bodies as well as inferences about beliefs, traits, attitudes, valence, and emotional responses. By contrast, central processes under our account would be generalized control/prioritization processes. We note that although both the representation system and priority maps might be usefully conceived as localized modules within the brain, the process of biased competition that integrates them reflects highly distributed and nonlocalizable patterns of activity that produce the crucial effect of allowing behavior to be driven in a coherent way by a single object, event, or episode.

Representation in social-information processing: cumulative person feature maps

Person perception in this context is broadly construed to reflect sensory, cognitive, and affective processes. In short, person perception refers to any information that can cue who people are and how they are likely to behave. Therefore, such person representations include person feature maps across multiple levels of description, and they are cumulative in that they represent the current representational "state" according to the relevant history of social interactions with interaction partners. In the following, three broad sources of person information that rely on largely distinct neural structures are outlined (Fig. 1b, left).

The first system consists of largely perceptual processes within sensory systems, which so far have been investigated predominantly in the ventral visual stream (Kanwisher, 2010). Such circuits span the (a) fusiform and occipitotemporal cortices, which respond to depictions of faces (Kanwisher, McDermott, & Chun, 1997) and bodies (Downing, Jiang, Shuman, & Kanwisher, 2001; Downing & Peelen, 2011); (b) the posterior superior temporal sulcus, which responds to biological motion (Grossman et al., 2000; Puce & Perrett, 2003); and (c) the inferior frontal and parietal cortices, which are sensitive to goal-directed actions (Caspers, Zilles, Laird, & Eickhoff, 2010; Molenberghs, Cunnington, & Mattingley, 2012). Other sensory modalities such as audition (Belin, Zatorre, Lafaille, Ahad, & Pike, 2000), touch (Gazzola et al., 2012; Loken, Wessberg, Morrison, McGlone, & Olausson, 2009; Morrison, Löken, & Olausson, 2010), and olfaction (Insel & Fernald, 2004) also contribute to the representation of others. The common feature among all these channels of information is that they permit the senses to detect distinct types of information about possible interaction partners, and they largely rely on functionally segregated neural circuits.

The second system of interest at the representational level is more cognitive in nature and relies on computations in the theory-of-mind network (C. D. Frith & Frith, 1999). The theory-of-mind network spans anterior medical prefrontal cortex, temporoparietal junction, and the temporal poles and is engaged across a wide variety of situations that involve reasoning about mental states, such as beliefs, desires, and attitudes (C. D. Frith & Frith, 1999; Saxe & Kanwisher, 2003; Van Overwalle, 2009). Furthermore, the theory-of-mind network is engaged when making judgments about another's traits or character (Mitchell, Cloutier, Banaji, & Macrae, 2006; Mitchell, Heatherton, & Macrae, 2002). Such inferential processes are largely different from the types of processing in sensory detectors, and they lead to the accumulation of a distinct but complementary type of person knowledge. Such person-knowledge representations regarding current beliefs and trait-based character are of course crucial for establishing how someone is likely to behave in a given social interaction.

The third representational system is associated valence and affect (Kuzmanovic, Jefferson, Bente, & Vogeley, 2013; Vuilleumier & Pourtois, 2007). Unlike the previous two representation levels, which may reflect processes that are largely tied to person perception and person inferences specifically, the processes associated with valence and affect are likely to generalize to any situation, social or otherwise. In terms of neurobiological underpinnings during social interactions, the processing of valence and affect have been associated with a distributed circuit spanning the ventral striatum, amygdala, thalamus, and cingulate cortex (Adolphs, 2010b; Insel, 2003; Kelley & Berridge, 2002; Krach, Paulus, Bodden, & Kircher, 2010; Pessoa & Adolphs, 2010; Spunt & Adolphs, 2019). In social contexts, individuals and groups will be tagged with a level of valence, which in part is likely to determine "liking" as well as approach and avoid behaviors (Insel, 2003; Kelley & Berridge, 2002). Thus, signals pertaining to valence are clearly important for forming impressions of others and guiding social behavior and make a distinct but complementary contribution to sensory and cognitive levels of representation.

Although these three processing streams rely on largely separate neural networks, it is likely that they also exchange signals through a process of functional integration (Park & Friston, 2013; Sporns, 2013). That is, at some level, a coherent person representation requires integration across a range of person features (Greven, Downing, & Ramsey, 2016; Greven & Ramsey, 2017a, 2017b; Over & Cook, 2018; Ramsey, 2018a). For example, one must be able to identify physical features in order to identify who the other is in a social interaction while also integrating and recalling other person knowledge, such as trait character judgments and valence (Over & Cook, 2018; Ramsey, 2018a). Such integration may ultimately lead to more holistic person representations that abstract away from the specific features, as has been outlined for processing in anterior temporal cortices (Binney & Ramsey, 2020; Lambon Ralph et al., 2017; Wang et al., 2017). Although of fundamental importance, much like functional integration research more generally (Park & Friston, 2013), the neural systems that bind social information together is a relatively unexplored topic.

An important characteristic of these person-feature maps is that they are cumulative; they represent the current representation of the person given the historical accumulation of signals in those maps. That is, for each person-feature map, the current representation is the result of the sum total of experience with that individual. Therefore, there is a memory component to person representations outlined in the current work (Amodio, 2019), which makes them cumulative. One implication is that the ongoing input during social interactions has to mesh and interface with stored person-representation information.

