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The Tree of Social Cognition: Hierarchically Organized Capacities of Mentalizing

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Abstract. Humans have a large number of capacities that allow them to make sense of other agents' minds. I discuss these mentalizing capacities under the broader label *social cognition* and propose that social cognition is hierarchically organized, ranging from lower-order capacities (e.g., detecting agents and their goals) to higher-order capacities (e.g., self-awareness and mental state ascriptions). Capacities at the lower order develop earlier in life, evolved earlier in human history, and are processed faster. In total, I introduce 15 social-cognitive capacities, present evidence for their developmental, evolutionary, and processing order, and discuss several hierarchical relations among them. Moreover, I explore the hypothesis that full-blown mental state ascriptions (near the top of the developmental and evolutionary order) have likely seen an increase in use and significance after humans settled down about 12,000 years ago. I close with a few of the many questions left to be answered about human social cognition.

Mental state inference, theory of mind, mentalizing, … all these terms denote the capacity to represent something beyond, behind, or simply different from physical objects, moving bodies, and expressive faces. Scholars of philosophy have for thousands of years pondered how "mind" works; psychology brought scientific methods to such investigations. A few scholars in the 20th century then discovered that not only they themselves but ordinary humans, too, wonder about the mind; and it became clear that such mind wondering underlies and enables social interaction, culture, and morality, as much as politics, religion, and technology.

The emerging picture is that, in response to intense demands of social group living, human beings have evolved a number of capacities that allow them to make sense of other agents—to interpret, explain, and predict their behavior, share their experiences, and coordinate interactions with them (e.g., Bloom, 2007; Dunbar & Shultz, 2007; Tomasello, 1998). These enabling capacities include simpler processes such as face detection or mimicry; complex processes such as imaginative simulation and mental state inference; and fundamental concepts such as *intentionality* and *belief*. The diversity of these capacities (Malle, 2008; Mitchell, 2006) and their different ways and degrees of representing mental states (Apperly & Butterfill, 2009; Poulin-Dubois, Brooker, & Chow, 2009; Sterck & Begeer, 2010) require a more inclusive term than *theory of mind* or *mentalizing*. I suggest that these capacities are best subsumed under the broader label *social cognition.* These social-cognitive capacities belong together, not because they form a "module" or can somehow be localized in a particular brain area; rather, what unites them is their responsiveness to other intentional agents and the benefits they convey when interacting with those agents. My investigation of mentalizing is thus contextualized within a broad framework of social cognition, which I introduce as a hierarchically organized structure.

1 *A Broad Framework: The Tree of Social Cognition*

How are the capacities of social cognition related to each other? I propose that the structure of social cognition is hierarchical, ranging from lower-order to higher-order capacities. This hierarchy appears in at least three ways: (a) lower-order capacities (LC) develop earlier in life and are likely to have evolved earlier in human history than higher-order capacities (HC); (b) LC have lower processing demands than HC and may only weakly rely on actual mind representations; and (c) LC are often inputs to or even requirements for HC. I am not proposing an LC-HC dichotomy but rather a multi-layered hierarchical structure: a tree of social cognition (Malle, 2015).

Figure 1 displays the approximate hierarchy of capacities of social cognition, starting at the bottom with the fundamental identification of agents in the environment and building from simpler processes of gaze following to the complex processes of mental state and trait inferences. The tree is not a comprehensive representation of all social-cognitive capacities, and the exact location of any given tool is imprecise and debatable. However, the evidence for an overall hierarchy is rather compelling, exemplified by evidence on orderings in development (Poulin-Dubois et al., 2009; Sirois & Jackson, 2007; Wellman, Cross, & Watson, 2001), evolution (Call & Tomasello, 2008; Povinelli & Preuss, 1995), and cognitive processing (Malle & Holbrook, 2012; Van Overwalle, Van Duynslaeger, Coomans, & Timmermans, 2012).[1]

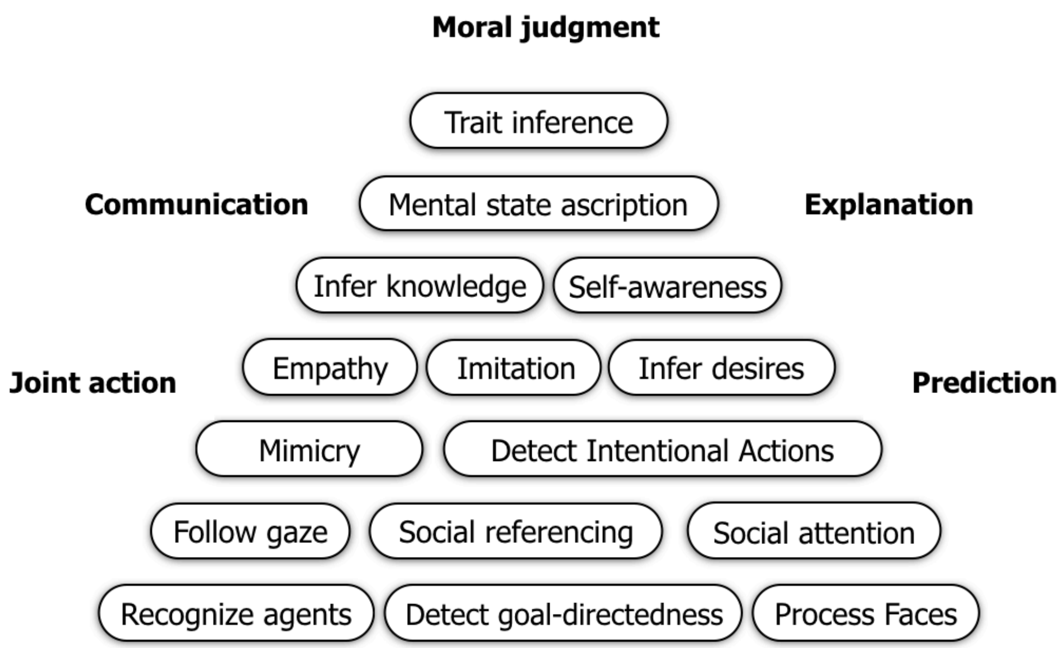

Figure 1. The tree of social cognition. In the bottom layers, we find lower-order capacities (earlier-developing and more likely to be present in nonhuman animals) that facilitate higher-order capacities in the upper layers. Bundles of capacities also enable more complex social-cognitive activities such as explanation, communication, and moral judgment. (This is a revised version of Figure 12.2 in Voiklis & Malle (2017)

[1] Despite the boundaries I drew around the capacities in Fig. 1, I do not assume that each of them has its own "circuit." A capacity here is really the pattern of performance of certain functions under certain conditions, and currently we don't know how distinct the computations and neural substrates are for these functions. In fact, because I argue that many capacities build on each other, I expect a smaller number of divisible substrates that differentiate and recombine to enable distinct performances.

