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# The Structure of Social Cognition: In(ter)dependence of Sociocognitive Processes

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## Keywords

social cognition, theory of mind, autism, imitation, empathy

## Abstract

Social cognition is a topic of enormous interest and much research, but we are far from having an agreed taxonomy or factor structure of relevant processes. The aim of this review is to outline briefly what is known about the structure of social cognition and to suggest how further progress can be made to delineate the in(ter)dependence of core sociocognitive processes. We focus in particular on several processes that have been discussed and tested together in typical and atypical (notably autism spectrum disorder) groups: imitation, biological motion, empathy, and theory of mind. We consider the domain specificity/generalizability of core processes in social learning, reward, and attention, and we highlight the potential relevance of dual-process theories that distinguish systems for fast/automatic and slow/effortful processing. We conclude with methodological and conceptual suggestions for future progress in uncovering the structure of social cognition.

## Contents

1. WHY IS ESTABLISHING THE IN(TER)DEPENDENCE OF SOCIOCOGNITIVE PROCESSES IMPORTANT? .....	244
2. AN OVERVIEW OF OUR APPROACH AND THE CURRENT STATE OF PLAY .....	246
2.1. Putative Components of Social Cognition .....	247
2.2. Types of Relationship Between Components of Social Cognition .....	247
2.3. Types of Evidence Currently Used to Establish Relationships .....	249
3. WHAT DO WE KNOW CURRENTLY ABOUT THE LANDSCAPE OF SOCIAL COGNITION? .....	249
3.1. Imitation, Empathy, and Theory of Mind: Synonymous, Developmental Cascade, or Distinct? .....	250
3.2. Self-Other Distinction and Control: A Common Factor? .....	251
3.3. Biological Motion and Imitation: Constituent Processes? .....	252
4. UNIQUELY “SOCIAL” PROCESSING? .....	254
4.1. Social Learning .....	254
4.2. Social Reward/Motivation .....	255
4.3. Social Attention .....	256
4.4. Dual-Process Theories and Social Cognition .....	257
5. HOW CAN WE MAKE FURTHER PROGRESS? .....	258
5.1. Available Methodologies .....	258
5.2. Recommendations for Further Progress .....	260

### 1. WHY IS ESTABLISHING THE IN(TER)DEPENDENCE OF SOCIOCOGNITIVE PROCESSES IMPORTANT?

Few would deny the functional importance of social interaction or the value of scientific study of the processes supporting it. The past few decades have seen a snowballing of interest in the cognitive and neural bases of social processing, much of it motivated by the desire to understand and ameliorate clinical conditions characterized by problems in social interaction. Despite this interest, little agreement exists as to the core sociocognitive processes or their interrelation or independence—we call this the structure of social cognition, which constitutes the focus of this review. We use the term cognition, as Morton & Frith (1995) do, to refer to the level of explanation lying between neural processes and behavior; cognition thus includes emotion. We define social cognition as the processing of stimuli relevant to understanding agents and their interactions.

In contrast to the study of intelligence or personality, little work has examined the factor structure of social cognition. Even limited sampling of recent papers shows how differently authors divide up social cognition. Reviewing work on social cognition in nonhuman animals, Seyfarth & Cheney (2015) propose that the core building blocks comprise individual recognition, knowledge of others’ relationships (e.g., dominance), and theory of mind (ToM; i.e., understanding of others’ mental states, mentalizing). A recent review of social cognition in schizophrenia (Green et al. 2015, p. 620) focused on “four general social cognitive processes—perception of social cues, experience sharing, mentalizing, and experiencing and regulating emotion.” In their comprehensive textbook, *Social Cognition: From Brains to Culture*, Fiske & Taylor (2013) identify 14 domains of social cognition, ranging from more basic concepts such as social attention, encoding of

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**Social cognition:** the processing of stimuli relevant to understanding agents and their interactions

**Theory of mind (ToM):** representing one’s own and others’ mental states (i.e., mentalizing)

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social stimuli, and social memory representations to higher-order social processes such as social decision making, social inference, attitudes, stereotyping, and prejudice. Happé & Frith (2014), reviewing the developmental neuroscience of atypical social cognition, sketched a hypothetical network including at least ten separable components (affiliation, agent identification, emotion processing, empathy, individuals' information store, mental state attribution, self-processing, social hierarchy mapping, social policing, and in-group/out-group categorization). The National Institute of Mental Health's research domain criteria (RDoC) initiative currently divides the domain of social processes (which includes both traditional social psychological processes such as attachment and sociocognitive processes such as animacy perception) into four constructs: affiliation and attachment, social communication, perception and understanding of self, and perception and understanding of others. Little consensus exists across authors as to which processes should be distinguished and which are interrelated. For example, RDoC combine emotions and intentions under the subconstruct of understanding mental states, whereas other authors have claimed these to be dissociable (e.g., Lewis & Todd 2005). RDoC also separate the understanding of self and others, whereas other authors have suggested that, for example, representing own and others' mental states requires common representational mechanisms (e.g., Carruthers 2009).

Does it matter how we divide the space of social cognition or whether we decipher its factor structure? It is helpful to note that these are two independent but complementary endeavors. The first relates to the development of a standard taxonomy and vocabulary of sociocognitive processes. At present, different authors use similar terms differently (e.g., empathy) and different labels for ostensibly similar or overlapping processes (e.g., motor empathy and imitation; cognitive empathy and ToM), leading to misunderstanding and confusion. Loose definitions and a failure to discriminate distinct processes will add to problems of nonreplication and cause difficulties in mapping cognitive to neural processes. Which term is used for a particular process and the dimensions one chooses to group sociocognitive processes are a matter of taste rather than empirical investigation; all that is required is for these terms (for precise and testable processes) to be standardized and applied consistently by researchers.

The second endeavor involves determining the relationship between different sociocognitive abilities; whether, for example, individual differences in emotion recognition predict individual differences in ToM. This question is empirically tractable and will allow sociocognitive ability to be described in terms of a smaller number of factor scores rather than a multitude of scores across different tests of social ability that may or may not measure distinct processes. Furthermore, the identification of latent factors that contribute to performance across a range of sociocognitive tests (as verbal ability contributes to a range of IQ subtests) is likely to aid in mapping sociocognitive processes to neural networks and in identifying the genetic contribution to individual differences. Identification of these factors will make it easier to test causal hypotheses that could be vital to developing, for example, interventions for social impairments, or to understanding the mechanism of putative treatments. Looking forward, having an agreed taxonomy of sociocognitive processes with an understanding of the structure of social cognition would be a starting point for developing a shared protocol of tasks, allowing assessment of specific profiles of ability across sociocognitive processes and across groups. Again, by analogy with intelligence testing, knowing an individual's peaks and troughs across subcomponents of social cognition would allow discrimination of phenocopies (e.g., attachment disorder versus autism), detailed measurement of change (e.g., decline in dementia), test of specificity of treatment effects, and cleaner mapping to neural or genetic bases of social ability.

In the following sections, we largely address the second endeavor, determining the structure of social cognition, since adding a further idiosyncratic taxonomy of sociocognitive abilities to those already in existence would be of little use to the field. This makes our task harder, however,

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**Empathy:** another's affective state mirrored in the self (with recognition that the other is the source of one's state, in some accounts)

**Imitation:** observation of an action causes the performance of a topographically similar action

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**Neurotypical:**

describes an individual who does not display ASD or other neurologically atypical patterns of thought or behavior

**Autism spectrum disorder (ASD):**

a neurodevelopmental disorder characterized by impaired communication and social interaction, and restricted and repetitive interests

**Biological motion:**

the motion profile of animate beings

**Domain specific:**

refers to psychological/neural mechanisms dedicated to the processing of specific content (e.g., social stimuli and information)

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because very little research has explicitly addressed this subject in large samples of neurotypical adults. As a result, we draw heavily on research addressing social processing in neurodevelopmental disorders, particularly autism spectrum disorder (ASD), the archetypal disorder of social cognition. Although this is a research area rich with relevant data, it should of course be acknowledged that the structure of social cognition in atypical populations may not reflect that in typical populations—due to compensation, for example—but we hope that this research may suggest fruitful methods of investigation in typical individuals (Section 5) as well as other clinical groups (e.g., individuals with acquired lesions). A second difficulty relates to the sheer scope of social cognition—the full range of processes that contribute to social ability has never been delineated, as far as we are aware, and if we were to attempt to list them all, we would likely have little space to do anything else. Therefore, the range of social abilities we discuss is limited and determined by the availability of evidence relating to their in(ter)dependence (much of which is from social neuroscience), the availability of existing reviews of the relevant literature, and our own fields of expertise. This necessarily means that we do not address a vast swath of literature on social ability, but several sections (detailed below) refer to general factors bearing on the structure of social cognition that are of relevance to many, if not all, areas of sociocognitive research.

