Theory of mind

In psychology, **theory of mind** refers to the capacity to understand other people by ascribing mental states to them (that is, surmising what is happening in their mind). This includes the knowledge that others' mental states may be different from one's own states and include beliefs, desires, intentions, emotions, and thoughts.[1] Possessing a functional theory of mind is considered crucial for success in everyday human social interactions. People use such a theory when analyzing, judging, and inferring others' behaviors. The discovery and development of theory of mind primarily came from studies done with animals and infants.[2] Factors including drug and alcohol consumption, language development, cognitive delays, age, and culture can affect a person's capacity to display theory of mind.

It has been proposed that deficits in theory of mind can occur in people with autism [4], anorexia nervosa,[5] schizophrenia, dysphoria, attention deficit hyperactivity disorder,[6] cocaine addiction,[7] and brain damage caused by alcohol's neurotoxicity;[8] deficits associated with opiate addiction are reversed after prolonged abstinence.[9] Having a theory of mind is similar to but not identical with having the capacity for empathy[10] or for sympathy.

Theory of mind develops throughout childhood as the prefrontal cortex develops. The violation-of-expectation procedure uses infants' tendency to look longer at unexpected and surprising events. Most typically developing children are able to pass the False-belief task from around age four. Children from Iran and China in a culture of collectivism develop knowledge access earlier and understand diverse beliefs later than Western children in a culture of individualism.[11]

Neuroimaging shows brain regions engaged during theory of mind include the medial prefrontal cortex (mPFC), and area around posterior superior temporal sulcus (pSTS), and sometimes precuneus and amygdala/temporopolar cortex. Patients with frontal lobe or temporoparietal junction lesions find some theory of mind tasks difficult.

Many researchers focus on animals' understanding of intention, gaze, perspective, or knowledge. A study showed orangutans and chimpanzees understood the difference between accidental and intentional acts. William Field and Sue Savage-Rumbaugh believe that bonobos have developed theory of mind.

Theory of mind is distinct from philosophy of mind, which is about the basic nature of the mind and how the brain enables it.

Definition

Theory of mind is a "theory" because the behavior of the other person, such as their statements and expressions, is the only thing being directly observed. Their mind and its contents cannot be observed directly, so the existence and nature of the mind must be inferred.[12] The presumption that others have a mind is termed a theory of mind because each human can only observe their own mind (via introspection); no one has direct access to the mind of another. It is typically assumed that others have minds analogous to one's own; this assumption is based on reciprocal social interaction, as observed in joint attention,[2] the functional use of language,[13] and the understanding of others' emotions and actions.[14] Theory of mind allows one to attribute thoughts, desires, and intentions to others, to predict or explain their actions, and to posit their intentions. It enables one to understand that mental states can be the cause of—and so can be used to explain and predict—the behavior of others.[12] Being able to attribute mental states to others and understanding them as causes of behavior implies, in part, that one must be able to conceive of the mind as a "generator of representations".[15] If a person does not have a mature theory of mind, it may be a sign of cognitive or developmental impairment.

Theory of mind appears to be an innate potential ability in humans that requires social and other experience over many years for its full development. Different people may develop more or less effective theories of mind. Neo-Piagetian theories of cognitive development maintain that theory of mind is a byproduct of a broader hypercognitive ability of the human mind to register, monitor, and represent its own functioning.[16]

Empathy—the recognition and understanding of the states of mind of others, including their beliefs, desires, and particularly emotions—is a related concept. Empathy is often characterized as the ability to "put oneself into another's shoes". Recent neuro-ethological studies of animal behaviour suggest that even rodents may exhibit empathetic abilities.[17] While empathy is known as emotional perspective-taking, theory of mind is defined as cognitive perspective-taking.[18]

Research on theory of mind, in humans and animals, adults and children, normally and atypically developing, has grown rapidly in the years since Premack and Guy Woodruff's 1978 paper, "Does the chimpanzee have a theory of mind?".[12] The field of social neuroscience has also begun to address this debate by imaging the brains of humans while they perform tasks that require the understanding of an intention, belief, or other mental state in others.