Figure 1 also displays, outside the tree, important activities that are enabled by combinations of social-cognitive (and other) capacities. For example, *communicating* with others involves at least the basic tools of gaze following and joint attention to understand linguistic reference, as well as speakers' inferences of what the listener already knows, doesn't want to hear, or tries to find out (Barker & Givón, 2005; Clark, 1996; Krauss & Fussell, 1991). Likewise, there is no doubt that *explaining* human behavior relies on the careful scrutiny of gaze and attention to infer intentionality, and on inferences of specific desires, knowledge, and more complex mental states (Malle, 2004). And *moral judgment* takes into account not just observed behavior and outcomes but the subtleties of intentionality, the agent's reasons, and what the agent should and could have known (Alicke, Buckingham, Zell, & Davis, 2008; Cushman, 2008; Malle, Guglielmo, & Monroe, 2014). These activities are important for a broader picture of social cognition and social interaction, but they are not the focus of this chapter.

In what follows I will discuss each of the depicted capacities and offer evidence in favor of their approximate location within the tree. This evidence will come to a significant extent from developmental research, which offers the richest currently available database, and also from some comparative work and adult cognitive and social psychology. My main goal is to show the diversity of ways in which "mentalizing" can occur—ways in which humans connect to other minds.

2 Capacities of Social Cognition

2.1 Agents

A foundational task in social life is to recognize objects in the world that are candidates for having minds: *agents*. A few features can turn an object into a candidate agent: having eyes, acting contingently (responsive turn taking), and self-propelled behavior with equifinality (i.e., continuing pursuit of the goal under changing conditions) (Johnson, Slaughter, & Carey, 1998; Luo & Choi, 2013; Premack, 1990). Part of what elicits perceived agency is biological motion, which already 3-5 month-old infants can identify (Moore, 2011) and which grows into a sophisticated bottom-up/top-down integrative body perception (Johnson & Shiffrar, 2013). However, even nonbiologically moving objects (fury blobs, boxes, or triangles) are treated as agents, by children and adults alike, when they exhibit the features of equifinality (Heider & Simmel, 1944; Johnson, Shimizu, & Ok, 2007; Király, Jovanovic, Prinz, Aschersleben, & Gergely, 2003), as long as the observed movement is continuous (Berry, Kean, Misovich, & Baron, 1991). Treating certain entities as *agents* is a prerequisite for making further inferences about those entities' minds or moral status, even in the case of robots (e.g., Fiala, Arico, & Nichols, 2014; Gray & Wegner, 2012). Some of those inferences are so intimately connected to agency that they both provide evidence for agent status and are expected once agent status is granted, including goal-directedness and gaze following, discussed next.

2.2 Goal-directedness

A particularly robust recognition of agents relies on detecting a behavior's goal-directedness. Within the first year of life infants show a sensitivity to agents' coordinated movements toward objects (Wellman & Phillips, 2001; Woodward, 1998). Equifinality appears to be the most diagnostic cue in those movements (Luo & Choi, 2013) and has been recognized as a fundamental element of the adult conception of intentionality (Heider, 1958). Appreciating goal-directedness is not itself a mental state inference but a sophisticated theory of behavior; it guides the perceiver's attention to certain patterns of behaviors (e.g., reaching, looking) by certain kinds of entities ("agents") and builds expectations about future behaviors by these entities. For example, when 6- to 9-month-old infants see a human arm repeatedly reach for an object, they expect it to continue to reach for that object even when the object changes location; but they do not expect this pattern of object-directedness from a mechanical claw (Woodward, 1998). A few months later, infants understand that even just gaze behavior (without a reach) can indicate the same object-directedness (Woodward, 2003). We of course know that reach and gaze are in fact diagnostic of desires, interest, and other mental states; infants thus carefully track the kinds of behavior patterns that guide them toward the minds of others even before they fully understand those minds.

2.3 Faces

Faces capture and maintain 6-month-old infants' attention, but not 3-month-olds' (Di Giorgio, Turati, Altoè, & Simion, 2012). After 7 months, infants are sensitive to point-light displays of dynamic facial expressions such as surprise (Ichikawa, Kanazawa, Yamaguchi, & Kakigi, 2010), and infants' brains differentiate between familiar and unfamiliar faces (de Haan & Nelson, 1999) and between happy and fearful faces (Jessen & Grossmann, 2015). In adults, the brain differentiates familiar from unfamiliar faces between 140 and 200 ms after exposure (Barragan-Jason, Cauchoix, & Barbeau, 2015), and a conscious recognition response is possible after just over 300 ms (Ramon, Caharel, & Rossion, 2011). However, more differentiated judgments, such as recognizing specific emotions, takes considerably longer (e.g., Dodonova & Dodonov, 2012).

Artists are aware of the power of face and eyes, contingent and equifinal behavior, as those features constitute the vocabulary to make inanimate objects come alive (Lundmark, 2017; Thomas & Johnston, 1995). They also provide the foundation for several further social-cognitive skills, discussed next, that can develop only because of the infant's keen attention to these features.

2.4 Gaze following

Following other agents' direction of attention is a powerful tool to learn about the world, about its treasures and its threats. A basic, perhaps reflexive ability to follow a body, head, and gaze has been found in several mammals, even birds (Kehmeier, Schloegl, Scheiber, & Weiß, 2011), and in infants from at least 6 months of age (Gredebäck, Astor, & Fawcett, 2018). More sophisticated gaze following involves a rudimentary idea of *seeing* as a mind-world connection: by about 11 months, infants selectively follow open eyes but not closed eyes (Brooks & Meltzoff, 2005), a distinction that may be too difficult for chimpanzees (Povinelli & Eddy, 2000). Inferring which object a person is looking at when the possible objects of attention are more numerous, partially occluded, or spatially more diverse comes online a little later, at about 14 months (Carpenter, Nagell, & Tomasello, 1998; Slaughter & McConnell, 2003). And only with additional maturation do children seem to interpret looking as an internal state that can express intention even in the absence of an object of interest (Moore & Povinelli, 2007).

We see here, as in other capacities, that gaze following undergoes development and refinement, from a more behavioral to a more mentalistic processing level. This mix of behavioral and mentalistic processing is apparent in adult behavior as well, enriched by social impact. A single person on the street looking up at a 6th-floor window induces over 40% of people to look up as well; two people looking up entice 60%; and five entice 80% (Milgram, Bickman, & Berkowitz, 1969). This response is induced by a behavioral trigger of another's looking behavior, but it goes beyond an orienting reflex; it includes a consideration of the diagnosticity of the gaze behavior: If an increasing number of people look up, they must have a reason. We wonder about *what* is up there but also why so people are interested in it.