Control in social-information processing: integrated priority maps

We now turn to control processes, which in general have been argued to regulate, guide, and manage other mental processes in order to shape human behavior (Duncan, 2010; Petersen & Posner, 2012). Priority maps have been studied extensively as a candidate system that guides the spatial focus of attention and ultimately regulates behavioral choices (Ptak, 2012). The basic premise follows the logic of stimulus salience maps, which suggested that the salient features of a stimulus drive the focus of attention (Itti & Koch, 2001). Thus, on the basis of bottom-up signals from environmental cues, attention is directed toward the stimulus features that “win” the race to capture attention by virtue of being the most salient.

Of course, during social interactions, we frequently interact with others while maintaining a variety of goals. For example, while at a train station, we may be looking for a friend or trying to find the correct platform. As a consequence, the relative salience of other people compared with platform information will be up- or down-regulated depending on the individual’s current goal. An important feature of priority maps, therefore, is that they are not restricted to the salience of stimulus features; instead, they have been shown to integrate stimulus features with current goal information (Bisley & Goldberg, 2003, 2010; Fecteau & Munoz, 2006; Ptak, 2012; Serences & Yantis, 2006). Therefore, priority maps orient attention on the basis of a qualitatively richer set of factors than stimulus features alone (Fig. 2). Likewise, more recent formulations of priority maps have expanded such factors to include a memory component (Awh, Belopolsky, & Theeuwes, 2012) as well as motivational, affective, and semantic processes (Todd & Manaligod, 2018). In sum, priority in this broader sense reflects the perceived quality of the stimulus given relevant context and history rather than an absolute physical quality of the stimulus (Fig. 2; Fecteau & Munoz, 2006; Ptak, 2012; Serences & Yantis, 2006).

Although there are different flavors of priority map, they all have common foundational principles, which are the main focus of the current article. First, priority maps have been identified in a dorsal frontoparietal network (Fig. 1, right), which anatomically overlaps with the orienting systems outlined by other researchers (Corbetta et al., 2008; Petersen & Posner, 2012), as well as aspects of the multiple-demand network that spans medial and lateral frontoparietal cortices (Duncan, 2010). Second, priority maps are independent of features, modalities, and responses; they can take diverse feature information from different modalities and combine them into single coherent priority map, which then guides behavioral responses in a flexible manner that is not tied to a particular response effector (Ptak, 2012). Importantly for social interactions, which involve a multitude of signals, priority maps can integrate exogenous cues such as stimulus features with broader classes of signal that endogenous cues, such as goals, memory, affective, and motivational information (Fig. 2; Awh et al., 2012; Todd & Manaligod, 2018). Below, we outline how the domain-general functionality of priority maps is well suited to orienting during social interactions while at the same time making contrastive predictions in comparison with alternative models of social-information processing.

Integration within and between representation and control systems: biased competition

In principle, biased-competition models offer a way to conceptualize how signals from different processing components may be integrated (Desimone & Duncan, 1995; Duncan et al., 1997). Within a biased-competition

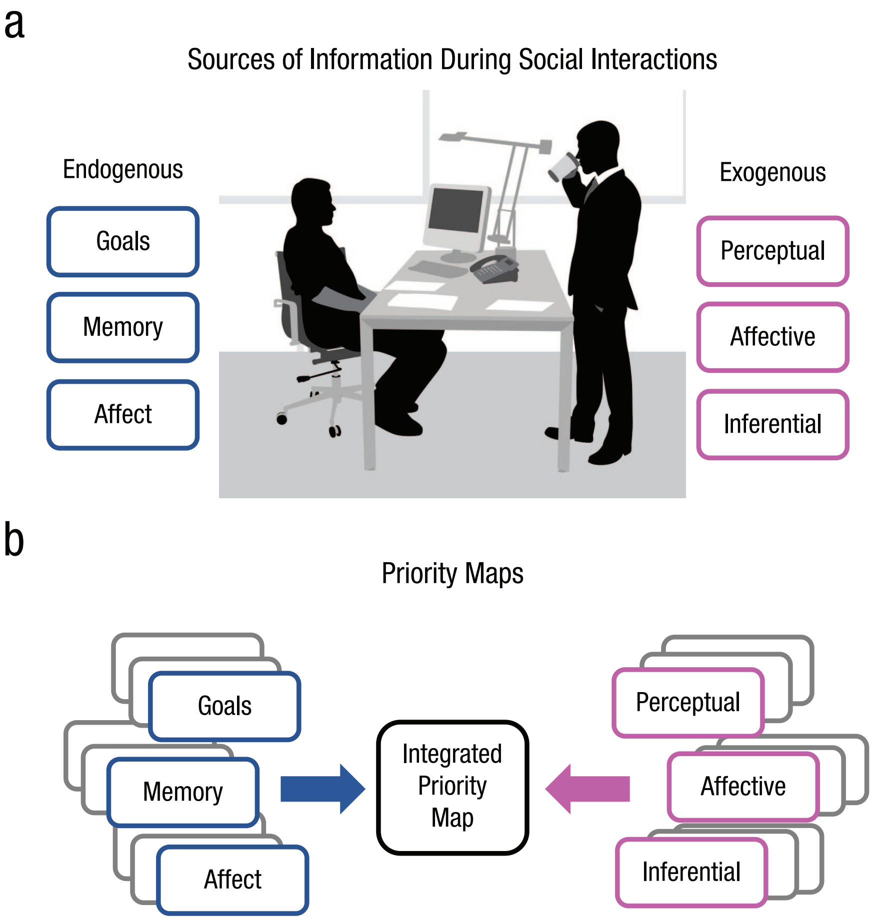

Fig. 2. Integration of endogenous and exogenous information during social interactions. (a) Two distinct sources of information need to be integrated during social interactions. These sources include endogenous cues, such as task goals, memory, and affective states, as well as exogenous cues, such as perceptual, affective, and inferential representations of other people. (b) An integrated priority map is able to bring these two distinct sources of information together into a common space. By integrating information, priority maps can incorporate diverse forms of bias, which ultimately guide the locus of attention. Shaded boxes indicate that endogenous and exogenous cues typically have a history, and thus the current representation is one that has emerged over time and reflects more than the current state.

framework, the human brain can be characterized as a complex information processor that has many specialized processors operating in parallel. For example, there would be specialized processors for object form, motion, and color, as well as complex feature combinations and spatial locations. For coherent behavior, the activity of these many different regions must be coordinated so that a single object or event guides response effectors. As one thinks beyond perceptual processing, one can see the need for coordinated brain activity that extends to specialized networks for memory, planning, and a range of executive functions.