## 2. AN OVERVIEW OF OUR APPROACH AND THE CURRENT STATE OF PLAY

In Section 2, we introduce the sociocognitive processes that form the focus of this review (Section 2.1), describe five ways in which sociocognitive processes may be related (Section 2.2), and discuss the types of evidence commonly used to establish the relationship between these processes (Section 2.3).

Section 3 takes four of the five ways in which social processes may be related and reviews literature in which this relationship has been empirically tested. Section 3.1 presents research addressing the relationships among imitation, ToM, and empathy in order to determine whether these three social abilities are unitary or distinct, or whether the development of one of these abilities is necessary for the development of the others. Section 3.2 assesses whether self-other distinction/control may be recruited by a number of sociocognitive processes, explaining correlated ability across seemingly distinct social abilities. Section 3.3 presents a possible example of one sociocognitive process constituting a necessary component of another: the abilities to perceive biological motion and to imitate the actions of others.

Section 4 addresses an issue bearing directly on the question of the factor structure of social cognition: the extent to which social ability relies on domain-specific, possibly modular/modularized (Karmiloff-Smith 1996), processes versus domain-general processes that are recruited for social and nonsocial processing alike. Although the domain specificity and factor structure questions are in principle distinct, if social ability were only to recruit general executive or perceptual processes, for example, one might expect much more overlap among social abilities than if distinct abilities relied on different domain-specific or dedicated modules/processes. Section 4 focuses specifically on the fifth way in which social abilities may be related: assessing whether factors affecting the speed and/or extent of social development are specifically social or whether they merely recruit general learning, attention, and reward mechanisms.

Section 5 addresses how we might make further progress in determining the structure of social cognition. Section 5.1 outlines the available methodologies to address the question and highlights their strengths and limitations. Section 5.2 makes general recommendations that could lead to future progress, focusing on conceptual rather than methodological issues.

## 2.1. Putative Components of Social Cognition

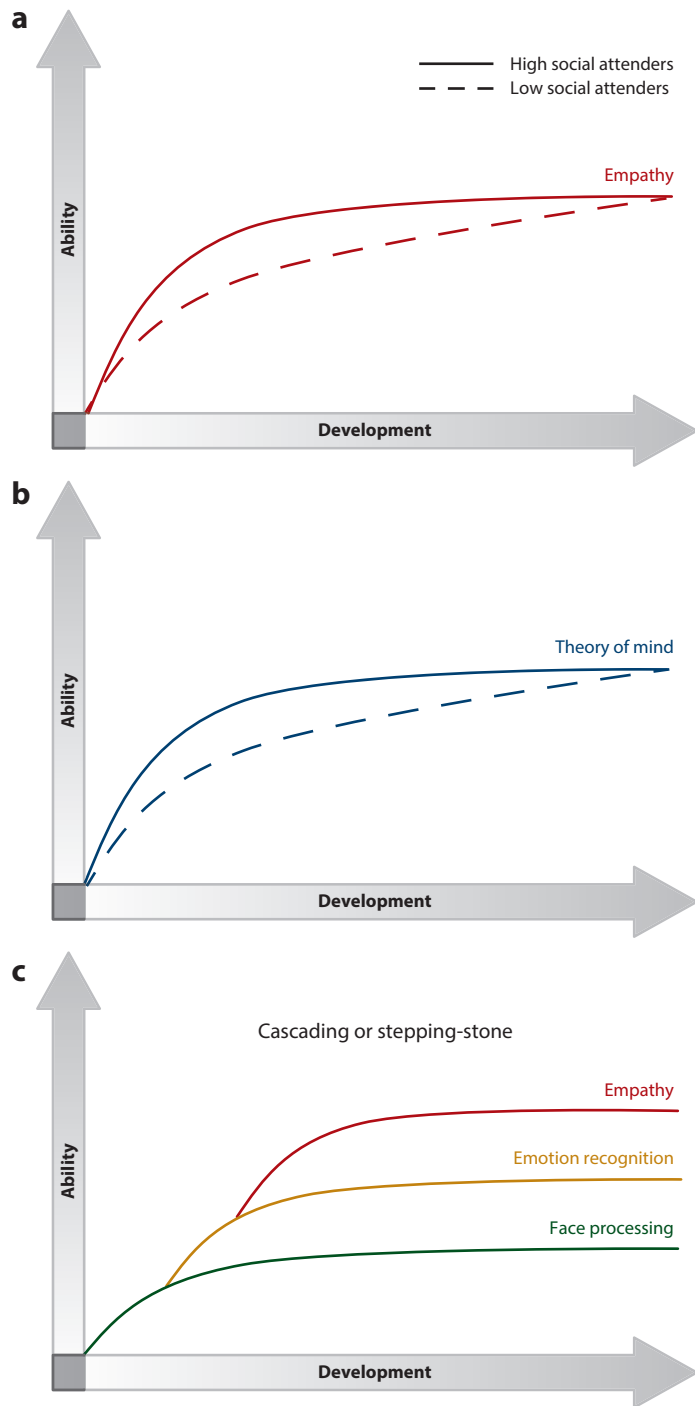
Potentially, any cognitive process may be called into the service of understanding social agents and social interactions. However, as previously described, this review discusses only a subset of social abilities to illustrate various ways in which different social abilities may be related. These abilities include those related to:

- (a) Affiliation and social motivation: factors influencing approach tendency and hence quantity of an individual's social interaction.
- (b) Agent recognition: allowing conspecifics to be individuated.
- (c) Biological motion perception, action recognition, and imitation: processes underlying the ability to determine which action is being performed by an agent and the reproduction of that action by the self.
- (d) Emotion recognition: the ability to determine the affective state of another.
- (e) Empathy: when recognition of another's affective state prompts the recognizer to adopt the same state (with the added requirement that one recognizes that the other is the source of one's state under some accounts).
- (f) Social attention: the degree of attention paid to social stimuli either due to a conscious choice (endogenous attention) or as a result of automatic capture of attention (exogenous attention).
- (g) Social learning: learning from other individuals.
- (h) Theory of mind: the ability to represent one's own mental states (i.e., propositional attitudes, e.g., beliefs) and those of others.

## 2.2. Types of Relationship Between Components of Social Cognition

Sociocognitive processes may be related in at least five ways.

- (a) They may actually be synonymous or alternative labels for the same core process. For example, although several authors claim that mirror neurons contribute to action understanding (Gallese & Sinigaglia 2011, Rizzolatti et al. 1996), others have suggested that action understanding is synonymous with either action perception (determining which action has been performed) or ToM (determining the intention driving the action) (Rizzolatti & Sinigaglia 2010).
- (b) One process may constitute a necessary (sub)component of another. For example, emotion contagion (in which the affective state of another is mirrored in the self) is thought to be a necessary component of empathy under frameworks in which empathy is said to have occurred when the empathizer recognizes that the other is the source of their current emotional state (de Vignemont & Singer 2006).
- (c) Processes may rely on at least one common process but also have distinct elements. For example, it has been argued that several sociocognitive processes rely on the ability to distinguish representations of the self and others (see Section 3.2). When empathizing with another, one must be able to distinguish between one's own emotional state and that of the other, and when inhibiting the tendency to imitate another, one must be able to distinguish between one's own motor plan and that of the other. Although both imitation inhibition and empathy may require self-other distinction processes, each is likely to recruit additional distinct processes.
- (d) Two sociocognitive processes may be developmentally associated, due to a direct causal link. This is sometimes referred to as cascading (**Figure 1c**), where, for example, imitation is proposed to be essential for development of ToM. Such cascades are often referred to in theories of atypical development; e.g., deficits in social motivation are hypothesized



to cause reduced attention to faces, in turn leading to failure of neuronal and cognitive specialization for face processing (Klin & Jones 2008).