2.5 Social referencing

Not only is another's gaze a useful piece of information, but the person's facial expression can indicate whether the attended object should be valued or not. Social referencing is the act of using such diagnostic information about an object's valence, significance, or meaning (Klinnert, Campos, Sorce, Emde, & Svejda, 1983). By 10-12 months, children begin to decode such facial reactions about the value of objects (Slaughter & McConnell, 2003; Walden & Ogan, 1988); and a little later they care about the specific object that the adult attends to, not another one nearby (Moses, Baldwin, Rosicky, & Tidball, 2001). There is also evidence that infants not only passively use social appraisals but actively *seek* them. Such seeking behavior was shown in a classic developmental study, where 12-month-olds looked to their caregiver to help interpret a potential threat (visual cliff) and crossed only when the caregiver emoted a positive attitude (Sorce, Emde, Campos, & Klinnert, 1985). The active search for information in others' behaviors, emotions, and attitudes when in ambiguous situations continues to be important in adulthood (Walle, Reschke, & Knothe, 2017), such as in the classic studies on bystander intervention, where the search for information is apparent but may lie below people's own awareness (Latané & Darley, 1968). More broadly, social referencing can be seen as the foundation for conformity, but it goes beyond mere copying of *behavior* to the adoption of the social partners' *interpretation* of the situation (Feinman, 1992).

2.6 Social attention

The maturing of social attention management from simpler, less mentalistic to more complex, mentalistic variants is visible in the increasingly sophisticated pointing behavior of 9-18-month-olds (Franco, 2005). In "imperative pointing," the child uses pointing gestures to express a desire for an object to another person (demonstrated before 12 months). Declarative pointing is intended to shift the other's attention toward an object (when the other is not yet aware of the object), and a majority of children do it by 12-15 months. Yet more sophisticated is coordinated joint attention, involving alternating gaze between the object of interest and the other person. This capacity emerges by about 15 months (Bakeman & Adamson, 1984), although first age of onset may be earlier (Carpenter, Nagell, et al., 1998). Human-reared chimpanzees do not seem to show such active joint attention (Tomasello & Carpenter, 2005). Active attentional engagement is a powerful prerequisite for learning, broader collective intentionality, and culture (Tomasello & Rakoczy, 2003). More generally, the sharing of experience strengthens memory (Hoerl & McCormack, 2005) and is psychologically rewarding (Higgins & Pittman, 2008).

2.7 Intentionality

We have seen that detecting goal-directedness is a basic and early-developing capacity; how is detecting intentionality different? To continue our theme, the former requires little to no consideration of a mind (but rather relies on recognizing certain systematic behavior patterns between an agent and an object); the intentionality detection does. For one thing, any social perceiver faces the challenge that behavior usually comes in continuous streams, so the most important intentional actions must be extracted from the stream. Already at 12 months, infants show sensitivity to the surface features that characterize intentional actions (e.g., timing, contact, direction of attention) and are able to recognize the points at which intended actions are completed (Baldwin & Baird, 2001; Saylor, Baldwin, Baird, & LaBounty, 2007). Between 14 and 18 months, they can make the categorical distinction between intentional and unintentional behaviors (Carpenter, Akhtar, & Tomasello, 1998), which is also available to chimpanzees (Call & Tomasello, 1998). In human adults, these basic intentionality judgments differentiate conceptually but are made along two paths, depending on available information and judgment demands. Along the "slow and measured" path, people take into account what they know about the agent's context, mental states, and so on. For example, when we wonder whether a colleague who made a hurtful remark did it intentionally, we consider whether he holds a grudge, knew about our vulnerability, was aware of what he was actually saying, etc. (Malle & Knobe, 1997). Along the "fast and configural" path, many observed behaviors simply "look" intentional, and these configurations are well learned from numerous experiences of one's own and others' actions. These configurations allow intentionality judgments to be made faster than other mental state judgments (Decety & Cacioppo, 2012; Malle & Holbrook, 2012), and some of them are encoded as prototypes into action verbs with a strong intentionality implication (e.g., *reach*, *walk*, *look*, *help*; Malle, 2002).

2.8 Mimicry

Humans show some degree of synchronization at fairly low levels, such as heart rate, muscle tension, and pupil dilation (Prochazkova & Kret, 2017), but most useful for social cognition is mimicry of movements, postures, and gestures, because they can confer and reflect socially affiliative behavior (Chartrand & Bargh, 1999; Leighton, Bird, Orsini, & Heyes, 2010). Also important is mimicry of emotional expressions in the face, because it can facilitate shared emotions. A well-known proposal of mimicry in newborns (Meltzoff & Moore, 1977, 1997) has been challenged both at the level of evidence and interpretation (Jones, 2009; Keven & Akins, 2016; Oostenbroek et al., 2016; Ray & Heyes, 2011; Vincini, Jhang, Buder, & Gallagher, 2017). A systematic study of a range of behaviors across a range of ages (6 to 20 months) showed no above-chance mimicry at 6 months but increasing mimicry between 12 to 18 months, varying by specific behavior (Jones, 2007). In natural play interactions, 16 month-old toddlers begin to mimic each other and increase such behavior steadily over their development (Eckerman, Davis, & Didow, 1989; Nadel, 2002). One study suggests that chimpanzees and gorillas mimic each other's facial expressions (Palagi, Norscia, Pressi, & Cordoni, 2018), but the specific situation (play fighting) may represent a third variable that causes similar expressions in both animals. However, some evidence exists for simple mimicry among nonhuman primates, such as contagious yawning (Campbell & de Waal, 2014) or entrainment of finger tapping and other simple motor behaviors (Yu, Hattori, Yamamoto, & Tomonaga, 2018).

Though mimicry is often taken to be an automatic, inevitable mechanism (Heyes, 2011), a good deal of mimicry in humans appears to be regulated, or at least modulated, by higher-order processes. Looking at facial mimicry, which appears to be both spontaneous and fast (Sato & Yoshikawa, 2007), we find that the copying is far too socially strategic to be left to "mirror neurons" (Fischer & Hess, 2017; Wang & Hamilton, 2012). That is, emotion mimicry is more likely to appear when there is already a social connection to the other—e.g., through liking (Blocker & McIntosh, 2016) or shared group membership (Rauchbauer, Majdandžić, Stieger, & Lamm, 2016)—or when such a connection is desired—e.g., when one seeks to repair group integration (Cheung, Slotter, & Gardner, 2015). Thus, the lower-level capacity is integrated into the higher-level project of social regulation (Hess & Fischer, 2013).

2.9 Inferring desire

Inferring desires is more demanding than recognizing the goal-directedness of behaviors (such as reaching for an object; Woodward, 1998), and it also goes beyond the category distinction of intentional vs. unintentional behavior. It involves representing the content of a desire "in" a person's mind. One way in which this representation manifests is through recognizing that another person can have a desire different from one's own, an ability that may emerge at 18 months (Repacholi & Gopnik, 1997), though subsequent replications found evidence no earlier than 24 months (Ruffman, Aitken, Wilson, Puri, & Taumoepeau, 2017). As mental state verbs of desire appear in children's speech around 18 months (Bartsch & Wellman, 1995), we can safely say that children begin to master desire inferences sometime in their second year (Wellman & Woolley, 1990).