An alternative account of theory of mind is given in operant psychology and provides empirical evidence for a functional account of both perspective-taking and empathy. The most developed operant approach is founded on research on derived relational responding and is subsumed within relational frame theory. According to this view, empathy and perspective-taking comprise a complex set of derived relational abilities based on learning to discriminate and respond verbally to ever more complex relations between self, others, place, and time, and through established relations.[19][20][21]

Philosophical and psychological roots

Discussions of theory of mind have their roots in philosophical debate from the time of René Descartes' *Second Meditation*, which set the groundwork for considering the science of the mind.

Two contrasting approaches in the philosophical literature to theory of mind are theory-theory and simulation theory. The theory-theorist posits a veritable theory—"folk psychology"—that people use to reason about others' minds. Such a theory is developed automatically and innately, though it is instantiated through social interactions.[22] It is also closely related to person perception and attribution theory from social psychology.

It is common and intuitive to assume that others are minded. People anthropomorphize non-human animals, inanimate objects, and even natural phenomena. Daniel Dennett referred to this tendency as taking an "intentional stance" toward things: we assume they have intentions, to help predict their future behavior.[23] However, there is an important distinction between taking an "intentional stance" toward something and entering a "shared world" with it. The intentional stance is a detached and functional theory we resort to during interpersonal interactions. A shared world is directly perceived and its existence structures reality itself for the perceiver. It is not just automatically applied to perception; it in many ways constitutes perception.

The philosophical roots of the relational frame theory (RFT) account of theory of mind arise from contextual psychology which refers to the study of organisms (both human and non-human) interacting in and with a historical and current situational context. It is an approach based on contextualism, a philosophy in which any event is interpreted as an ongoing act inseparable from its current and historical context and in which a radically functional approach to truth and meaning is adopted. As a variant of contextualism, RFT focuses on the construction of practical, scientific knowledge. This scientific form of contextual psychology is virtually synonymous with the philosophy of operant psychology.[24]

Development

The study of which animals are capable of attributing knowledge and mental states to others, as well as the development of this ability in human ontogeny and phylogeny, identifies several behavioral precursors to theory of mind. Understanding attention, understanding of others' intentions, and imitative experience with others are hallmarks of a theory of mind that may be observed early in the development of what later becomes a full-fledged theory.

Simon Baron-Cohen proposed that infants' understanding of attention in others acts as a "critical precursor" to the development of theory of mind.[2] Understanding attention involves understanding that seeing can be directed selectively as attention, that the looker assesses the seen object as "of interest", and that seeing can induce beliefs. A possible illustration of theory of mind in infants is joint attention. Joint attention refers to when two people look at and attend to the same thing. Parents often use the act of pointing to prompt infants to engage in joint attention; understanding this prompt requires that infants take into account another person's mental state, and understand that the person notices an object or finds it of interest. Baron-Cohen speculates that the inclination to spontaneously reference an object in the world as of interest, via pointing, ("protodeclarative

pointing") and to likewise appreciate the directed attention of another, may be the underlying motive behind all human communication.[2]

Understanding of others' intentions is another critical precursor to understanding other minds because intentionality, or "aboutness", is a fundamental feature of mental states and events. The "intentional stance" was defined by Daniel Dennett[25] as an understanding that others' actions are goal-directed and arise from particular beliefs or desires. Both two- and three-year-old children could discriminate when an experimenter intentionally vs. accidentally marked a box with stickers as baited.[26] Even earlier in ontogeny, Andrew N. Meltzoff found that 18-month-old infants could perform target manipulations that adult experimenters attempted and failed, suggesting the infants could represent the object-manipulating behavior of adults as involving goals and intentions.[27] While attribution of intention (the box-marking) and knowledge (false-belief tasks) is investigated in young humans and nonhuman animals to detect precursors to a theory of mind, Gagliardi et al. have pointed out that even adult humans do not always act in a way consistent with an attributional perspective.[28] In their experiment, adult human subjects made choices about baited containers when guided by confederates who could not see (and so could not know) which container was baited.