Models of biased competition represent a general approach for achieving this coordinated brain activity (Desimone & Duncan, 1995; Duncan et al., 1997). Biased competition, as achieved by competition within processors and excitation between, means that a bias for an object or event in one processor will tend to propagate through the network. Bias can arise from both stimulus factors (i.e., exogenous environmental salience) as well as from task goals or context (i.e., endogenous bias). In either case, the network converges onto the properties and the implications of a single object for behavior. We can call this the *selected* object or event.

In our model, the systems of person representation and priority mapping are functionally distinct and operate in parallel (see Fig. 1). Biased competition addresses the serious danger in a system that contains specialized, parallel processors, which is that behavior can become incoherent if different processors are representing the properties of different objects. For example, what if the activity of the priority map was focused on one location, but the activity of the person representation was focused on a person at a different location? Because there is only one set of effectors, which of these systems would guide behavior? Biased competition ensures coherent behavior given that the properties of a single object or event will come to dominate across both principal systems (Fig. 1c).

Integration and coherent activity mean, for example, that activity from person representations can be integrated with current goals and a prior history, as well as affective and motivational factors constituting the current priority map. Within this context, one can see that brain regions associated with social-stimulus processing, such as face- and body-selective brain areas and also higher-level networks for theory of mind, are just other forms of specialized processors and likewise require and benefit from integration and coordination with other brain activity. In fact, although not an explicit part of the model here, a process of biased competition could serve to integrate the variety of contextual, environmental, and task factors making up the priority map. This map would be updated in a dynamic fashion as social signals change over time.

There will be a diverse range of processors that might influence bias, as suggested in our discussion of person representation and as illustrated in Figure 2, for example, processors for space, affect, goals, inferred states, and others. Biases from any and all processors might influence the final selected state, and conversely, none of them may be strictly required. In particular, we have been emphasizing the role of spatial bias in the form of a priority map. This is for good reasons given that social interactions involve other people and that other people occupy space. However, at any given time, the most influential sources of bias will vary according to context, and even space is just one such source (albeit a very useful one). For example, an internal affective state of happiness might bias competition so that a memory of a happy event comes to dominate processing. In this instance, the selected target of attention would be an internal representation, not an object present in the real world. However, in the context of an ongoing interaction with a nearby person, we would expect spatial bias to play a crucial role in guiding behavior.

Our proposal is falsifiable. Several predictions follow from this proposed neurocognitive structure (i.e., the idea that a biased competition simultaneously operating over social representations and nonsocial or domain-general processes would converge on a single object or event). First, and perhaps most importantly for the current argument, social stimuli gain control of behavior through the same general mechanism as any other form of stimulus. There is no need for socially specific forms of control. As long as there is a domain-specific representation of social stimuli, a general process can allow these representations to be selected and guide behavior.

Second, social and nonsocial processors are expected to show mutual influence. Convergence and integration through biased competition means that both the social and nonsocial properties of the selected social object are selected concurrently. For example, an angry person occupies space, and so processing of this stimulus is subject to both social and spatial biases. A bias for angry stimuli may lead to convergence on an angry social object, which results in all properties of this object, both social (e.g., identity, race, gender) and nonsocial (e.g., location, motion, form), being available to control behavior.

A third and related prediction is that when an object has been selected, the final converged state of the network will be similar regardless of the initial source of bias. For example, an angry person might be selected because of a bias toward anger or because of a bias toward the location that person is occupying. In both cases, properties of the relevant person will be simultaneously activated and available to control behavior.

Fourth, in the model, given that the final converged state representing selection arises from biased competition over all processors, selection for social and nonsocial objects cannot be readily dissociated. That is, there will be no "social focus" of attention that is dissociable from a parallel "nonsocial" focus. Instead, there is a single focus representing the convergence of activity over all processors.

Finally, although our model has no domain-specific social-control system, it can mimic deficits in social control. The structure of our hybrid model, with domain-specific person representation and domain-general control processes, would suggest that specific deficits in the selection of social stimuli can be explained as deficits in the richness of representation on which competition operates rather than a deficit in the general-control process itself. For example, if the person-representation system were degraded, then the processes of competition within this representation and the excitation with relevant priority maps would be less effective in driving behavior (e.g., Ward, 1999). The network would converge more slowly and less reliably on the social object of interest. That is, even when domain-general control systems are intact, they will not be able to operate as effectively if the domain-specific representations they depend on are disordered.

A Comparison With Alterative Models and the Data

We use proposals put forward by Haig (2014) as the framework for comparing models as well as how all these models compare against the accumulated data in systems neuroscience to date. For example, simplicity and explanatory breadth are emphasized as particularly important factors to consider when evaluating theories or models (Haig, 2014). We use this framework to compare the current model to two types of prior model, which each make contrasting predictions, because we feel comparison with multiple types of social-information-processing models can be instructive.