Advanced desire inferences are grounded not just in obvious behavioral cues (e.g., reaching movement) but in observed emotional reactions and, somewhat later, in observed eye gaze and pointing (Lee, Eskritt, Symons, & Muir, 1998). Desire inferences should also be apparent when the goal is not directly visible. Meltzoff (1995) suggested that 18-month-olds can infer what goal an actor is trying to achieve (e.g., in manipulating a novel object) and perform the kinds of actions that achieve the inferred goal. The exact mix of behavioral cues, object affordances, and inferred mental states is difficult to tell, but it is clear that there is a difference between analyzing behavior patterns that fairly directly reveal "corresponding" mental content (reaching for X = being directed to X) and analyzing behavior patterns that require some inference to reveal "noncorresponding" mental content (doing X → must want Y). Looking behind the observable and the obvious is of course the strength of sophisticated mental state inference—which later allows people to see through self-presentation, irony, and deception.

2.10 Imitation

Imitation is more involved than mimicry as it capitalizes on the newly gained ability to infer desires. In imitation, the perceiver attends to the other performing a novel behavior or manipulating an object in a novel way but with a particular desire or intention. The imitator then reproduces not just the observed behaviors but implements the inferred intentions or goals. Earliest evidence for such inference-based social imitation is found at 15-18 months of age (Johnson, Booth, & O'Hearn, 2001; Meltzoff, 1995). The evidence for this kind of imitation in nonhuman primates is suggestive but inconsistent and debated (Carrasco, Posada, & Colell, 2009; Herrmann, Call, Hernàndez-Lloreda, Hare, & Tomasello, 2007; Persson, Sauciuc, & Madsen, 2018; Subiaul, Renner, & Krajkowksi, 2016).

Imitation undergoes several developmental stages: Two-year-olds show the ability to infer a model's goal and copy only the relevant behaviors to achieve that goal (and not the ones that lead to failure). However, 3-year-olds start showing what is called overimitation (Lyons, Young, & Keil, 2007), as they also copy a model's *failed* attempts (Huang, Heyes, & Charman, 2006) as well as causally irrelevant behaviors (which other primates never do; Clay & Tennie, 2018). These patterns are robust across a number of cultural communities (Nielsen, Mushin, Tomaselli, & Whiten, 2014; Nielsen & Tomaselli, 2010), though they may appear later in some (Hewlett, Berl, & Roulette, 2016). Children have not lost their ability to distinguish intentional from unintentional behaviors, as they overimitate only intentional behaviors (Lyons, Damrosch, Lin, Macris, & Keil, 2011). Their detailed mimicking of new behavior may represent an openness to learn novel skills, unusual social norms and rituals, and thus to affiliate with members of their community (Nielsen, 2018; Wen, Herrmann, & Legare, 2016). Indeed, overimitation is more likely in the presence of a social audience (Marsh, Ropar, & Hamilton, 2019), is more strongly triggered by the behavior of ingroup members (Gruber, Deschenaux, Frick, & Clément, 2017), and is sustained even in adult years (Flynn & Smith, 2012; Hewlett et al., 2016).

2.11 Empathy/Emotion Matching

There is a bundle of terms that refer to some form of emotional reaction to another person's emotions: empathy, empathic concern, sympathy, and emotional contagion. I will focus here on empathy, understood as having the same emotion as another person because one observes the other's emotion (Feshbach & Roe, 1968). This is similar to emotional contagion (Hatfield, Cacioppo, & Rapson, 1994), but additional cognitive and motivational mechanisms may facilitate or moderate the contagious response (e.g., Cameron et al., 2019).

Negative reactions to another's distress emerge early in infancy, but the mechanisms do not meet the adopted definition of empathy. Genuine empathy requires a differentiated matching of experienced emotions with observed emotions—so that the perceiver experiences E_1 when observing E_1, E_2 when observing E_2, etc. Contagious crying in newborns (if contagion at all; Ruffman, Lorimer, & Scarf, 2017) and 1-2 year-olds' concern for others' distress (Roth-Hanania, Davidov, & Zahn-Waxler, 2011) are relatively undifferentiated; no matter what the other's specific distress is, the perceiver has a general response of concern—which corresponds rather to sympathy, a particular emotion felt in response to a large variety of negative states in the other person. Likewise, nonhuman primates show consolation behavior, and if regarded as an emotional response (de Waal & Preston, 2017), they could be counted as sympathy.

The age of emergence of genuine empathic emotion matching is under debate, but even skeptics' results (Ruffman, Then, Cheng, & Imuta, 2019) suggest that in the 2nd year of life, happy and sad videos lead to differential emotional responses on the happy-to-sad dimension. However, in that study and other studies on the same age group (e.g., Scambler, Hepburn, Rutherford, Wehner, & Rogers, 2007), happy stimuli elicited far stronger matching responses than sad stimuli. With age, this asymmetry declines somewhat. About half of 3- to 5-year-olds showed increasing sadness expressions to a video story when it moved to the sad climax (Stiles, 1985). And among 6-7 year-olds, both happy and sad story sequences led to high rates of matching self-reported emotions; however, corresponding rates were low for anger or fear (Feshbach & Roe, 1968). Likewise, among adults, happy and sad faces elicit happy and sad feelings, respectively, whereas anger, fear, and disgust at best do so inconsistently (Blairy, Herrera, & Hess, 1999; Hess & Blairy, 2001). These results suggest that perceivers do not simply "catch" emotions by mimicking the parallel emotional expression. The age-dependent conceptual interpretation of the emotion is necessary to perceive and replay the correct emotion; and some emotions are better matched than others, whether due to difficulty or motivation.

In adults, genuine and specific empathy occasionally results from mimicry, such as in studies that expose perceivers to extended dynamic video stimuli or a live interaction partner (Stel, Van Baaren, & Vonk, 2008; Stel & Vonk, 2010). However, even when mimicry emerges, it typically does not cause matching emotions (Blairy et al., 1999; Hess & Blairy, 2001). Empathy can come about through other means, such as hearing an emotional tone of voice

(Neumann & Strack, 2000), imagining the other's emotion (Hawk, Fischer, & Van Kleef, 2011), or simulating the mere idea of an emotion (Hess, Houde, & Fischer, 2014). And empathy can be moderated by self-regulation (Hodges & Klein, 2001; Ochsner, 2013; Powell, 2018). It seems that actual emotional contagion is relatively rare, and empathy as emotion matching (through contagion or not) is a more learned, refined, and regulated response.

2.12 Inferring Knowledge

Between 18 and 30 months, children recognize that talking to someone or a nodding gesture can transmit knowledge from one person to another (Fusaro & Harris, 2013; Song, Onishi, Baillargeon, & Fisher, 2008). Children themselves also begin to use gestures to transmit information (Begus & Southgate, 2012) and pose a large number of questions (Chouinard, 2007) to seek information. By the middle of the third year they selectively provide information, verbally or nonverbally, to others who don't know that information (O'Neill, 1996). Their language use, too, begins to reflect their emerging understanding of affirmed, denied, and requested knowledge (Harris, Yang, & Cui, 2017).