Research in developmental psychology suggests that an infant's ability to imitate others lies at the origins of both theory of mind and other social-cognitive achievements like perspective-taking and empathy.[29] According to Meltzoff, the infant's innate understanding that others are "like me" allows it to recognize the equivalence between the physical and mental states apparent in others and those felt by the self. For example, the infant uses his own experiences, orienting his head/eyes toward an object of interest to understand the movements of others who turn toward an object, that is, that they will generally attend to objects of interest or significance. Some researchers in comparative disciplines have hesitated to put a too-ponderous weight on imitation as a critical precursor to advanced human social-cognitive skills like mentalizing and empathizing, especially if true imitation is no longer employed by adults. A test of imitation by Alexandra Horowitz[30] found that adult subjects imitated an experimenter demonstrating a novel task far less closely than children did. Horowitz points out that the precise psychological state underlying imitation is unclear and cannot, by itself, be used to draw conclusions about the mental states of humans.

While much research has been done on infants, theory of mind develops continuously throughout childhood and into late adolescence as the synapses (neuronal connections) in the prefrontal cortex develop. The prefrontal cortex is thought to be involved in planning and decision-making.[31] Children seem to develop theory of mind skills sequentially. The first skill to develop is the ability to recognize that others have diverse desires. Children are able to recognize that others have diverse beliefs soon after. The next skill to develop is recognizing that others have access to different knowledge bases. Finally, children are able to understand that others may have false beliefs and that others are capable of hiding emotions. While this sequence represents the general trend in skill acquisition, it seems that more emphasis is placed on some skills in certain cultures, leading to more valued skills to develop before those that are considered not as important. For example, in individualistic cultures such as the United States, a greater emphasis is placed on the ability to recognize that others have different opinions and beliefs. In a collectivistic culture, such as China, this skill may not be as important and therefore may not develop until later.[32]

Language

There is evidence that the development of theory of mind is closely intertwined with language development in humans. One meta-analysis showed a moderate to strong correlation (r = 0.43) between performance on theory of mind and language tasks.[33] Both language and theory of mind begin to develop around the same time in children (between ages two and five), but many other abilities develop during this same time period as well, and they do not produce such high correlations with one another nor with theory of mind.

Pragmatic theories of communication[34] assume that infants must possess an understanding of beliefs and mental states of others to infer the communicative content that proficient language users intend to convey. Since a verbal utterance is often underdetermined, and so it can have different meanings depending on the actual context, theory of mind can play a crucial role in understanding the communicative and informative intentions of others and inferring the meaning of words. Some empirical results[35] suggest that even 13-month-old infants have an early capacity for communicative mind-reading that enables them to infer what relevant information is transferred between communicative partners, which implies that human language relies at least partially on theory of mind skills.

Carol A. Miller posed further possible explanations for this relationship. Perhaps the extent of verbal

communication and conversation involving children in a family could explain theory of mind development. Such language exposure could help introduce a child to the different mental states and perspectives of others.[36] Empirical findings indicate that participation in family discussion predicts scores on theory of mind tasks,[37] and that deaf children who have hearing parents and may not be able to communicate with their parents much during early years of development tend to score lower on theory of mind tasks.[38]

Another explanation of the relationship between language and theory of mind development has to do with a child's understanding of mental-state words such as "*think*" and "*believe*". Since a mental state is not something that one can observe from behavior, children must learn the meanings of words denoting mental states from verbal explanations alone, requiring knowledge of the syntactic rules, semantic systems, and pragmatics of a language.[36] Studies have shown that understanding of these mental state words predicts theory of mind in four-year-olds.[39]