- (e) Two processes may be developmentally associated due to a third factor of importance to both. For example, two processes that are learned through social interaction during development (for example, imitation and empathy) may develop at the same speed/level as a result of an individual's degree of social attention. An individual who is a good social learner may learn to imitate and empathize quickly and thoroughly (**Figure 1a,b**), whereas the opposite may be true of a poor social learner.

### 2.3. Types of Evidence Currently Used to Establish Relationships

Broadly speaking, researchers interested in the relationships between cognitive components of social processing currently refer to five types of evidence.

- (a) Single or double dissociation of abilities in developmental or acquired clinical groups: If process *X* is intact but process *Y* is impaired in one group, and process *X* impaired and process *Y* intact in another group, then it is concluded that process *X* is distinct from process *Y*.
- (b) Neuroimaging data demonstrating overlapping or distinct brain activity during different tasks/processes: Differential activation caused by two different social tasks follows the dissociation logic described above, but common activation of neurological networks by two social processes often prompts the conclusion that the social processes recruit common cognitive mechanisms.
- (c) Correlations (cross-sectional) between individual differences in two or more sociocognitive processes: Patterns of covariation across individuals have been used to support claims of common mechanisms between processes.
- (d) Longitudinal associations of individual differences: Covariation within individuals across development has been used to argue for developmental cascading, where the acquisition of one social ability leads to the acquisition of another.
- (e) Intervention effects: If interventions (psychological, pharmacological, etc.) can differentially affect social abilities, then they are seen as distinct.

## 3. WHAT DO WE KNOW CURRENTLY ABOUT THE LANDSCAPE OF SOCIAL COGNITION?

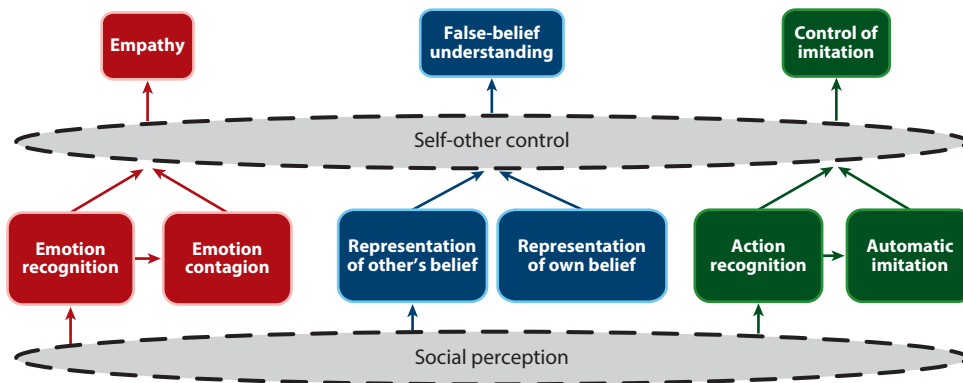
In this section, we turn to empirical evidence concerning the factor structure of social cognition. Research directly addressing this question is scarce, but we have sought to illustrate four of the

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### Figure 1

Some sociocognitive abilities are related because of a common factor that is important at some point in the development of each ability. For example, social attention may be important for the development of (a) empathy and (b) theory of mind; individuals who could be characterized as high social attenders would develop these abilities more quickly than would low social attenders, resulting in a correlation between the two abilities. One should note that if an ability has a critical period (not shown), then an early deficit in one ability (e.g., social attention) may result in a lifelong impact on another ability (e.g., empathy). Although these examples are hypothetical, they serve to illustrate the importance of accounting for development when assessing the factor structure of social cognition: In certain periods of development, abilities that require common processes (e.g., empathy and theory of mind) may be correlated, but this correlation may vanish at different developmental stages. (c) Some sociocognitive abilities may be related via a cascading or stepping-stone effect, whereby the development of one ability (e.g., face processing) acts as a stepping-stone for the further development of other abilities (e.g., emotion recognition and empathy).





**Figure 2**

Schematic illustration of two ways in which sociocognitive abilities may be related. In the first hypothesized relationship, some processes may constitute necessary subcomponents of others (e.g., emotion recognition is a necessary subcomponent of empathy). In the second relationship, seemingly distinct sociocognitive functions (e.g., empathy, false-belief understanding, control of imitation) may recruit common subcomponents (e.g., self-other control, social perception). Ovals illustrate common processes, and rectangles represent distinct processes relating to empathy (*red* route), false-belief understanding (*blue*), and control of imitation (*green*).

five ways in which social abilities may be related using examples from the literature. We address the fifth relationship in Section 4.

### 3.1. Imitation, Empathy, and Theory of Mind: Synonymous, Developmental Cascade, or Distinct?

Although research that attempts to determine the factor structure of social cognition is in its infancy, several sets of social abilities have been examined together, typically because they are associated with psychopathological conditions or because one ability is hypothesized to be either a stepping-stone or subcomponent (**Figure 2**) of the others. All of these motivations underlie research examining imitation, ToM, and empathy together; all three processes have been hypothesized to be impaired in ASD, and imitation has been proposed as a necessary building block for the development of ToM and empathy. Indeed, the concept of empathy has sometimes been extended to include imitation (motor empathy), ToM (cognitive empathy), and affective empathy, and it has been argued that empathizing ability is a primary trait governing individual (and gender) differences in social ability (Baron-Cohen 2009).

Recent evidence, however, does not support a link between these three processes. The idea that imitation leads to the development of ToM and empathy due to the operation of an innate module (Meltzoff & Moore 1977) is not supported by data showing that imitation relies on domain general learning rather than an innate module (Anisfeld 1979, R. Cook et al. 2014, Jones 2009, Ray & Heyes 2011). In addition, McEwen et al. (2007) found that some typically developing children who were reported at age 2 years to show no imitation nonetheless had social skills in the average range at age 8 years. Thus, imitation may not be a vital stepping-stone to later mental state attribution.

The hypothesized links among imitation, ToM, and empathy were bolstered by the discovery of mirror neurons, neurons that fire when actions are both executed and observed (di Pellegrino et al. 1992). These cells are thought to support imitation (Catmur et al. 2009, Heiser et al. 2003)



and were originally thought to code the goal of an action (Bonini & Ferrari 2011, Rizzolatti & Craighero 2004, Rizzolatti & Sinigaglia 2010); goal is a nonspecific term commonly construed as the intention behind an action, i.e., a mental state. By coding for own or others' intention, mirror neurons were proposed to provide a neural basis for ToM (Rizzolatti & Sinigaglia 2010).

However, more recent evidence calls into question the straightforward interpretation that mirror neurons code the goals of actions and therefore form a connection between own and others' intentions (for summaries, see R. Cook et al. 2014, Cook & Bird 2013). Perhaps most convincingly, a meta-analysis of neuroimaging studies of ToM that set out to determine the contribution of mirror neurons concluded, "The mirror system is not activated and does not aid the mentalizing system in detecting intentionality" (Van Overwalle & Baetens 2009, p. 579).

As mentioned above, one important motivation for hypothesizing the interdependence of imitation, empathy, and ToM has been the claim that all three social processes are affected in ASD. If ASD is characterized by impairments in all three areas, then a parsimonious explanation is that the three are developmentally linked or rely on a common underlying process (online or developmentally) (Colombi et al. 2009, Eckerman & Whitehead 1999, Hobson 1989, Rogers & Pennington 1991).