A comparison with specialized versions of control

Specialized accounts of control largely rely on the theory-of-mind network to control or regulate social interactions in some way. Such accounts are largely premised on control in terms of controlling self-other processes. For example, researchers who used a task that required the inhibition of automatic imitation (Brass, Bekkering, Wohlschlager, & Prinz, 2000) argued that conflict between one's own action intention and another's action is regulated by the same theory-of-mind system that is engaged when representing other people's mental states, such as beliefs, desires, and attitudes (Brass et al., 2009; Sowden & Shah, 2014; Spengler, von Cramon, & Brass, 2009; Wang & Hamilton, 2012). Therefore, such claims are founded on the idea that a neurocognitive system (the theory-of-mind network) that is domain-specific and dedicated to social-information processing is also involved in "regulating" social interactions between individuals via the control of self-other interactions. Note that for present purposes, domain-general forms of control, which we outlined above, such as prioritization, inhibition, and selection, were not explicitly mentioned in these accounts. Thus, these accounts did not present roles for general and specific forms of control but instead focused only on the role of the theory-of-mind network and specialized forms of control.

On the one hand, during social interactions, it seems clear that there must be some system (or set of subsystems) that distinguishes self from other; otherwise, social exchanges would be incoherent (Decety & Sommerville, 2003; Georgieff & Jeannerod, 1998). On the other hand, however, there seems no a priori reason why such a process would necessarily need to rely on a specialized and domain-specific set of control processes. Indeed, as we illustrate in Figure 3, an information-processing account of the inhibition of automatic imitation can be realized without the need for socially specific forms of control. Furthermore, the domain-general view has more explanatory breadth because it provides a plausible account of control processes, such as priority mapping, in all situations (i.e., situations that include social interactions as well as those that do not).

In our analysis, specialized accounts of any process (including control processes) run the risk of exploding in number to account for ever more social circumstances that may require different types of control process. Indeed, more and more supplementary systems of control may be required for a full account of social-control mechanisms to emerge. A further complicating factor for specialized accounts of control is the added requirement for integration between specialized and generalized forms of control and, indeed, between different forms of specialized control. That is, although there are interesting and informative counterexamples following damage and disruption (Shallice & Cipolotti, 2018), the mature human cognitive system tends to operate smoothly, whether interacting with others or making a cup of tea. Indeed, there is a coherent sense with which people work toward task goals in the presence of environmental cues. Therefore, any model of information processing during social interactions that rests partly on specialized control systems needs a solution to the combinatorial problem that occurs. This very problem has been repeatedly raised in robotic subsumption architectures in which action selection must be arbitrated among many specialized control systems (Brooks, 1991). Put differently, alternative accounts need to (a) explain how multiple systems of control, which include specialized and generalized forms, are integrated into a coherent action plan, and (b) detail the benefits that specialized control systems then offer given the need for integration with general control systems.

A comparison with general theories of social cognition

General theories of social cognitive neuroscience have made a valuable contribution to the field by stipulating the range of processes that is likely to be involved in social-information processing (Adolphs, 2009, 2010a; C. D. Frith & Frith, 2012; U. Frith & Frith, 2010; Lieberman, 2007). These general theories frequently distinguish between social perception, cognition, and regulation (Adolphs, 2010a). Social perception and cognition would map directly onto the representational level of the current model, whereas social regulation would reflect the control component in the current model. Although cognitive control is mentioned briefly in several of these general accounts of social cognition as a