Handling such knowledge transfer is a critical capacity that not only conceptualizes mental states of knowing but separates knowledge as information from the minds that hold that knowledge. This allows perceivers to distinguish between people who know and those who don't know (Koenig & Harris, 2005) and to guide their social interactions by such differences. This in turn explains why children ask adults about food but other children about toys (VanderBorght & Jaswal, 2009), and it also enables us to do fine knowing very little about many things, as long as we know who in our community knows (Sloman & Fernbach, 2017).

Handling rapidly shifting belief and knowledge inferences is also critical in conversation, both to make subtle linguistic decisions (e.g., about "a" vs. "the"; Barker & Givón, 2005) and to tailor utterances to one's conversation partner, taking into account what they know, see, and hear (Fukumura, 2015; Krauss & Fussell, 1991).

2.13 Self-awareness

Proto forms of self-awareness occur when infants' experiences of their own actions become models for understanding the actions of others (Sommerville, Woodward, & Needham, 2005), and several theorists would argue that experiences of one's own mental states are models for understanding the mental states of others (Goldman, 2009; Gordon, 1986). Evidence for the development of self-awareness is typically associated with body self-recognition in the famous mirror test (Gallup, 1970), in which the agent has to recognize themselves in the mirror by touching a mark on their own body (rather than on the mirror surface). Between 18 and 24 months, a majority of children pass the test, and many chimpanzees do too (Povinelli, Rulf, Landau, & Bierschwale, 1993).

However, being aware of one's present (bodily) state is one thing (Suddendorf & Butler, 2013); bridging one's past and present selves is more challenging. When children watched a video of themselves in which the experimenter put a sticker on their forehead, only a quarter of 2- and 3-year-olds immediately checked their forehead for the sticker, whereas three fourths of 4-year-olds did (Povinelli, Landau, & Perilloux, 1996). Such time-extended self-awareness emerges only slowly. Three-year-olds have trouble recognizing that their own past (false) beliefs actually motivated their own actions (Atance & O'Neill, 2004). Four- to five-year-olds who were just taught some novel facts normally do not realize that they didn't know those facts a little earlier (Taylor, Esbensen, & Bennett, 1994). And only after 5 years of age can children report what they were thinking a short while ago (Flavell, Green, & Flavell, 1995; Louca-Papaleontiou, Melhuish, & Philaretou, 2012).

Awareness of the present moment is easier. Three- to four-year-olds can recall a concrete false belief they had just moments ago (about the contents of a box; Gopnik & Slaughter, 1991); they can reflect on their own current mental images (Estes, 1994); and they accurately report on their knowledge (or lack thereof) about the contents of a box in front of them (Gonzales, Fabricius, & Kupfer, 2018). Moreover, children who gave such accurate self-reports were more likely to accurately report on *other* people's states of seeing and knowing 7 months later (Gonzales et al., 2018). This form of state self-awareness thus has a scaffolding effect on third-person inferences.

We see that self-awareness, just like other social-cognitive capacities, has layers of complexity: from motor or mind experiences to self-identification to state awareness to memory continuity. Additional levels have barely been researched, such as the emergence of *public* self-awareness (a person's recognition that other people are observing and evaluating the person), which enables the emotions of shame and embarrassment (Chobhthaigh & Wilson, 2015; Lewis, 1997), rich with inferences about the audience's thoughts and evaluations about one's own flawed behavior or character.

2.14 Mental state ascriptions

It should be clear by now that there is no one way to "mentalize"; that many processes connect a perceiver to another's mind. It can be through categorization (e.g., intentionality judgments), attention (e.g., gaze following), coordinated behavior (e.g., imitation), and representation (e.g., inferring knowledge). What is left to discuss are the most sophisticated representations of mental states, demanded by the following challenging circumstances:

- when the states themselves are complex (false belief, self-conscious emotions such as guilt, distinctions such as jealousy and envy);
- when behavioral evidence for the states is ambiguous (e.g., when a person tries to hide their mental state) or sparse ("what's her goal in sending this email?"); or when the inferred state is a counterfactual ("could she have known?").
- when inferred mental states are combined and incorporated into action explanations ("He was afraid of our reaction and thought that by being quiet we wouldn't notice").
- when the observer wants to know not just *what* another person sees (involved in social referencing) but how another person *interprets* a visual display (e.g., as a "6" or a "9") (see Lalonde & Chandler, 2002).

I call these inferences "ascriptions" to signal that they are often more explicit, with clearer awareness of an "other mind," and are supported by increasingly rich language (e.g., Bartsch & Wellman, 1995) and concepts (Andrews, 2018). Underlying such complex ascriptions are both knowledge-based inferential processes ("he loves hops, he must have a special reason to decline this IPA") and flexible simulation processes ("what would I do if I felt so terrible?"). Both of them allow the perceiver to go beyond defaults, stereotypical assumptions, and mere projection (Ames, 2004; Clement & Krueger, 2000; Van Boven & Loewenstein, 2003).

Along the developmental path, we are now at the last step of differentiation into a wide range of inferred mental states: not just desires and knowledge, but also false beliefs and intentions. The distinctions emerge fairly gradually and ordered over the course of development from ages 2 to 7 (Astington, 2001; Flavell, Everett, Croft, & Flavell, 1981; Schult, 2002; Wellman & Liu, 2004) and continue into ages 7 to 9 if we include third- and fourth-order false beliefs (Osterhaus, Koerber, & Sodian, 2016) as well as action explanations (Atance, Metcalf, Martin-Ordas, & Walker, 2014). Evidence for desire and knowledge inferences in other primates is compelling (e.g., Kaminski, Call, & Tomasello, 2008; Myowa-Yamakoshi, Scola, & Hirata, 2012), but evidence for false belief inferences is absent (e.g., Call & Tomasello, 2005; Povinelli & Vonk, 2003). Recent studies suggest the possibility that great apes may have an implicit grasp of false beliefs (Buttelmann, Buttelmann, Carpenter, Call, & Tomasello, 2017; Krupenye, Kano, Hirata, Call, & Tomasello, 2016), just as it has been suggested for infants before the age of 2 (Baillargeon, Scott, & He, 2010; Onishi & Baillargeon, 2005; Southgate, Senju, & Csibra, 2007). The interpretation of implicit false-belief results continues to be debated (Andrews, 2018; Perner & Ruffman, 2005; Ruffman & Taumoepeau, 2014), and a number of failed replications of infant results (see Sabbagh & Paulus, 2018) should make us pause and avoid overly strong conclusions. But whatever conclusions we might draw from the implicit tasks, there is little doubt that explicit false-belief ascriptions are robust in 5-year olds and do not occur in 2-year-olds; that great apes fail such explicit false-belief tasks; and that many more explicit mental-state inferences are made possible by complex concepts (e.g., emotion categories) and by language (enabling composite representational contents). There is therefore little doubt that social-cognitive capacities ascend in development and evolution and that explicit, contentful mental state ascriptions have evolved and develop late. Consistent with this perspective, we also see that adults take longer to process belief inferences (Malle & Holbrook, 2012; Qureshi, Apperly, & Samson, 2010), have more difficulty at performing them accurately (Epley, Morewedge, & Keysar, 2004; Ickes, 1997; Keysar, 1994), and show the ability for top-down control if there is motivation for improvement (Klein & Hodges, 2001),.