Again, recent evidence calls into question the claim that ASD is a condition characterized by deficits in imitation and empathy. Studies of automatic imitation (whereby observation of another's action prompts the tendency to produce an identical action) reveal that individuals with ASD have at least a typical, if not increased, tendency to copy simple hand and finger actions (Cook & Bird 2012, Sowden et al. 2016, Spengler et al. 2010) and emotional facial expressions (Press et al. 2010). Deficits in voluntary, nonautomatic imitation in ASD are likely due to nonspecific factors such as attentional control, working memory, and/or pragmatic language understanding (Leighton et al. 2008). In addition, available evidence either is unable to support mirror neuron deficits in ASD (Hamilton 2013) or suggests that abilities that are claimed to depend upon mirror neuron function (e.g., action understanding and prediction) are typical in ASD (Hamilton et al. 2007).

Further evidence from clinical groups also suggests that affective empathy and ToM are distinct and demonstrate a double dissociation. Although ASD does not seem to be directly linked to problems with affective empathy (Bird et al. 2010), most individuals with ASD show impaired ToM (Happé 1994, White et al. 2009). By contrast, individuals with high levels of psychopathic traits demonstrate intact ToM but impaired affective empathy (Jones et al. 2010, Lockwood et al. 2013, Schwenck et al. 2012). Furthermore, meta-analyses of neuroimaging of ToM and empathy in typical and atypical populations have identified reliable but nonoverlapping networks, including the medial prefrontal cortex, temporoparietal junction (TPJ), and precuneus for ToM (Frith & Frith 2010, Saxe et al. 2006) and anterior insula and anterior cingulate cortex for empathy (Singer & Lamm 2009).

### 3.2. Self-Other Distinction and Control: A Common Factor?

Although imitation, ToM, and empathy appear to be distinct processes, evidence suggests that false-belief attribution (a key test of ToM; tracking a character's mistaken belief), empathy, and the ability to inhibit imitation may call on a common process—that of self-other distinction and control (**Figure 2**). This proposal was originally made by Brass and colleagues (2005), who noted that imitation inhibition caused activation of a neural network commonly seen during ToM tasks. They suggested that this activation may reflect a common process, self-other distinction, that is necessary for both imitation inhibition and ToM. It was argued that in order to inhibit imitation, it is necessary to distinguish between one's own motor intention and that of another, and, at least in classic false-belief tests of ToM, one must be able to distinguish between one's own knowledge

states and those of another (inhibiting own true belief to predict behavior based on another's false belief). This explanation was tested in typical individuals and those with ASD (Spengler et al. 2010), who completed a test of imitation inhibition and verbal and nonverbal tests of ToM. Within the ASD group, performance on the imitation inhibition test predicted performance on the verbal ToM test and neural activation in the ToM network when completing the nonverbal ToM task. These measures were not associated in the group of typical adults, which in principle could reflect a meaningful difference between the ways in which typical individuals and those with ASD complete the tasks, but in this case it likely reflects the fact that the tests of ToM were less sensitive to individual differences in typical individuals due to ceiling effects.

The hypothesis of a common self-other distinction process recruited by multiple sociocognitive processes (see **Figure 2**) was tested using two intervention studies in which individuals were trained to inhibit imitation (theorized to increase their ability to distinguish and control representations of the self and others) before completing other sociocognitive tests to identify transfer effects. Santiesteban et al. (2012b) tested the impact of imitation inhibition training on a visual perspective-taking task. It was predicted that the visual perspective-taking task would recruit the same self-other distinction process as ToM and imitation inhibition; in order to represent another's perspective, it must be distinguished from one's own. This prediction was fulfilled—performance on the visual perspective-taking task was improved by imitation inhibition training but not by imitation training, nor by training on a standard Stroop inhibition task closely matched for difficulty. Using a study with a similar design, de Guzman et al. (2016) demonstrated an effect of imitation inhibition training on empathy for pain; the effect was thought to be due to the fact that in order to be empathic, one must be able to distinguish one's own nonpain state from the pained state of the other.

A number of studies using functional magnetic resonance imaging (fMRI) and/or transcranial magnetic stimulation have demonstrated an important role for the TPJ in self-other distinction (Brass et al. 2005; Hogeveen et al. 2015; Santiesteban et al. 2012a, 2015; Sowden & Catmur 2015). In line with these demonstrations, Santiesteban et al. (2012a) used transcranial direct current stimulation to excite the TPJ and showed a corresponding enhancement of the ability to take another individual's perspective. However, Santiesteban et al. (2012a) also showed, in the same individuals, that exciting the TPJ led to a reduction in imitation. Santiesteban et al. (2012a) therefore suggest that the common process may be self-other control rather than distinction, defined as the ability to switch attentional focus between coactivated self- and other-related representations. This ability would allow the selective enhancement of the self and inhibition of the other, or vice versa, according to task demands.

### 3.3. Biological Motion and Imitation: Constituent Processes?

As listed in Section 2.2, one of the possible ways in which two putative sociocognitive processes might be related is that one constitutes a subcomponent of or a necessary input to another. An example of such a potentially constitutive relationship is between biological motion processing and imitation; a strong argument can be made that one can only imitate another's action if one can accurately perceive the action. Traditionally, biological motion processing and imitation have been treated as distinct topics of inquiry; however, the fact that both abilities are thought to be impaired in individuals with autism has led to their investigation in some depth in this population.

Biological motion, which refers to the movements of other animate beings, has been studied using a variety of stimuli, from animations of moving people (e.g., Pelphrey et al. 2003) to single dots moving with a velocity profile that matches human movement (Dayan et al. 2007). Annaz and colleagues (2012) investigated attention to biological motion in young children with ASD and

found that whereas typical children preferentially attended to biological motion, children with ASD showed no such preference. Together with work from other labs (Dawson et al. 1998, Klin et al. 2009), this finding suggests that, unlike typical children, those with ASD do not demonstrate preferential attention to social stimuli. Given that individual differences in some aspects of biological motion processing have been correlated with sociocognitive abilities (Miller & Saygin 2013, Sevdalis & Keller 2011), it has been suggested that atypical attention to biological motion from an early age could be part of a developmental cascade resulting in atypical sociocognitive abilities in ASD (Dawson 1991, Klin et al. 2003).

Reduced attention to biological motion from an early age may be causally related to atypical development of biological motion processing. Annaz and colleagues (2010) demonstrated that between the ages of 5 and 12, typical children improve in their ability to determine human form from biological motion, whereas children with ASD do not (see also Blake et al. 2003), and data from Koldewyn and colleagues (2010) suggest that atypical biological motion processing in ASD extends into adolescence. Though the ability of autistic adults to process biological motion is a matter of debate (Koldewyn et al. 2010, Murphy et al. 2009, Saygin et al. 2010), Kaiser and colleagues (2010) demonstrated that, unlike typical adults, adults with ASD do not exhibit greater visual sensitivity for human motion relative to the motion of a vehicle. Likewise, using stimuli that require only local, not global, motion processing, Cook and colleagues (2009) demonstrated that adults with ASD were less sensitive to perturbations to biological motion compared to typical adults, but they were equally sensitive to perturbations to gravitational motion.

As discussed in Section 3.1, most studies have reported typical automatic imitation in ASD. However, there are some exceptions—and explicating the relationship between imitation and biological motion perception may shed light on these. J. Cook and colleagues (2014a) asked participants to perform horizontal arm movements while observing congruent (horizontal) or incongruent (vertical) arm movements conducted by a virtual reality agent with either human or robot form. For typical individuals, incongruent arm movements conducted by the human, but not the robot avatar, interfered with ongoing action control. In contrast, individuals with ASD were not affected by human or robot movements.