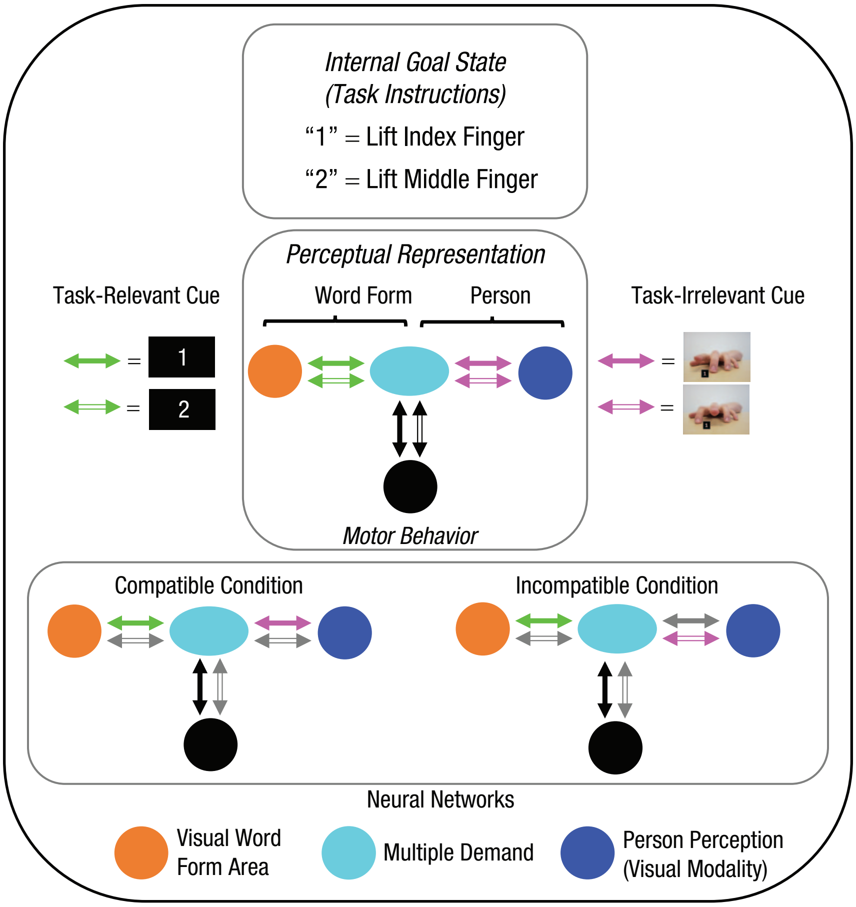

Fig. 3. A model of information processing during the inhibition of automatic imitation (a social-stimulus–response compatibility paradigm). An alternative model of the processes involved in resolving a social-stimulus–response compatibility paradigm that does not include any domain-specific forms of control. Instead, task-relevant cues are assigned a stimulus–response mapping, which is in relation to number cues and finger responses. Concurrently, there is also a task-irrelevant mapping that emerges, which is in relation to the observed finger movement and the associated motor response. Consequently, in the compatible condition, the task-relevant and task-irrelevant mappings both bias the same finger response. In contrast, in the incompatible condition, the task-relevant and task-irrelevant cues bias different finger responses, and this conflict needs to be resolved before the correct response can be initiated. It is this conflict that leads to the reported reaction-time difference between compatible and incompatible conditions. In contrast to Brass et al. (2009), we do not assume that the need to distinguish self from other generates conflict in this task, nor do we require the engagement of the theory-of-mind network to resolve this kind of conflict because under our formulation, there is nothing special about this type of stimulus–response mapping conflict. Rather, it is just another form of stimulus–response mapping, and thus general systems for prioritization and control, which are coordinated through frontoparietal cortex, can engage with domain-specific word and person (finger) representations in more specialized representation systems.

supervisory or integration system (Adolphs, 2009, 2010a; C. D. Frith & Frith, 2012), it receives minimal attention and lacks a detailed description on a neurobiological level. Thus, general models of social cognition place little focus on generalized control processes, which leaves them relatively neglected.

When making comparison with our model, the first and most important thing to note is that there is no direct conflict between these general accounts and the current proposal. Rather, there is a difference in the emphasis and associated level of detail that is placed on generalized forms of control process. We propose a much larger role for generalized control processes and attempt to demonstrate how they have direct consequence for how social-information processing is conceived, how theories are generated, and the types of hypotheses that might serve to be most fruitful in understanding social brain mechanisms. In contrast, these prior general accounts minimize the role of generalized control. As we demonstrate in the implications section, although these theories may be qualitatively equivocal on grounds of cognitive architecture, we feel there are important reasons to increase the focus on generalized control processes given that they have important knock-on consequences for how researchers may understand relationships between distinct processing components and thus illuminate the structure of cognitive and brain systems more generally.

Compared against current empirical evidence

In this subsection, we compare the central tenets of the model with the extant literature in social and cognitive neuroscience. We take each component of the model and compare it against the data in turn. First, we consider the representational level of the model. Although the exact nature of selectivity in the visual system, for example, is debated (Tarr & Gauthier, 2000; Yovel & Kanwisher, 2004), there is consensus in broad terms regarding functional segregation as a cardinal feature of brain organization (Park & Friston, 2013) and in particular in reference to social-information processing (Adolphs, 2009, 2010a; Kanwisher, 2010). Therefore, at a broad level, the one that we are focusing on here, there is widespread agreement that largely distinct processing components show sensitivity to information that pertains to other people in terms of sensory and perceptual processing as well as mental state ascription. In sum, there is strong evidence for a set of distributed neural circuits that are preferentially tuned to process a range of person-related information (Kanwisher, 2010).

Second, as previously acknowledged, there is considerable evidence that details neural structures that support generalized forms of cognitive control. Indeed, the proposal that generalized forms of control are associated with medial and lateral frontoparietal cortices is supported by a comprehensive evidence base, which has sufficient depth and breadth to engender confidence in the claims being made. For instance, the evidence consists of thousands of studies in humans across a range of complementary methods and is also supported by comparative work in nonhuman species (for reviews, see Badre, 2008; Corbetta et al., 2008; Desimone & Duncan, 1995; Duncan, 2010; Miller, 2000; Petersen & Posner, 2012). The further proposal that one component of these generalized systems of control concerns orienting of attention and priority mapping and that this relies on dorsal frontoparietal cortex is also supported by a wealth of evidence (Awh et al., 2012; Bisley & Goldberg, 2003, 2010; Fecteau & Munoz, 2006; Ptak, 2012; Serences & Yantis, 2006; Todd & Manaligod, 2018).

Third, and by contrast, there is relatively weak evidence for specialized forms of control. There is some evidence that specialized forms of control exist to regulate social interactions that rely on the operation of the theory-of-mind network, but it is relatively weak in the sense that it relies on a small number of studies that lack powerfully designed replications (Brass et al., 2009; Sowden & Shah, 2014; Spengler et al., 2009; Wang & Hamilton, 2012). One specific weakness of the current evidence is that some of the neural claims lack clear evidence of functional specificity, which means that such evidence could reflect the operation of more general processing systems. In addition, much of the evidence from functional MRI (fMRI) relies on reverse inference, whereby activity in a given anatomical region is taken to be indicative of a functional signature caused by a brain region's prior association with certain functions (Poldrack, 2006). The use of reverse inference is particularly important for regions such as the medial prefrontal cortex and temporoparietal junction because they have a particularly heterogeneous functional profile at the systems level (Amodio & Frith, 2006; Patel, Sestieri, & Corbetta, 2019; Rushworth, Buckley, Behrens, Walton, & Bannerman, 2007).