A third hypothesis is that the ability to distinguish a whole sentence ("Jimmy thinks the world is flat") from its embedded complement ("the world is flat") and understand that one can be true while the other can be false is related to theory of mind development. Recognizing these sentential complements as being independent of one another is a relatively complex syntactic skill and correlates with increased scores on theory of mind tasks in children.[40]

There is also evidence that the areas of the brain responsible for language and theory of mind are closely connected. The temporoparietal junction (TPJ) is involved in the ability to acquire new vocabulary, as well as to perceive and reproduce words. The TPJ also contains areas that specialize in recognizing faces, voices, and biological motion, and in theory of mind. Since all of these areas are located so closely together, it is reasonable to suspect that they work together. Studies have reported an increase in activity in the TPJ when patients are absorbing information through reading or images regarding other peoples' beliefs but not while observing information about physical control stimuli.[41]

Theory of mind in adults

Neurotypical adults have theory of mind concepts that they developed as children (concepts such as belief, desire, knowledge, and intention). They use these concepts to meet the diverse demands of social life, ranging from snap decisions about how to trick an opponent in a competitive game, to keeping up with who knows what in a fast-moving conversation, to judging the guilt or innocence of the accused in a court of law.[42]

Boaz Keysar, Dale Barr, and colleagues found that adults often failed to *use* their theory of mind abilities to interpret a speaker's message, even though they were perfectly well aware that the speaker lacked critical knowledge.[43] Other studies show that adults are prone to "egocentric biases", with which they are influenced by their own beliefs, knowledge, or preferences when judging those of other people, or else they neglect other people's perspectives entirely.[44] There is also evidence that adults with greater memory and inhibitory capacity and greater motivation are more likely to use their theory of mind abilities.[45]

In contrast, evidence about indirect effects of thinking about other people's mental states suggests that adults may sometimes use their theory of mind automatically. Agnes Kovacs and colleagues measured the time it took adults to detect the presence of a ball as it was revealed from behind an occluder. They found that adults' speed of response was influenced by whether or not an avatar in the scene thought there was a ball behind the occluder, even though adults were not asked to pay attention to what the avatar thought.[46] Dana Samson and colleagues measured the time it took adults to judge the number of dots on the wall of a room. They found that adults responded more slowly when an avatar standing in the room happened to see fewer dots than they did, even when they had never been asked to pay attention to what the avatar could see.[47] It has been questioned whether these "altercentric biases" truly reflect automatic processing of what another person is thinking or seeing, or whether they instead reflect attention and memory effects cued by the avatar, but not involving any representation of what they think or see.[48]

Different theories seek to explain such results. If theory of mind is automatic, this would help explain how people keep up with the theory of mind demands of competitive games and fast-moving conversations. It might also explain evidence that human infants and some non-human species sometimes appear capable of theory of mind, despite their limited resources for memory and cognitive control.[49] If theory of mind is effortful and not automatic, on the other hand, this explains why it feels effortful to decide whether a defendant is guilty or innocent, or whether a negotiator is bluffing, and economy of effort would help explain why people sometimes neglect to

use their theory of mind.

Ian Apperly and Stephen Butterfill suggested that people have "two systems" for theory of mind,[50] in common with "two systems" accounts in many other areas of psychology.[51] In this account, "system 1" is cognitively efficient and enables theory of mind for a limited but useful set of circumstances. "System 2" is cognitively effortful, but enables much more flexible theory of mind abilities. Philosopher Peter Carruthers disagrees, arguing that the same core theory of mind abilities can be used in both simple and complex ways.[52] The account has been criticised by Celia Heyes who suggests that "system 1" theory of mind abilities do not require representation of mental states of other people, and so are better thought of as "sub-mentalising".[48]

Ageing

In older age, theory of mind capacities decline, irrespective of how exactly they are tested (e.g. stories, eyes, videos, false belief-video, false belief-other, and faux pas).[53] However, the decline in other cognitive functions is even stronger, suggesting that social cognition is better preserved. In contrast to theory of mind, empathy shows no impairments in aging.[54][55]