Imitation involves the activation of motor representations upon activation of a visual representation of action. Atypical imitation could therefore be the result of atypical visual biological motion processing. In line with this hypothesis, it is notable that paradigms demonstrating typical imitation in ASD tend to have employed stimuli that rely on apparent motion—stimuli in which still images of body positions are presented and the viewer infers the kinematics of movement (as in a flicker book or traditional cartoon). With such stimuli, the viewer's inferred kinematics are unconstrained and need not necessarily follow the kinematics of typical biological motion. However, some paradigms constrain participants' representation of movement kinematics by showing videos or using live stimuli. For example, the stimuli presented by J. Cook and colleagues (2014a) were animations displayed at a high refresh rate, meaning that the representation of the kinematics of the movement was driven by perceptual input and not inferred by participants. In other words, evidence from the biological motion literature suggests that individuals with ASD may represent the kinematics of movement atypically, and this may have a concomitant effect on imitation if perception of action kinematics is a crucial component of the imitation task.

This literature provides a good example of the importance of considering that some sociocognitive abilities may comprise a constituent component of other abilities. When imitation and biological motion processing are viewed in isolation, it is difficult to explain why imitation appears atypical in some, but not all, situations in autistic individuals. However, if one considers the extent to which an imitation paradigm constrains biological motion processing, then the ambiguity may be resolved.

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**Developmental cascade:** a sequential model in which the development (or absence) of one process is necessary for the development (or absence) of later processes

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## 4. UNIQUELY “SOCIAL” PROCESSING?

As discussed in Section 2, the extent to which social ability relies on domain-specific, possibly modular or modularized processes versus domain-general processes that are recruited for social and nonsocial processing alike has an impact on the question of the factor structure of social cognition. Although the domain specificity and factor structure questions are in principle distinct, if social ability were only to recruit general processes, then one might expect more overlap among social abilities than if distinct abilities relied on distinct domain-specific modules (for a review of this issue within the face-processing literature, see Duchaine & Yovel 2015).

If one accepts that social ability is, to a greater or lesser degree, learned from others over development, then factors affecting the speed and depth of such social learning (i.e., learning from conspecifics) are likely to affect social ability. Assuming that social ability is typically a product of learning from others and individual trial-and-error learning (e.g., learning to imitate may rely on observation of others and on individual learning based on trial-and-error to control one's own actions), then whether social learning is governed by socially specific or domain-general factors will impact the interdependence of social processes. If good individual learners are also good social learners because both types of learning are governed by domain-general factors, then these individuals will excel in all social abilities regardless of the degree to which a particular social ability relies on social, rather than individual, learning. In contrast, if factors affecting social learning are domain specific and distinct from those governing individual learning, then social abilities may dissociate from one another as a function of the degree to which they rely on social versus individual learning. We therefore provide an overview of research examining the domain specificity of social learning (Section 4.1), social reward (Section 4.2), and social attention (Section 4.3). Finally, we discuss the potential relevance of dual-process accounts to the question of domain specificity of sociocognitive processes (Section 4.4).

### 4.1. Social Learning

A domain-general view is that all learning, including social learning, is governed by the operation of a few general learning principles (e.g., associative and instrumental learning; Heyes & Pearce 2015). Heyes (2012a) presents a summary of the evidence supporting a domain-general view of social learning. Perhaps most important is the finding that social learning covaries with nonsocial learning: In male zebra finches, song complexity (social learning) is correlated with the rate of learning in an extractive foraging task (nonsocial learning) (Boogert et al. 2008). Such correlations are seen not just within species, but also across species, such that species that tend to be good social learners are also good nonsocial learners (Lefebvre & Giraldeau 1996, Reader et al. 2011, Reader & Laland 2002). This correlation between social and nonsocial learning is consistent with the view that there is just one set of domain-general learning principles. Heyes (2012a) also notes that if social learning were an adaptation for social living, it would not be present in solitary species; however, at least two solitary species [the common octopus (Fiorito & Scotto 1992) and the red-footed tortoise (Wilkinson et al. 2010)] are capable of social learning.

By contrast, theoreticians in the domain-specific camp have argued that living in social groups has specifically favored the evolution of social learning: Social learning is an adaptation for social living (Klopfer 1961, Templeton et al. 1999). Neuroimaging studies have demonstrated that social learning and nonsocial learning are associated with activity in dissociable neural networks, thus raising the possibility of distinct and specialized mechanisms. For example, Behrens and colleagues (2008) used fMRI to demonstrate that learning from individual experiences about reward outcomes was associated with activity in a network of brain regions including the ventral striatum and anterior cingulate sulcus, whereas social learning—from an adviser—was associated with activity

in a distinct network of brain regions including the TPJ and anterior cingulate gyrus. Further evidence for dissociable mechanisms underlying social learning and nonsocial learning comes from a recent study by J. Cook et al. (2014b) that demonstrated that social and nonsocial learning dissociate with respect to their relationship with social dominance. Whereas social dominance predicted social learning ability, it was not related to ability to learn via nonsocial means. This result is consistent with the domain-specific view that dissociable mechanisms underpin social and nonsocial learning.

With many questions yet to be addressed, the debate concerning the domain specificity of social learning continues. For example, with respect to the neural correlates of social and nonsocial learning, Behrens and colleagues (2009) have argued that although the neural correlates may be dissociable in terms of their spatial location, it may still be the case that the same computational learning mechanisms are employed for both social and nonsocial learning. This issue has been examined using computational modeling approaches in which formal mathematical models of learning are used to model the learning behavior of real individuals. These studies have shown that models developed to explain nonsocial learning can explain social learning (Diaconescu et al. 2014), although in some cases they may need to be modified to adequately explain social behavior (Boorman et al. 2013).

## 4.2. Social Reward/Motivation

Learning efficiency is affected by reward, and here we review evidence concerning the domain specificity of social reward and the idea of specific social motivation. A number of theories have argued for domain specificity in this area; in particular, several theories suggest that ASD is characterized by a specific deficit in social motivation. The social motivation theory of autism (Chevallier et al. 2012, Dawson 2008) postulates that the starting point for the sociocognitive differences in ASD is that social stimuli and activities are intrinsically less motivating for infants with ASD. For example, Van Etten & Carver (2015) have suggested that reduced social motivation explains reported imitation deficits in ASD (but see Section 3.1). Such a theory implies that reward systems have a modular organization, in which social motivation can be selectively impaired while the processing of other motivational factors (e.g., food or monetary rewards) is spared. Whether a separable social reward system exists, however, is still a matter of debate.

Social reward and motivation are subserved by a network of brain regions including the amygdala, the ventral striatum, and orbital and ventromedial regions of the prefrontal cortex (Chevallier et al. 2012). A long-standing debate in the reward-processing literature concerns whether primary rewards (i.e., rewards essential for the maintenance of homeostasis and reproduction; e.g., food, sex, and shelter) and secondary rewards (i.e., rewards not directly related to survival; e.g., money and power) are processed in common or distinct brain structures (Schultz 2000). Some investigators have speculated that primary and secondary rewards may be represented in phylogenetically distinct brain regions (Knutson & Bossaerts 2007), but the majority of researchers within the decision neuroscience and neuroeconomics fields have argued that both primary and secondary rewards are compared on a common scale in which the unit of comparison is decision value (for a review, see Peters & Büchel 2010). This debate can be extended to encompass social reward: Does one common reward-processing network exist, or is it feasible that social reward processing is subserved by at least partly dissociable neural mechanisms? Sescousse and colleagues (2013) reviewed the human neuroimaging literature concerning the processing of monetary, food, and erotic rewards. They demonstrated that a core set of brain regions, including the striatum, anterior insula/frontal operculum, mediodorsal thalamus, amygdala, and ventromedial prefrontal cortex, is associated with reward processing in an indiscriminate fashion, consistent with the idea of a

common reward circuit. In addition, comparative analyses between rewards revealed that some regions are more specifically recruited by one type of reward compared to the others; for example, the bilateral amygdala, the ventral anterior insula, and the extrastriate body area are more robustly activated by erotic than by monetary and food rewards. At face value this result suggests that although all types of rewards recruit core reward-processing mechanisms, different types of rewards may be discriminated on the basis of neural mechanisms outside of the common reward circuit. This result makes it feasible that social reward processing could be subserved by neural mechanisms at least partly dissociable from those related to other rewards. However, it should be noted that it is unclear whether the partially dissociable networks identified by Sescousse et al. (2013) are specifically related to reward processing; for example, the extrastriate body area activation observed in relation to processing of erotic rewards may simply reflect the fact that these stimuli, but not money or food stimuli, contained images of bodies. In other words, differences in neural activation may simply reflect different types of input to a common reward system.