Take temporoparietal junction, for example, which has been consistently implicated in orienting of attention and social cognition (Patel et al., 2019). Without clear distinction between social and nonsocial processes, one could wrongly conclude that the region's performance in a given task is more specialized than it is. Moreover, if spatially distinct portions of temporoparietal junction show different effects that relate to social and attentional functions (Scholz, Triantafyllou, Whitfield-Gabrieli, Brown, & Saxe, 2009), then it seems even more important to functionally distinguish between these subdivisions when making specific claims about this brain area (Krall et al., 2015). Furthermore, the largest fMRI work to date, which used a multiexperiment, high-power approach (Darda, Butler, & Ramsey, 2018), and a meta-analysis of all related fMRI work (Darda & Ramsey, 2019) showed very limited evidence for specialized control processes in the context of imitation inhibition but compelling evidence for generalized control. Such evidence contrasts with the initial fMRI research on imitation inhibition that used much smaller sample sizes and argued for a socially specific form of control in right temporoparietal junction (Brass et al., 2001, 2005, 2009; Spengler et al., 2009). Therefore, the sum total of evidence for specialized control systems is weak. This said, a lack of evidence does not rule out the plausibility of such a system in principle. Rather, it means that the theory should be reevaluated in light of this evidence before further claims are made regarding specialized control systems during social interactions.

Fourth, there is limited evidence to date that shows how systems of representation and control interact during social interactions. The term *limited* in this sense means that only a few studies have examined links between representation and control compared with the work that has studied them separately. Some work has shown domain-general interactions with person representations either directly by functional integration measures (Baldauf & Desimone, 2014; Quadflieg et al., 2011) or less directly by proposing distinct but complementary processing components for specialized and generalized systems (Ramsey, Hansen, Apperly, & Samson, 2013). The latter approach follows a long tradition of studying theory of mind in cognitive psychology that proposes complementary roles for perspective computation and perspective selection, which reflects specialized and generalized processes, respectively (Leslie, German, & Polizzi, 2005; Leslie & Thaiss, 1992).

Other work has suggested that domain-specific systems, such as the theory-of-mind network, provide a controlling signal that modulates person representations (Wang & Hamilton, 2012; Wang, Ramsey, & Hamilton, 2011). One piece of evidence for this claim comes from an fMRI study using functional connectivity analyses. Wang and colleagues (2011) showed that the response in medial prefrontal cortex influenced activity in frontal and temporal cortices when one person looks at another during an imitation-inhibition task. Although it is plausible that medial prefrontal cortex provides a control signal over other-person representations, the claim is currently based on a small number of studies, and it is hard to distinguish from an account on the basis of functional integration across different types of person representation. For instance, an explanation at the person-representation level would suggest that when Person A looks at Person B, it influences the intentions and mental states that Person B ascribes to Person A. In an imitative context, such mental state-person information would need to be integrated with other person features, such as observed action representations, and this may occur through functional integration between neural networks. Therefore, an updated person representation that shares multiple features (perceptual and inferential) could also account for the same findings (Over & Cook, 2018; Ramsey, 2018a) without the need to engage specialized control processes per se. Therefore, more work is needed in terms of understanding integration between levels of representation and control.

Implications for Understanding Cognitive and Brain Mechanisms of Social-Information Processing

By far, the broadest implication of the current proposal is that a purely piecemeal approach to understanding any cognitive faculty (social or otherwise) is fundamentally limited (Churchland, 2013). Take attempts to understand vision, for example. Vision relies on general-intelligence competencies that make one aware of concepts and guide expectations; vision is not reducible to mental operations housed within visual cortex alone, such as edge, color, motion, and shape sensitivity (Churchland, 2013). The systems that support social interactions are likely to be no different; they just may include a more varied set of signals and hence more integration and control. To be clear, a piecemeal approach is valuable in its own right, and it has made a sizable impact in social neuroscience, and it will continue to do so. At the same time, such an approach is limited in important ways, which we feel has been relatively neglected in social (and human) neuroscience and ultimately has been detrimental to progress.

Given this first broad implication, we suggest that social neuroscience needs to change its default approach and embrace general processes alongside specialized processes from the outset. A deeper appreciation and acknowledgment of domain-general processes in social cognition means that nonsocial but well-studied processes can offer valuable insight into the cognitive and neural processes associated with navigating social interactions. A similar argument has been made for understanding memory (Amodio, 2019; Spunt & Adolphs, 2017), semantic (Lambon Ralph et al., 2017; van Elk et al., 2014), and motor-control systems (Cisek, 2007; Cisek & Kalaska, 2010). Indeed, much as for these other areas of research, ignoring generalized processes seems equally inefficient given their potential relevance to the problem at hand. Consequently, these more established research programs can help guide expectations regarding the division of labor between more specialized and general systems.

Moreover, considering the substantial and multimethod evidence for the involvement of frontoparietal brain circuits in prioritization, any specialized claims should show that the results do not reflect operations of the domain-general system. In other words, the burden of proof is on specialized accounts to present compelling and consistent evidence that specialized brain circuits and processes underpin social control. Moreover, domain-general processes by definition operate across all contexts (to some extent), which would therefore include social contexts. In terms of explanatory mechanisms, therefore, we may expect less from specialized control process but more from generalized control processes. This suggestion is important because it is in direct opposition to the modal and dominant approach in social neuroscience.