2.15 Trait attributions

"We perceive other people as causal agents, we infer intentions, we infer emotional states, and we go further to infer enduring dispositions or personality traits" (Hastorf, Schneider, & Polefka, 1970). In the spirit of such ascent I placed the process of trait attributions at the top of the tree of social cognition. However, it should not be considered the crowning achievement but rather a consequence of cognitive recombination and abstraction, such that inference of attention, desire, emotion, and belief enable attributions of attitude, temperament, and personality, aided by conceptual distinctions and semantic differentiations. At one point, social psychology treated trait attribution as the most important, frequent, and inevitable tools of social cognition (Jones & Davis, 1965; Shaver, 1975; see Malle, 2011a, for a review); and this trend culminated in the charge that people were "dipositionists" (Ross & Nisbett, 1991), primarily concerned with attributing stable traits or dispositions to others. Against this charge, however, recent evidence shows that people use traits to explain behavior far less often than one would expect (summing to about 5% of explanations; Malle, Knobe, & Nelson, 2007). Moreover, when the behavior in question is highly unusual, some models predicted that trait explanations should increase (Skowronski & Carlston, 1989), but in fact they decrease (Korman & Malle, 2016). Finally, when people encounter text or video displays of ordinary behavior, trait inferences are slower and less prevalent than mental state inferences (Malle & Holbrook, 2012; Van Overwalle et al., 2012).

Along the developmental path, trait attributions seem to emerge later than all other tools of social cognition we have considered. To wit, whether as ascriptions or predictions of future behavior, verbal trait attributions in the good-bad domain begin at age 4 (Boseovski & Lee, 2006). A little later children make such attributions in the domain of competence: They use evidence for both physical strength and knowledge to make corresponding trait inferences, and those inferences mediate later selective trust to rely on one or another person (Hermes, Behne, & Rakoczy, 2015). Five-year-olds do not yet grasp preferences as traits, instead frequently explaining behavior by reference to norms (Kalish & Shiverick, 2004). Differentiation into trait attributions beyond valence and competence develop from age 6 to 10 (Gnepp & Chilamkurti, 1988), whereas already 5-year-olds can describe their own personality traits in quite differentiated ways along the Big Five dimensions (Measelle, John, Ablow, Cowan, & Cowan, 2005). This suggests once more that self-directed inferences may facilitate later other-directed inferences.

However, as in many other domains of social cognitive development, some authors have proposed that infants make trait attributions already at the end of their first year of life. Infants seem to infer that a circle “likes” a triangle that has previously helped the circle (Kuhlmeier, Wynn, & Bloom, 2003), and they prefer agents performing “good” (facilitative) actions over agents performing “bad” (hindering) actions (e.g., Hamlin & Wynn, 2011; Hamlin, Wynn, & Bloom, 2007). Thus, evidence is limited to a proto-moral distinction of good/nice vs. bad/mean. Questions may be raised about such results’ specific interpretation and their replicability across different laboratories (Margoni & Surian, 2018), but it is a plausible hypothesis that implicit trait attributions along the valence dimension launch the ability to more generally attribute traits to others. In their full-fledged form, traits attributions occur along a host of dimensions (not just valence), come in degrees (not just categories), and within a conceptual space that includes temperament, personality, moral character, values, and ideology. Arriving at this sophisticated space of trait attributions requires a good deal of concepts and language, experiences with a variety of individuals, and an understanding of the stability but also context specificity of traits.

2.16 The Tree, Once More

Some of the evidence I have reported on the likely development of social-cognitive capacities and on their presence in nonhuman primates is incomplete, open to interpretation, or still under debate. Nonetheless, Figure 2 offers a tentative summary of evidence on the developmental time scale and an even more tentative assessment of evidence from the animal behavior literature. Within the latter, brighter shades of gray indicate higher confidence for a capacity’s presence in nonhuman animals in light of scholarly consensus on replicated evidence, both in field and lab; darker shades of gray indicate lower confidence in light of scholarly consensus on a capacity’s absence or simply absence of evidence. In between are mixed data and debate.

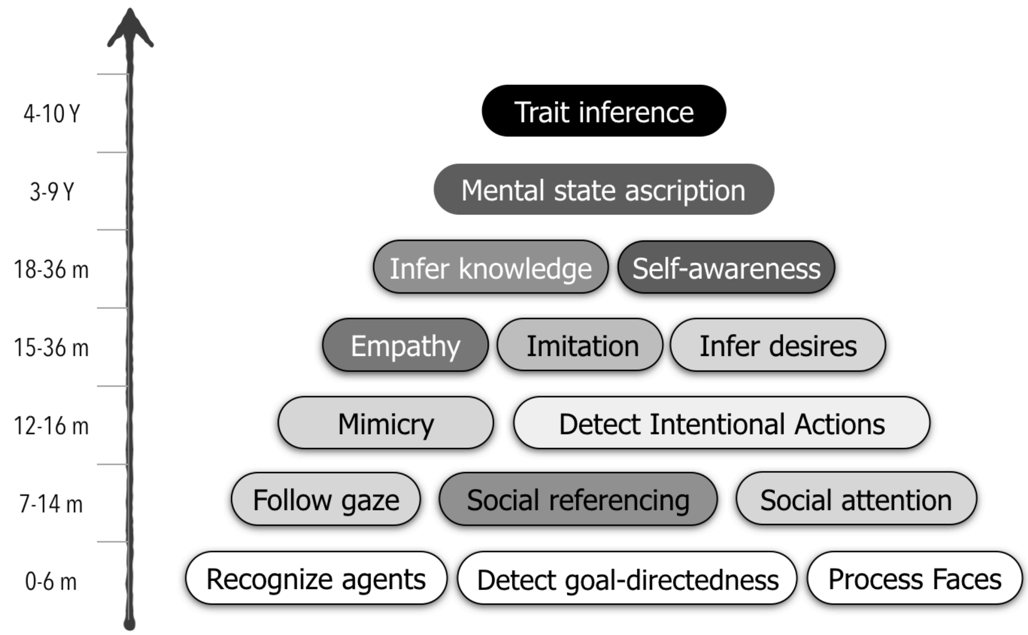

Figure 2. The tree of social cognition and its hierarchically ordered processes, roughly aligned with a time scale of emergence in human development and shaded by likely presence, given current evidence, in nonhuman animals (the darker the shading the less likely to be present).