### 4.3. Social Attention

Objects with social importance are prioritized by attention; social stimuli automatically (exogenously) capture attention rather than requiring deliberate (endogenous) attentional control. Numerous studies demonstrate that infants preferentially attend to face-like stimuli rather than to scrambled or inverted faces (Goren et al. 1975, Morton & Johnson 1991). This preference is maintained throughout the lifetime, such that in human adults attention is rapidly captured by human faces and bodies (Fletcher-Watson et al. 2008, Shah et al. 2013), masked faces are detected more quickly and accurately than are masked objects (Purcell & Stewart 1988), and changes to faces are detected better than are changes to nonface objects (Kikuchi et al. 2009, Salva et al. 2011).

It has been proposed that a subcortical face-detection system, present at birth, underlies this preferential orientation toward faces (Johnson 2005). However, critics have argued that humans are simply biased to attend to top-heavy, as opposed to bottom-heavy, stimuli and that faces fall into this top-heavy stimulus category (Simion et al. 2002). More recent research controlled for top-heavy stimuli and still found a significant bias for attending to face-like stimuli in adult participants (Shah et al. 2013, Tomalski et al. 2009). Humans appear to have a specific, and perhaps innate, bias to attend to stimuli that possess the same orientation and polarity as real-life faces.

Deliberate (or endogenous) attention to social stimuli has been much discussed in theories of ASD (Chawarska et al. 2016). Several developmental accounts (e.g., Chevallier et al. 2012; Dawson 1991; Klin et al. 2003, 2015) trace a pathway from a specific reduction in orientating to social stimuli (due to reduced social motivation or problems of attentional disengagement, for example), through reduced exposure to relevant learning opportunities, to poor social cognition (e.g., ToM). Such theoretical accounts underpin a number of prominent intervention approaches for young children with ASD; these interventions focus on increasing attention to social stimuli and establishing joint attention.

Perhaps the most pertinent evidence regarding these cascade theories comes from studies of infants at high genetic risk of autism (those born into families with a child with ASD); to date, results show little in the everyday social behavior of infants under 12 months of age that discriminates those children who will later receive an ASD diagnosis, and in the lab, attention abnormalities (evident from approximately age 6 months) do not appear to be strongly domain specific (Elsabbagh & Johnson 2016). Claims of sustained abnormalities in attention to social stimuli (e.g., reduced looking at other's eyes, more looking at mouths) in ASD (Klin et al. 2002) did not receive support in a recent review of eye-tracking studies in ASD (Guillon et al. 2014), and at least one study suggests that attention to faces in general and the ratio of eye to mouth fixations



may be differentially affected by ASD and alexithymia (the inability to identify and describe one's own emotional state), respectively (Bird et al. 2011). Interestingly, domain-general properties of ostensibly social stimuli (such as point-light displays of biological motion) may determine whether children with ASD pay preferential attention or not; a greater preference for exact predictability or contingency at key stages of development may distinguish children with ASD from typically developing children (Klin et al. 2009).

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**Alexithymia:** the inability to identify and describe one's own emotional state

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#### 4.4. Dual-Process Theories and Social Cognition

A broader issue within the domain-specific versus domain-general debate concerns the issue of whether two types of social cognition exist. These types are consistent with classic dual-process theories, which posit two systems: one is cognitively efficient, fast, and automatic [system 1 in Kahneman and colleagues' terminology (Kahneman & Frederick 2002, Stanovich 1999)]; the other is cognitively demanding, slow, controlled, and of limited capacity (system 2). Many instantiations of dual-process theory suggest that system 1 is domain specific and system 2 is domain general (Evans 2008).

This issue has been discussed extensively within the ToM literature (e.g., Apperly & Butterfill 2009, Butterfill & Apperly 2013). The suggestion of two systems for ToM was prompted by the observation that although typical children below the age of 4 years on average do not pass verbal, explicit tests of ToM (as measured by classic false-belief tests), 18-month-old infants pass implicit false-belief paradigms based on eye gaze behavior (Onishi & Baillargeon 2005). A dual-system view of ToM was supported by the finding that individuals with ASD who were able to pass explicit tests of false-belief understanding did not show eye gaze behavior consistent with false-belief understanding on implicit tasks (Senju et al. 2009).

Several authors have claimed to demonstrate automatic, cognitively efficient ToM in typical adults (where it is often labeled implicit mentalizing). For example Samson et al. (2010) introduced the dot perspective task, in which participants are presented with an image of a blue room with red dots on the walls. An avatar faces toward one of the walls, and participants are asked to count the number of dots they can see and to ignore the avatar. Despite this instruction, participants respond faster when the avatar can see the same number of dots that they can see. This consistency effect has been interpreted as evidence for automatic mentalizing: The avatar's visual perspective (i.e., knowledge state) is automatically processed in addition to the participant's own.

The problem with tests of implicit ToM, however, is that it is difficult to establish that the observed effects are a consequence of the automatic representation of mental states (Heyes 2014a,b). For example, Santiesteban and colleagues (Catmur et al. 2016, Santiesteban et al. 2014) demonstrated that the consistency effect could be observed in the dot perspective task when the avatar was replaced with an arrow, a stimulus clearly not appropriate for the attribution of mental states. They argued that the effect observed in the avatar condition was a result of domain-general processes such as attentional orienting, where the avatar's gaze acted as a directional cue, rather than the attribution of mental states to the avatar. A similar debate occurred following the publication of another paper claiming that adults automatically represent an avatar's false belief (Kovács et al. 2010). In a replication and extension of this study, Phillips et al. (2015) demonstrated that the effect was due to an experimental confound.

While the debate surrounding the existence of implicit mentalizing continues, the general principle of separating sociocognitive processes into system 1 and system 2 promises to bear fruit. Perhaps all core social abilities could be accomplished via two routes, one being an automatic, cognitively efficient process that relies in part on heuristics and learned associations, and the other a deliberative reasoning process. If each aspect of social processing can be accomplished via either



route, then the relationship between different social abilities may depend on whether the automatic or deliberative route is used to accomplish a particular social goal (and hence, what type of task provides the relevant evidence on interrelations). Presumably, any time the rational, deliberative system 2 route is used, performance will be affected, in part, by individual differences in general processes such as working memory, executive function, and intelligence, and correlations will be observed between different social abilities. As discussed previously, if system 1 processes are learned over development, then factors that determine learning speed (such as social attention, social reward, and social learning ability) will produce associations in the speed of acquisition or extent of learning in each of these processes. By contrast, if system 1 processes rely on dedicated domain-specific modules, then dissociations between different system 1 social abilities are more likely to be seen.

## 5. HOW CAN WE MAKE FURTHER PROGRESS?

### 5.1. Available Methodologies

We began our review of the structure of social cognition by contrasting it with the structure of intelligence. Although many in that field would argue that much is still to be determined about the structure of intelligence, the general methodological approach has been successful. Typically, large numbers of participants complete various tests designed to measure some aspect of intelligence, and the relationships among tests are examined with statistical techniques such as factor analysis. The result is the identification of factors that explain performance on those tests. Such an approach would be of obvious benefit when it comes to determining the structure of social cognition. For example, in Section 3.2, we hypothesized that a common ability to distinguish between and select representations of the self and others may be recruited by empathy, ToM, and imitation inhibition. One would therefore expect that a factor analysis of tests assessing these abilities would identify a common factor corresponding to this self-other ability. Such techniques could examine the (in)dependence of a large number of tests of social ability and determine whether evidence exists for factors underlying performance on multiple tests of the sort hypothesized in Section 4, such as social learning ability, social attention, and social motivation.