There are two kinds of theory of mind representations: cognitive (concerning the mental states, beliefs, thoughts, and intentions of others) and affective (concerning the emotions of others). Cognitive theory of mind is further separated into first order (e.g., I think she thinks that) and second order (e.g. he thinks that she thinks that). There is evidence that cognitive and affective theory of mind processes are functionally independent from one another.[56] In studies of Alzheimer's disease, which typically occurs in older adults, patients display impairment with second order cognitive theory of mind, but usually not with first order cognitive or affective theory of mind. However, it is difficult to discern a clear pattern of theory of mind variation due to age. There have been many discrepancies in the data collected thus far, likely due to small sample sizes and the use of different tasks that only explore one aspect of theory of mind. Many researchers suggest that theory of mind impairment is simply due to the normal decline in cognitive function.[57]

Cultural variations

Researchers propose that five key aspects of theory of mind develop sequentially for all children between the ages of three and five:[58] diverse desires (DD), diverse beliefs (DB), knowledge access (KA), false beliefs (FB), and hidden emotions (HE).[58] Australian, American, and European children acquire theory of mind in this exact order,[11] and studies with children in Canada, India, Peru, Samoa, and Thailand indicate that they all pass the false belief task at around the same time, suggesting that children develop theory of mind consistently around the world.[59]

However, children from Iran and China develop theory of mind in a slightly different order. Although they begin the development of theory of mind around the same time, toddlers from these countries understand knowledge access (KA) before Western children but take longer to understand diverse beliefs (DB).[11][60] Researchers believe this swap in the developmental order is related to the culture of collectivism in Iran and China, which emphasizes interdependence and shared knowledge as opposed to the culture of individualism in Western countries, which promotes individuality and accepts differing opinions. Because of these different cultural values, Iranian and Chinese children might take longer to understand that other people have different beliefs and opinions. This suggests that the development of theory of mind is not universal and solely determined by innate brain processes but also influenced by social and cultural factors.[11]

Historiography

Theory of mind can help historians to more properly understand historical figures' characters, for example Thomas Jefferson. Emancipationists like Douglas L. Wilson and scholars at the Thomas Jefferson Foundation view Jefferson as an opponent of slavery all his life, noting Jefferson's attempts within the limited range of options available to him to undermine slavery, his many attempts at abolition legislation, the manner in which he provided for slaves, and his advocacy of their more humane treatment. This view contrasts with that of revisionists like Paul Finkelman, who criticizes Jefferson for racism, slavery, and hypocrisy. Emancipationist views on this hypocrisy recognize that if he tried to be true to his word, it would have alienated his fellow Virginians. In another example, Franklin D. Roosevelt did not join NAACP leaders in pushing for federal anti-lynching legislation, as he believed that such legislation was unlikely to pass and that his support for it would alienate Southern congressmen, including many of Roosevelt's fellow Democrats.

Empirical investigation

Whether children younger than three or four years old have a theory of mind is a topic of debate among researchers. It is a challenging question, due to the difficulty of assessing what pre-linguistic children understand about others and the world. Tasks used in research into the development of theory of mind must take into account the *umwelt*[61] of the pre-verbal child.

False-belief task

One of the most important milestones in theory of mind development is the ability to attribute *false belief*: in other words, to understand that other people can believe things which are not true. To do this, it is suggested, one must understand how knowledge is formed, that people's beliefs are based on their knowledge, that mental states can differ from reality, and that people's behavior can be predicted by their mental states. Numerous versions of false-belief task have been developed, based on the initial task created by Wimmer and Perner (1983).[62]

In the most common version of the false-belief task (often called the "'Sally-Anne' test" or "'Sally-Anne' task"), children are told or shown a story involving two dolls, Sally and Anne, who have a basket and a box, respectively. Sally also has a marble, which she places into her basket, and then leaves the room. While she is out of the room, Anne takes the marble from the basket and puts it into the box. Sally returns, and the child is then asked where Sally will look for the marble. The child passes the task if she answers that Sally will look in the basket, where Sally put the marble; the child fails the task if she answers that Sally will look in the box, where the child knows the marble is hidden, even though Sally cannot know this, since she did not see it hidden there. To pass the task, the child must be able to understand that another's mental representation of the situation is different from their own, and the child must be able to predict behavior based on that understanding.[63]