One repeated theme in the overview of these social-cognitive capacities is that the capacities vary in their degree of representing the actual *mind* of another (not just their behavior) and how many knowledge structures aide this representation. In addition, many of the capacities themselves come in such degrees of mind representation (e.g., variants of gaze following, social attention, imitation), and mentalizing may therefore be seen as a continuum. A second repeated theme is the impact of self-awareness, self-regulation, and of social context in differentiating and modifying numerous capacities, thus providing important functions that make social living possible. A third theme is the affinity and facilitation among many of the capacities; I now elaborate on these relations.

3 *Hierarchical Dependencies*

Perhaps the most important feature of a hierarchical conception of social cognition is that the results of many lower-order tools (often in combination) are inputs to the processing that is performed by higher-order tools. This characterization has affinity with models of hierarchical cognitive control (Badre & Nee, 2018) but runs counter to the picture of a dichotomous division into two levels or systems of mentalizing (e.g., Apperly & Butterfill, 2009; Coricelli, 2005), akin to the well-known "System 1/System 2" division. Though it is likely that, in general, lower-order capacities (LC) tend to be "automatic" and "unconscious" and higher-order capacities (HC) tend to be "reflective" and "conscious," such assignments should not be considered categorical or fixed. LC can become reflective (e.g., an intentionality judgment in the jury box), and HC can become automatized in the presence of familiar stimuli (e.g., repeated inferences of specific mental states for close others). In the picture of a tree of social cognition, some bundles of LC tend to be engaged first (and perhaps continuously) to solve certain social challenges, and some HC step in to integrate this early information or take over when the LC cannot by themselves solve the challenge at hand. For example, LC may track referents in a conversation and HC may try to resolve a possible misunderstanding in the conversation. Many such LC-HC relationships exist, and I describe three of them below. I indicate joint operation with a "+" sign and facilitation with the notation "⇉".

3.1 Recognizing agent + detecting goal-directedness + gaze following ⇉ Detecting intentionality + infer desires

Once people identify agents as the entities of greatest interest to them—e.g., by noticing eyes or experiencing contingent responses—they can appropriately code actions as goal-directed toward certain objects. By attending to breakpoints in the behavior stream (e.g., turning body and head, movement slowing just before object touch) and tracking gaze as well as selective physical actions (e.g., grasping one rather than another object), the perceiver can recognize the equifinality of a behavior and, with additional observation of the object, infer the agent's likely desire (e.g., food is desired for eating, complex objects are desired for taking apart). With repetition, certain movement patterns (e.g., shaking hands, putting down keys) become distinct configurations and are instantaneously recognized as "intentional."

3.2 Process faces + social referencing + mimicry ⇉ empathy

With improved decoding of facial expressions comes a more refined capacity for mimicry, which has long been considered the basis for emotional contagion (Hatfield et al., 1994) and empathy (Lipps, 1907). But even though people mimic others' emotional expressions and are able to empathize with others, the mimicking itself may rarely cause the empathic response directly (Hess & Fischer, 2013). Nonetheless, mimicry may be an indicator of a dispositionally heightened responsiveness to others' behavior (Franzen, Mader, & Winter, 2018; Sonnby-Borgström, Jönsson, & Svensson, 2003), and if mimicry is reciprocal, it can contribute indirectly to emotion matching by stabilizing each person's emotion (and mutual empathy) through stabilizing their expression.

Furthermore, with improved decoding of facial expressions and body postures come more opportunities for social referencing. To the extent that this referencing process often aligns people's evaluations, it will also align their emotions (and expressions thereof, which could look like mimicry). Such emotion matching is not a form of contagion but arises from recognizing how the other evaluates an object, action, or person and adopting (or agreeing with) this evaluation. Finally, simulation of others' feelings and ascriptions of specific emotions can create congruent emotional expressions (Hawk et al., 2011).

3.3 Social attention + detecting intentionality + infer desires ⇉ imitation

Mature joint attention and social referencing processes allow agents to align their attention and evaluations for shared experience and joint actions, including both complementary and imitative behavior, suggesting a facilitative linkage between attention and imitation (Kana, Wadsworth, & Travers, 2011). Recognizing the other's intentional actions and object-specific desires further facilitates imitation, because the perceiver understands not only the other's observable behavior but their "invisible" goals.

3.4 *Postscriptum:* Concepts

I have not said much about concepts, even though I am on record for proposing that "theory of mind" is first and foremost a conceptual framework (Malle, 2005, 2008). My current view is that several of the described processes of social cognition build on basic categorizations (e.g., into agents and nonagents, intentional vs. unintentional behaviors) that are initially aided by sensitivity to certain perceptual markers and reinforced in social interaction. Over the course of development, many processes of social cognition get more refined and build up abstractions that form finer-grained concepts, such as shades of desire, intention, belief, knowledge, etc. All the basic and more fine-grained concepts guide information search and processing—such as when the agent category initiates gaze following or when the intentionality category triggers a desire inference. Moreover, as these concepts mature, they can stand in specific (again, often hierarchical) logical relations to one another and shape expectations about what can actually be observed. For instance, observing an intentional action implies that the agent had some desire and belief, and further inferential processes have to determine what those states are. The intentionality concept, in particular, grows into a complex but systematic conceptual structure (Malle & Knobe, 1997, 2001) whose embedded processes guide both moral judgments (Monroe & Malle, 2017) and behavior explanations (for a review, see Malle, 2011).

4 Climb to the Top: The Cultural History of Mental State Ascriptions

Studying this broad literature has convinced me that the emergence of mentalizing as full-blown mental state ascriptions, and of trait ascriptions building on them, requires many steps: maturation, continued learning, social interactions that scaffold, and reliance on lower-order capacities. Language, moreover, facilities conceptual distinctions (e.g., Barsalou, 1983) and is therefore a key vehicle to support these ascriptions and their increasing differentiations—for example, among shades of desires and intention (wanting, planning, intending, deciding, committing; Malle & Knobe, 2001) or among the many shades of emotions. I want to put forth an additional hypothesis, not about the emergence of the *principled* ability to make mental state ascriptions, but about a powerful increase in the use and significance of such ascriptions in human cultural evolution: the hypothesis that mental state ascriptions, and also trait ascriptions, exploded after humans settled down about 12,000 years ago.