Such a study, although useful, would not be able to uncover all relationships between different social abilities. One such relationship is where process  $X$  is necessary, at a certain developmental stage, in order to develop process  $Y$  (the cascading or stepping-stone model) (**Figure 1c**). Such a potential relationship could have been uncovered by the study described in Section 3.1 (McEwan et al. 2007), in which imitation was measured at 2 years of age and social ability was measured in the same individuals at 8 years of age. If all of those who could not imitate at 2 years were socially impaired at 8 years, then one might conclude that the ability to imitate at 2 is necessary to develop appropriate social ability in later childhood. Of course, we could not make that claim solely on the basis of data from such a cross-lagged design—there may be another factor, process  $Z$ , that actually determines social ability in later childhood and that also happens to covary with imitation at 2 years of age. Regardless of the inability of cross-lagged designs to demonstrate definitively a causal influence of one process on another, the fact remains that if imitation at 2 years is necessary for appropriate development of other social abilities, then collecting and factor analyzing data from a large group of adults on multiple tests of social ability are unlikely to uncover this developmental relationship because most adults can successfully imitate, leaving little variance in this ability to predict other social abilities.

This issue is an example of a more general problem associated with developmental influences of one process on another. Consider the case of empathy and the recognition of one's own emotions.

In some developmental accounts, the ability to recognize one's own emotion is necessary for the development of empathy. These accounts suggest that infants learn to associate the experience of a state, whether pain, sickness, or joy, with the expression of that state in another. For example, the infant falls and is hurt, and caregivers mimic a pained facial expression and vocalize pain. Over repeated painful experiences, learning will result in a link between the feeling of pain in the self and its expression in another. Several theories suggest that this learning is sufficient for empathy (at least for emotion contagion; e.g., Bird & Viding 2014, Heyes & Bird 2007). After these links have been learned, recognition of one's own emotion may play no further role in the expression of empathy. Under this model, individual differences in empathy and own-emotion recognition will no longer be correlated, meaning the factor analysis strategy using adult data will erroneously conclude that they are unrelated. Although potentially true in adulthood, such a conclusion would not capture the necessary role of recognition of one's own emotion in the development of empathy.

In order to postulate a causal connection between two processes such that one can claim that ability in one sociocognitive domain determines ability in another or that two abilities share common components, one must randomly assign individuals to groups, experimentally increase or decrease social ability in one group, and compare this group following the intervention with another that received a control nonsocial intervention. Such studies are not easy to design, however; one must be extremely careful in ensuring that the control intervention is matched in every way with the social intervention. Although difficult to achieve in practice, such designs are very powerful in determining causality. They are not a panacea, however, and several factors may limit their use. First, if used in adulthood, they are insensitive to the kind of developmental relationships described previously (e.g., imitation at 2 years of age relating to ToM in later childhood). Second, unless several such experiments are performed or extremely subtle (or numerous) control conditions are used, it is hard to determine the process whereby the training is having an effect because it is unclear exactly what is being trained.

Neuroimaging methods, particularly fMRI, have often been used to answer questions about the relationships among different sociocognitive processes. For example, Quirin and colleagues (2013) demonstrated that brain areas coding for dominance relationships did not overlap with those coding for affiliative relationships. Such evidence of dissociation is powerful if a number of design issues are addressed; given tasks equated for sensitivity and difficulty, reliable dissociations are likely to signal processes that are at least partially distinct. Of course, dissociations cannot be claimed on the basis of one study (a lack of evidence that empathy activates TPJ in one study is not the same as evidence that empathy does not activate TPJ) but rather can be made on the basis of multiple studies with appropriate Bayesian statistics.

Studies demonstrating associations between different sociocognitive processes on the basis of shared activation are on shakier ground, however. Such studies find that one process activates a network including region A, and another process activates a more or less distinct network that also includes region A. The problem with this logic is that the unit of analysis common in fMRI studies may contain 7 to 9 million neurons. It is therefore perfectly possible that two processes activate distinct sets of neurons that cannot be distinguished with the existing spatial resolution of fMRI. More promising is a technique known as repetition suppression or fMRI adaptation, which takes advantage of the fact that repetition of a particular stimulus or stimulus class causes a reduction in the signal measured with fMRI. For example, in order to identify which brain areas encode facial identity, one can compare the neural activation elicited by a particular face when it is preceded by the same face to the neural activation elicited when it is preceded by a different face. If an area shows reduced activation to the repetition of the particular face, then it is concluded that the area codes for face identity rather than the mere presence of a face. The cellular mechanisms underlying such reduced activation are unclear (Grill-Spector et al. 2006), but

the presence of repetition suppression is thought to reflect the activation of the same population of neurons. At present, this technique has been little used to examine the relationships among different sociocognitive processes, but if the assumption that suppression reflects activation of common neurons holds, it could prove a very powerful technique.

A further class of techniques seeks to find a differential impact of modulators—whether these be drugs, organic or experimental neurological lesions, personality types, or neurodevelopmental disorders—with the aim of demonstrating single or double dissociations. The logic of this approach is simple: If one factor can be shown to modulate sociocognitive process A without affecting sociocognitive process B, and another factor can be shown to modulate process B without affecting A, then we assume A and B are independent. We have already referred to the fact that ASD and psychopathy provide strong evidence for the independence of ToM and empathy; individuals with ASD appear to be impaired at ToM but not empathy, whereas individuals with psychopathy are impaired at empathy but not ToM (Jones et al. 2010). Such dissociations may also be observed with acquired brain lesions: One patient may experience a loss of premorbid ability in a particular social domain whereas another domain is unimpaired, but another patient may have the opposite pattern of deficits. For example, Calder (1996) reported the case of patient D.R., who had a specific impairment in recognizing fear but was able to recognize facial identity, and Tranel et al. (1995) reported a series of patients with acquired prosopagnosia, a deficit in recognizing facial identity, who were still able to recognize emotional facial expressions, including fear.

Although such examples are powerful, their effectiveness rests on the tests of social ability being very finely matched. If one test is speeded and another is not, if one requires holistic processing and another is featural, or if one makes demands on memory and another does not, then dissociations may reflect the differential demands of the tests rather than of the social abilities being tested. Furthermore, dissociations observed in patients with psychiatric or neurodevelopmental conditions or acquired brain lesions may reflect patterns of compensation (over development or in response to brain injury) within an atypical cognitive system. For example, Brewer et al. (2015) demonstrated that emotion recognition and moral reasoning are associated in typical individuals, an association thought to reflect the fact that moral judgments involve a combination of emotional processes, such as empathy, and the application of socially agreed-upon rules arrived at through deductive reasoning (Greene et al. 2001, 2004). In individuals with ASD, however, emotion recognition and moral reasoning are uncoupled, with the hypothesis being that those with ASD rely less on emotional heuristics in decision-making tasks (di Martino et al. 2008).

## 5.2. Recommendations for Further Progress

As we reviewed the little available literature on the structure of social cognition, it became clear that several factors may be inhibiting progress in this area. First, the vocabulary of sociocognitive ability is highly variable and nonspecific. Happé & Frith (2014) surveyed a multitude of social abilities that still represent only a fraction of the myriad hypothesized social abilities in the literature. The problem is that the relationship between the terms used for different sociocognitive abilities is often not specified, leading to the use of numerous terms that may or may not refer to the same construct. For example, affective ToM, emotion contagion, empathy, emotional mirroring, emotion understanding, and emotional resonance all appear to refer to remarkably similar, or even the same, processes. Therefore, it is difficult to integrate all of these terms into a factor structure of social cognition because they may be synonyms for a single ability. Adopting an agreed-upon lexicon for aspects of social abilities would likely accelerate research in this area and increase the comprehensiveness and utility of meta-analyses relating to these abilities. Such a lexicon is also likely to improve the consistency with which the results of certain tests are interpreted. For

example, the Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al. 2001) involves participants being presented with images of the eye region of faces and asked to pick (from four choices) the mental state or emotional term that best describes the image. This task has been claimed to index ToM, empathy, and emotion recognition, but a clear decomposition of task demands, or evidence of differential relationships to performance on other assays of these processes, is lacking. Adopting an agreed-upon lexicon would allow researchers to decide whether ToM, empathy, and emotion recognition are distinct entities and then to determine which is tested by the RMET and other commonly used tasks.