A further broad implication of the current approach, which was previously outlined (Adolphs, 2009), is that it emphasizes the importance of distinguishing between input-specificity and mechanism-specificity. That is, just because a social process or behavior may rely in part on a generalized control process, it does not prevent it from being a fundamentally social process or behavior. Indeed, representational content, such as a human face or an emotional response, can be unambiguously social without the need for every mental process associated with it to be specialized and domain-specific. Although this has been made clear many times before, it is worth repeating because it has important consequences for what we can expect from social processes. Moreover, it is a central aspect of the current model that generalized control processes are the first calling point when modeling control processes during social interactions. In short, social cognition is still interesting if it relies partly on general-processing mechanisms. That is, one can attempt to explain fully fledged social processes with a combination of general and specialized mechanisms (Spunt & Adolphs, 2017), just as has been argued in the domain of memory (Cabeza & Moscovitch, 2013).

The current proposal has straightforward clinical implications. If the basic cognitive and brain systems that operate in social contexts are less specialized than has been previously acknowledged, especially in terms of control and regulation of other processes, then it substantially changes the likelihood that an atypical domain-specific information processor may underpin the condition. In other words, the range of possible socially specific mechanisms that may operate in an atypical manner may be a lot more narrow than is typically considered. Likewise, any characterization of a disorder of social-information processing should also explicitly model general information-processing components because the range of social difficulties need not be underpinned solely by specialized, socially specific information processors. A related clinical implication is that deficits in the control of social processing can arise as a consequence of deficits or degradation in the systems for domain-specific social representation. For example, a difficulty in identifying emotional states in others could lead to inappropriate behavior in a given social context, which might otherwise look like a deficit in the control or regulation of social actions. Generally speaking, deficits in domain-specific representation can mimic a deficit in domain-specific control. In seeking to understand clinical social disorders, researchers must therefore look first to whether the social information is being encoded and accessed effectively.

Constraints on Generality

Constraints on generality are important to identify because they place explicit limits on the scope of the claims being made rather than letting implicit assumptions dictate how others may interpret a given proposal (Simons, Shoda, & Lindsay, 2017). In the following, we outline three constraints on generality. First, the characterization of social-information processing presented above does not in principle preclude any form of domain-specific social control. Rather, the model says that given an assessment of the theoretical underpinnings as well as the evidence to date, it is simpler and has more explanatory breadth without the need for specialized forms of priority mapping in social contexts. Therefore, specialized forms of control are possible, but they are not necessary, and they have limited empirical support to date.

What we are saying, however, is that the bar for identifying a domain-specific process of control should be high. We suggest that convincing evidence for domain-specific control systems would be based on the following principles, as borrowed from research on the visual system, which has identified tuning functions for particular classes of objects that are tied to distinct patches of visual cortex (Kanwisher, 2010, 2017). First, at a general level, evidence for a separate specific control system that applies to social interactions should be dissociable from social representations as well as general forms of control. Second, the evidence should come from multiple methodological approaches (e.g., patients, neuroimaging, neurostimulation, and comparative) and satisfy new recommendations from the open science movement regarding improvements in methodological rigor, such as replication, preregistration, and the use of powerful designs, among a host of other things (Munafò et al., 2017). More generally, claims regarding specificity of function would benefit from considering the principles recently put forward in another heavily studied domain, which relates to inferring emotions and facial expressions (L. F. Barrett, Adolphs, Marsella, Martinez, & Pollak, 2019).

Second, we are modeling information processing here during ongoing social interactions. We are not covering the whole of social-information processing or the many varied relationships between different types of general and social processes. Instead, our main focus in the current article is that at any given point in time, one has a representation of the world (and people in it) along with a set of task goals. In other contexts, such as semantics, for example, there may well be general control processes and more specialized control processes for social semantics that engage ventral portions of frontoparietal cortex (see Binney & Ramsey, 2020). We are also not covering the emergence and development of social representations (i.e., representational content; Meyer, Bekkering, Haartsen, Stapel, & Hunnius, 2015; Weigelt et al., 2014) or how expertise shapes such representations (Bukach, Gauthier, & Tarr, 2006; Gerson, Bekkering, & Hunnius, 2015). We speculate that learning about other people along with social concepts are also likely to involve integration between general control and input modules. But this remains open for researchers to pursue further. We also do not attempt to cover the entire range of possible relationships between different types of general and specifically social processes. Given that general processes operate across a diverse set of situations to some extent, we would expect the relationships between general and specifically social processes to be largely unrestricted. That is, we expect a range of general processes that relate to attention, memory, semantics, and motor control to be relevant to a range of processes related to person perception and interaction that span perceptual, affective, and inferential (i.e., theory of mind) mechanisms. We may want to tighten these initially loose constraints only after further research.

Third, even though large sections of frontoparietal cortex are consistently engaged across a range of tasks (Duncan, 2010; Fedorenko, Duncan, & Kanwisher, 2013), this does not preclude functional specification (by degree) in subsections of the network (Cole et al., 2013; Petersen & Posner, 2012). The nature and structure of such fractionation in the multiple-demand network is largely unknown and needs to be established. For example, it is possible that within the multiple-demand network, there are dedicated subsystems that are involved more (to some extent) with some types of representational input than with others. Relatedly, it is possible that control is similar in a qualitative sense but that it just operates on different inputs (i.e., social inputs), which makes the multiple-demand network potentially graded in its operation. A graded structure would be one that is largely based on general processes with some smaller proportion of subspecialization. However, this is still a very different model of control from the type of social control that is regularly offered in the social domain, which is that social networks associated with reward, empathy, and theory of mind provide control in social contexts (Brass et al., 2009; Sowden & Shah, 2014; Spengler et al., 2009; Wang & Hamilton, 2012). Therefore, we are making a claim that control will predominantly take a general form and rely on the multiple-demand network with just a limited contribution from social circuits such as the theory-of-mind network. Hence, we are making a claim on a systems level about a grossly defined neural network (multiple demand vs. specialized) that does not rule out functional division within a given network.