Sedentism was caused by and caused a considerable number of cascading changes: population increase, agriculture and animal husbandry, religion, architecture, organized fighting, and many more (Aurenche, Kozłowski, & Kozłowski, 2013; Boserup, 1965; Peregrine, Ember, & Ember, 2007; Redman, 1978; Renfrew, 2007; Zeder, 2011). I will focus on the ones that may have specifically contributed to the rise of mental state ascriptions.[2]

4.1 Population Explosion

Between 10,000 and 8,000 BCE, a first population growth began in many human settlements from camps to villages and towns across Europe and West Asia (Atkinson, Gray, & Drummond, 2008; Gignoux, Henn, & Mountain, 2011; Hawks, Wang, Cochran, Harpending, & Moyzis, 2007; Lee, 1972). Among the causes of this growth were broader environmental opportunities (the end of the Last Glacial; Shultziner et al., 2010), specific local circumstances of fauna and flora (Aurenche et al., 2013), but also the impact of settlement on child bearing. In nomadic communities, mothers had to carry their newborns for thousands of kilometers a year and breast-

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[2] For the sake of a cultural history perspective I express the reported background evidence as claims about the past, even when actual archeological evidence is often lacking and our knowledge stems from the study of present-time hunter-gatherer and sedentary societies.

fed for a longer time, which limited them to one child every 3 to 4 years (Lee, 1972; Shostak, 2009). Once settled, pregnancy frequencies increased substantially, dramatically raising child birth rates (Buikstra, Konigsberg, & Bullington, 1986).

As families grew in size, kinship became a stricter boundary of ingroup and outgroup (Alt et al., 2013; Wilson, 1988). Thus, empathy and imitation were practiced more within families than in the community at large. In contrast to living in hunter-gatherer groups of 10-100 (Williams, 1985), in which most everybody knew everybody else, living in communities increasing to 1,000 (around 7000 BCE) and later to 100,000 (around 1200 BCE; Modelski, 2003) created significant distance (Sutcliffe, Dunbar, Binder, & Arrow, 2012). The sheer number of people, and especially the number of people with whom one had weak or no relations, made understanding more difficult, owing to fewer interactions, fewer joint experiences, and more suspicion of the other's benevolent motives. To overcome such gaps of understanding, uncertainty, and threats of conflict, mental state ascriptions must have gained in importance.

4.2 Visibility

As towns grew into cities and empires, built structures rapidly increased in number, size, and complexity (Flannery, 2002; Wilson, 1988). Buildings created barriers, defined spheres of inside and outside, private and public (Duru, 2018; Hodder, 1990). When actions and minds were hidden behind private walls, people could no longer attend to and monitor each other (Wilson, 1988) and needed to exert additional efforts to recognize others as understandable and trustworthy. None of the lower-order capacities we have examined operate at a distance; only the two highest-order ones do. With increased use of mind perception at a distance we can also better understand the rise of agentic, doctrinal religion (Cauvin, 2000; Dunbar, 2013; Hodder, 2018), in which the minds of Gods and spirits were objects of heavy mental ascriptions (Guthrie, 1993; Tremlin, 2006), and are so to this day (Heiphetz, Lane, Waytz, & Young, 2016).

4.3 Diversification

By staying in place, people had more opportunity and benefit for differentiation of practices, crafts, and positions in society (Benz & Bauer, 2013). This diversity demanded tracking of different agents' motives and traits and updating that knowledge in each interaction. Moreover, the explosion of tools manufactured for food production and building construction required many different skills and, aided by genetic diversification (Ricaut et al., 2012), individual differences in abilities and personality increased. This in turn commanded complex trait inferences and their underlying mental state inferences.

4.4 Possessions, Law, and War

Over the millennia, ownership of land, livestock, and tools led to wealth that was inherited within families, thus further intensifying kinship boundaries. Accumulated wealth came with threats to lose it and with competition for more wealth through vending and trading. This situation called for norms and laws of inheritance, theft, and economic exchange (Binder, 2002; Milgrom, North, & Weingast, 1990), along with institutional forms of enforcement and accompanying requirements for mental state ascriptions to keep such enforcements fair (Monroe & Malle, 2019; Voiklis & Malle, 2017). The law, of course, famously implements many of the fundamental distinctions of mental state ascription (Duff, 1990; Marshall, 1968). At a societal level, territorial expansions provoked broader and more frequent intergroup conflict that gave rise to organized warfare. Whereas a duel of two individuals can rely on many of the lower-order social-cognitive capacities in shared space, organized warfare is collective, tactical, strategic, and thus requires social cognition at a distance, leaving once more only the highest-order capacities in contention.

5 *Implications and Open Questions*

This is then my picture of mentalizing: a broad, closely intertwined hierarchy of social-cognitive capacities, among which the late-developing, slower, and cognitively demanding forms were substantially amplified in very recent human history. This picture offers a number of implications and unanswered questions, three of which I touch on; and it demands numerous revisions, which the scientific community at large, I hope, will undertake.

Theoretical pluralism. The tree of social cognition welcomes a diversity of theoretical positions and structures: theory theory's inference processes, simulation theory's self-based models, massive bottom-up learning, abstract concepts, and even various degrees of "preparedness." It seems doubtful that any of the branches of this tree are completely encapsulated processes (Fodor, 1983); but sensitivities to certain stimuli (e.g., biological movement, eyes) may indeed be formative in the human mind with little learning, and mimicry may be facilitated by old and ready mappings between visual representations and motor programs (Iacoboni, 2009). Most other capacities, however, are complex and rely on multiple interacting processes, grow with experience, and benefit from social scaffolding (Barrett, 2015). The tree even provides space for the somewhat radical claims of scholars who question whether others' minds are "hidden" (Gallagher, 2008; Gibbs, 1999; Hutto, 2007). There is truth in the claim that often we are not "thinking about what might be going on in the other person's mind" (Gallagher, 2008, p. 540); the numerous lower-order processes of social-cognitive certainly attest to that. But we also must acknowledge the substantial role of higher-order, explicit mentalizing, especially with increasing age and in the vast society of strangers *homo sapiens* has formed.

Measurement. If social cognition is conceptualized as a hierarchical network of more than a dozen processes, their distinct measurement is a major challenge, especially if we want to put the claims of hierarchical and facilitative relationships to a test. Developmental and comparative psychologist have done impressive work in creating and collating such measures and experimental tasks for infants, children, and animals (see Herrmann et al., 2007, for a particularly commendable project). For assessments in adulthood, tests have been designed in different literatures and, because of their separation, have provided very little information about discriminative validity. A review and evaluation of these literatures goes beyond this chapter but would obviously be worthwhile. Once such measures have been validated behaviorally and cognitively, then we would be able to systematically examine cultural variations, neural correlates, or genetic markers.

Cultural factors. The hypothesis of recent cultural pressures on the practice and refinement of mental state and trait ascriptions poses interesting challenges and suggestions. In particular, it encourages expansion of existing lines of research on the differential engagement of social cognition in remote settings vs. co-presence; for strangers vs. close others; for ingroup vs. outgroup members; or in competitive vs. cooperative contexts (e.g., Ames, 2004; Haslam, 2006; Lin, Qu, & Telzer, 2018). Cross-cultural variations may also be studied in a more nuanced matter—less as a categorical difference between East and West and more as a function of the differential learning and the social-cognitive challenges that come with demands, tasks, and rewards that particular cultural contexts provide.

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