A second, potentially important, distinction to be made when determining the structure of social cognition is between the ability to carry out a social computation and the propensity to do so. The paradigmatic case for this distinction is ToM in ASD. When tested on explicit ToM tasks in a laboratory setting, intellectually able adults with ASD often perform at the same level as typical adults. In everyday life, however, individuals with ASD usually exhibit problems interacting with others, difficulties with pragmatic language understanding, and other impairments thought to result from impaired ToM. Assuming laboratory-based tests are sensitive enough to detect a ToM impairment should it exist, then a potential explanation for this discrepancy is that these adults with ASD are able to use ToM but have a reduced propensity to do so (see also Cage et al. 2013).

The distinction between ability and propensity may interact with our third recommendation, that a distinction should be drawn between system 1 and system 2 social processes. If there really are two routes by which a particular social task can be accomplished, then care should be taken to determine how participants are addressing the task: Are they using a fast, automatic, heuristic-based process, or are they instead using a slow, deliberative, rational approach? It may well be that the ability and propensity distinction interacts with the system 1 and system 2 distinction such that differences in propensity reflect the degree to which system 1 processes are automatically engaged during social interaction, whereas ability reflects the degree to which rational deliberative social reasoning (system 2) can produce accurate results.

Finally, there is growing evidence of significant cultural learning in the development of various social abilities (Heyes 2012b, Heyes & Frith 2014). Exposure to literature (Kidd & Castano 2013) and playing video games with a narrative story line (Bormann & Greitemeyer 2015) cause better performance on the RMET, and reading fiction increases self-reported empathy (Bal & Veltkamp 2013). Also, the degree to which mothers use mental state language predicts the development of mental state and emotion understanding in infants from 15 to 33 months of age (Taumoepeau & Ruffman 2006, 2008). The implication of this research is that tests need to be sensitive to participants' cultural background and developmental history. Although this fact has long been acknowledged within social perception research, where there is significant evidence of impaired facial identity recognition with other-race face stimuli, for example (Barkowitz & Brigham 1982, Chance et al. 1975, Chiroro & Valentine 1995, Elliott et al. 2013), it is less often appreciated in other areas of sociocognitive research. For example, although my ToM system may function perfectly in that it enables me to represent the propositional attitudes of others and how attitudes determine their behavior, if my developmental environment consists of a restricted range of individuals (with respect to political or religious affiliation, social class, education level, etc.), then I may frequently fail to infer accurately the mental states of others when in more mixed environments. Happé & Frith (1996), for example, suggested that conduct-disordered children from adverse family backgrounds might have developed a "theory of nasty minds." In everyday life, then, social abilities such as ToM, emotion recognition, and empathy may be determined by the range of minds one has encountered previously and is therefore able to model, as well as the accuracy with which one can determine which model to apply to a particular individual.

## FUTURE ISSUES

1. An agreed-upon lexicon for sociocognitive processes would accelerate research.
2. New methodologies are necessary to uncover the factor structure of social cognition (e.g., large-scale normative factor analysis, randomized modulator/intervention designs, fMRI adaptation).
3. Conceptual and empirical distinctions are needed [e.g., ability versus propensity for specific social processes, dual systems (i.e., fast and automatic versus slow and effortful) for social cognition].

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Proposes two systems for belief tracking: one efficient but inflexible, the other flexible but cognitively demanding.

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Adopting a developmental framework, this article delineates a mechanistic (neuro)cognitive model of empathy.

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Early paper showing reduced orienting to attention-grabbing stimuli (particularly social stimuli) in children with autism.

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Uses dissociable deficits revealed by developmental disorders to outline a putative network of sociocognitive abilities.

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Argues that social learning relies on the mechanisms that support individual/asocial learning.

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Argues that social learning relies on the mechanisms that support individual/asocial learning.

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Argues that domain-general cognitive mechanisms (e.g., attentional orienting) can provide an efficient alternative to mentalizing.

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Argues that the modular organization of the mind develops from the process of modularization.

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# Contents

Eavesdropping on Memory <i>Elizabeth F. Loftus</i> .....	1
Memory: Organization and Control <i>Howard Eichenbaum</i> .....	19
Neural Mechanisms of Selective Visual Attention <i>Tirin Moore and Marc Zirnsak</i> .....	47
Learning, Reward, and Decision Making <i>John P. O'Doherty, Jeffrey Cockburn, and Wolfgang M. Pauli</i> .....	73
Reinforcement Learning and Episodic Memory in Humans and Animals: An Integrative Framework <i>Samuel J. Gershman and Nathaniel D. Daw</i> .....	101
Social Learning and Culture in Child and Chimpanzee <i>Andrew Whiten</i> .....	129
Survival of the Friendliest: <i>Homo sapiens</i> Evolved via Selection for Prosociality <i>Brian Hare</i> .....	155
Numerical Development <i>Robert S. Siegler and David W. Braithwaite</i> .....	187
Gene × Environment Interactions: From Molecular Mechanisms to Behavior <i>Thorhildur Halldorsdottir and Elisabeth B. Binder</i> .....	215
The Structure of Social Cognition: In(ter)dependence of Sociocognitive Processes <i>Francesca Happé, Jennifer L. Cook, and Geoffrey Bird</i> .....	243
Toward a Social Psychophysics of Face Communication <i>Rachael E. Jack and Philippe G. Schyns</i> .....	269
Social Motivation: Costs and Benefits of Selfishness and Otherishness <i>Jennifer Crocker, Amy Canevello, and Ashley A. Brown</i> .....	299
Attitude Strength <i>Lauren C. Howe and Jon A. Krosnick</i> .....	327
How Power Affects People: Activating, Wanting, and Goal Seeking <i>Ana Guinote</i> .....	353

The Psychology of Close Relationships: Fourteen Core Principles <i>Eli J. Finkel, Jeffrey A. Simpson, and Paul W. Eastwick</i> .....	383
Moving Beyond Correlations in Assessing the Consequences of Poverty <i>Greg J. Duncan, Katherine Magnuson, and Elizabeth Votruba-Drzal</i> .....	413
Culture Three Ways: Culture and Subcultures Within Countries <i>Daphna Oyserman</i> .....	435
Learning from Errors <i>Janet Metcalfe</i> .....	465
Mindfulness Interventions <i>J. David Creswell</i> .....	491
Hidden Wounds? Inflammatory Links Between Childhood Trauma and Psychopathology <i>Andrea Danese and Jessie R. Baldwin</i> .....	517
Adjusting to Chronic Health Conditions <i>Vicki S. Helgeson and Melissa Zajdel</i> .....	545
Health Behavior Change: Moving from Observation to Intervention <i>Paschal Sheeran, William M.P. Klein, and Alexander J. Rothman</i> .....	573
Experiments with More than One Random Factor: Designs, Analytic Models, and Statistical Power <i>Charles M. Judd, Jacob Westfall, and David A. Kenny</i> .....	601
Interactions with Robots: The Truths We Reveal About Ourselves <i>Elizabeth Broadbent</i> .....	627

## Indexes

Cumulative Index of Contributing Authors, Volumes 58–68 .....	653
Cumulative Index of Article Titles, Volumes 58–68 .....	658

## Errata

An online log of corrections to *Annual Review of Psychology* articles may be found at <http://www.annualreviews.org/errata/psych>