Strengths and Limitations

A key strength of the proposed model is that it makes clear predictions that can be falsified. If evidence accumulates to suggest that there are dedicated control mechanisms that are specific to social contexts, it would refute one basic tenet of the proposed model, which suggests that a largely domain-general priority mapping system interfaces with largely specialized input modules. For a convincing domain-specific claim to be made, however, such evidence would have to be based on the principles that we outlined in the previous section regarding the type and quality of evidence required. A call for clearly specified predictions is consistent with recent recommendations (Gray, 2017) that have emphasized the importance of being able to clearly articulate the features of a theory or model in order for them to be tested. Thus, model testability as well as specifying constraints of generality are of key importance to lay a foundation for a productive research program, and we outline both of them here.

A possible criticism is that we present an overly simplistic account that artificially reduces the complexity of social-information processing. We would respond, however, that for a field that has emerged only in the past 25 years, we may need to walk before we can run. That is, it may be time to reconsider that the complexity of the signal and associated mental computations that underpin social interactions does not necessitate a combinatorial explosion of processing systems to be articulated. Put differently, maybe as a field we need to take a moment to step back and reevaluate some core assumptions, such as how much focus we should place on generalized systems (Amodio, 2019; Michael & D'Ausilio, 2015; Spunt & Adolphs, 2017), in order to make firmer progress. On the other hand, if this is an overly simplistic account, it will be easy to falsify. It would also be easy to point to robust evidence or theory that argues against the current formulation. Therefore, we think that the current formulation adds value to the field of social and cognitive neuroscience given that it has not focused on the integration of domain-specific and domain-general processes even though some have suggested that they could be complementary (Michael & D'Ausilio, 2015).

Open Questions and Future Directions

The preceding analysis raises more difficult questions than clear answers. We focus on two broad questions that we hope will stimulate distinctive future directions and result in significant research progress. The first question surrounds the extent to which control processes in social and nonsocial contexts are qualitatively and/or quantitatively different, and whether they rely on distinct information-processing components. A quantitative difference would emerge if the same basic system of control, which is underpinned by the multiple-demand network and resembles a domain-general priority map, is engaged to different degrees in social and nonsocial contexts. A qualitative difference would emerge if a different type of control is engaged during social interactions that is distinct from a domain-general priority map and possibly engages a different brain network. Consideration of this distinction prompts several questions for future research. Does this distinction help to set boundary conditions between social and nonsocial cognition? Is social cognition primarily different from nonsocial cognition in terms of the type of inputs or representational-level content, the control processes of which are largely similar?

If priority maps link together saliency maps and behavioral relevance in a completely independent sense (i.e., a feature-, modality- and response-independent representation of the environment), can we add domain independence to this list (social, nonsocial)? Are there just more diverse and complex types of input in the social domain, such as emotions, beliefs, desires, attitudes, and trait and character judgments? Under this view, the mechanisms that control social representations are not special in any sense. Instead, other people are special in only one sense: They have some unique features in comparison with inanimate objects and other animals. But the same can be said of inanimate objects and other species—for example, planes can travel at 30,000 feet above ground, and birds can fly, but humans cannot (unaided). Therefore, the fact that humans have some unique qualities is not in itself unique (Adolphs, 2009). On this basis, we may need to temper expectations regarding the need for specialized control mechanisms during social interactions.

The second big question that this analysis brings to the forefront regards functional integration (Bullmore & Sporns, 2009; Park & Friston, 2013). Estimating, investigating, and characterizing the relationship between generalized control processes, such as priority maps, and person representations, will be important for future work. Some work has already begun on this front, but more is needed given that it is likely to be complex. Indeed, it may be the interaction between domain-general control processes and social inputs that distinguishes social from nonsocial information-processing streams. In addition, what about integration between social modules, such as perceptual and inferential processes (Greven et al., 2016; Over & Cook, 2018; Ramsey, 2018a)? How do these "holistic" representations interact with domain-general priority maps? This gets complex quickly, but that is all the more reason to learn from wider and more developed research programs, such as semantic cognition (Lambon Ralph et al., 2017) and attention (Petersen & Posner, 2012), because it may help researchers in social neuroscience specify more precisely what can already be expected from generalized control processes in terms of explanatory value.

Conclusion

For an emergent field of research, the initial job of carving out an existence has been sufficiently achieved by social neuroscience. Now, to develop into a more complete research program, we argue that it cannot attempt to understand only one part of a system at a time; instead, it needs to consider component parts in the context of other constituent parts. As we outlined in the current article, for example, models of social-information processing would benefit from explicitly incorporating the integration of specialized and generalized information-processing mechanisms. Although this suggestion may sound obvious to some people, the consequences of doing so are substantial. First, as we demonstrated, it reshapes expectations regarding the division of labor between specialized and generalized systems, which in many cases may substantially reduce the expected role of specialized mechanisms in social-information processing. Second, if one considers the scarce and costly nature of scientific resources, it seems important to harness understanding gained from more established disciplines, such as domain-general cognition, and thereby avoid the danger of inadvertently reinventing the wheel of general cognition in a social guise. In summary, the general approach that we advocate and defend in this article represents a substantial change to the modal approach in social neuroscience and would therefore have consequences for basic theory development as well as clinical disorders whose symptoms are typified by impaired social-information processing.

Transparency

Action Editor: Aina Puce
Editor: Laura A. King
Declaration of Conflicting Interests
The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Note

1. Here we use the term *module* to refer only to functionally related brain regions. We do not use it to refer to additional features that were initially proposed by Jerry Fodor to define information-processing modules.

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