Another example depicts a boy who leaves chocolate on a shelf and then leaves the room. His mother puts it in the fridge. To pass the task, the child must understand that the boy, upon returning, holds the false belief that his chocolate is still on the shelf.[64]

The results of research using false-belief tasks have been fairly consistent: most typically developing children are able to pass the tasks from around age four.[65] Notably, while most children, including those with Down syndrome, are able to pass this test, in one study, 80% of children diagnosed with autism were unable to do so.[66]

Adults may also struggle with false beliefs, for instance when they show hindsight bias—"the inclination to see events that have already happened as being more predictable than they were before they took place."[67] In one experiment, adult subjects who were asked for an independent assessment were unable to disregard information on actual outcome. Also in experiments with complicated situations, when assessing others' thinking, adults can fail to correctly disregard certain information that they have been given.[64]

Unexpected contents

Other tasks have been developed to try to extend the false-belief task. In the "Unexpected contents", or "Smarties" task, experimenters ask children what they believe to be the contents of a box that looks as though it holds a candy called "Smarties". After the child guesses (usually) "Smarties", it is shown that the box in fact contained pencils. The experimenter then re-closes the box and asks the child what she thinks another person, who has not been shown the true contents of the box, will think is inside. The child passes the task if he/she responds that another person will think that "Smarties" exist in the box, but fails the task if she responds that another person will think that the box contains pencils. Gopnik & Astington found that children pass this test at age four or five years.[68]

Other tasks

The "false-photograph" task[69] also measures theory of mind development. In this task, children must reason about what is represented in a photograph that differs from the current state of affairs. Within the false-photograph task, either a location or identity change exists.[70] In the location-change task, the examiner puts an object in one location (e.g. chocolate in an open green cupboard), whereupon the child takes a Polaroid photograph of the scene. While the photograph is developing,

the examiner moves the object to a different location (e.g. a blue cupboard), allowing the child to view the examiner's action. The examiner asks the child two control questions: "When we first took the picture, where was the object?" and "Where is the object now?" The subject is also asked a "false-photograph" question: "Where is the object in the picture?" The child passes the task if he/she correctly identifies the location of the object in the picture and the actual location of the object at the time of the question. However, the last question might be misinterpreted as "Where in this room is the object that the picture depicts?" and therefore some examiners use an alternative phrasing.[71]

To make it easier for animals, young children, and individuals with classical (Leo Kanner-type) autism to understand and perform theory of mind tasks, researchers have developed tests in which verbal communication is de-emphasized: some whose administration does not involve verbal communication on the part of the examiner, some whose successful completion does not require verbal communication on the part of the subject, and some that meet both of those standards. One category of tasks uses a preferential-looking paradigm, with looking time as the dependent variable. For instance, nine-month-old infants prefer looking at behaviors performed by a human hand over those made by an inanimate hand-like object.[72] Other paradigms look at rates of imitative behavior, the ability to replicate and complete unfinished goal-directed acts,[27] and rates of pretend play.[73]

Early precursors

Research on the early precursors of theory of mind has invented ways to observe preverbal infants' understanding of other people's mental states, including perception and beliefs. Using a variety of experimental procedures, studies show that infants from their first year of life have an implicit understanding of what other people see[74] and what they know.[75][76] A popular paradigm used to study infants' theory of mind is the violation-of-expectation procedure, which exploits infants' tendency to look longer at unexpected and surprising events compared to familiar and expected events. The amount of time they look at an event gives researchers an indication of what infants might be inferring, or their implicit understanding of events. One study using this paradigm found that 16-month-olds tend to attribute beliefs to a person whose visual perception was previously witnessed as being "reliable", compared to someone whose visual perception was "unreliable". Specifically, 16-month-olds were trained to expect a person's excited vocalization and gaze into a container to be associated with finding a toy in the reliable-looker condition or an absence of a toy in the unreliable-looker condition. Following this training phase, infants witnessed, in an object-search task, the same persons searching for a toy either in the correct or incorrect location after they both witnessed the location of where the toy was hidden. Infants who experienced the reliable looker were surprised and therefore looked longer when the person searched for the toy in the incorrect location compared to the correct location. In contrast, the looking time for infants who experienced the unreliable looker did not differ for either search locations. These findings suggest that 16-month-old infants can differentially attribute beliefs about a toy's location based on the person's prior record of visual perception.[77]

Methodological problems

With the methods used to test theory of mind, it has been experimentally shown that very simple robots that only react by reflexes and are not built to have any complex cognition at all can pass the tests for having theory of mind abilities that psychology textbooks assume to be exclusive to humans older than four or five years. Whether or not such a robot passes or fails the test is influenced by completely non-cognitive factors such as placement of objects and the structure of the robot body influencing how the reflexes are conducted. It has therefore been suggested that theory of mind tests may not actually test cognitive abilities.[78]

Deficits

Theory of mind impairment, or *mind-blindness*, describes a difficulty someone would have with perspective-taking. Individuals with theory of mind impairment struggle to see phenomena from any other perspective than their own.[79] Individuals who experience a theory of mind deficit have difficulty determining the intentions of others, lack understanding of how their behavior affects others, and have a difficult time with social reciprocity.[80] Theory of mind deficits have been observed in people with autism spectrum disorders, people with schizophrenia, people with nonverbal learning disorder, people with attention deficit hyperactivity disorder,[6] people under the influence of alcohol and narcotics, sleep-deprived people, and people who are experiencing severe emotional or physical pain. Theory of mind deficits have also been observed in deaf children who are

late signers (i.e. are born to hearing parents), but such a deficit is due to the delay in language learning, not any cognitive deficit, and therefore disappears once the child learns sign language.[81]

Autism

In 1985 Simon Baron-Cohen, Alan M. Leslie, and Uta Frith suggested that children with autism do not employ theory of mind[66] and that autistic children have particular difficulties with tasks requiring the child to understand another person's beliefs. These difficulties persist when children are matched for verbal skills[82] and they have been taken as a key feature of autism. Although in a 2019 review, Gernsbacher and Yergeau argued that "the claim that autistic people lack a theory of mind is empirically questionable", as there have been numerous failed replications of classic ToM studies and the meta-analytical effect sizes of such replications were minimal to small.[83]

Many individuals classified as autistic have severe difficulty assigning mental states to others, and some seem to lack theory of mind capabilities.[84] Researchers who study the relationship between autism and theory of mind attempt to explain the connection in a variety of ways. One account assumes that theory of mind plays a role in the attribution of mental states to others and in childhood pretend play.[85] According to Leslie,[85] theory of mind is the capacity to mentally represent thoughts, beliefs, and desires, regardless of whether or not the circumstances involved are real. This might explain why some autistic individuals show extreme deficits in both theory of mind and pretend play. However, Hobson proposes a social-affective justification,[86] in which deficits in theory of mind in autistic people result from a distortion in understanding and responding to emotions. He suggests that typically developing individuals, unlike autistic individuals, are born with a set of skills (such as social referencing ability) that later lets them comprehend and react to other people's feelings. Other scholars emphasize that autism involves a specific developmental delay, so that autistic children vary in their deficiencies, because they experience difficulty in different stages of growth. Very early setbacks can alter proper advancement of joint-attention behaviors, which may lead to a failure to form a full theory of mind.[84]

It has been speculated[73] that theory of mind exists on a continuum as opposed to the traditional view of a discrete presence or absence. While some research has suggested that some autistic populations are unable to attribute mental states to others,[2] recent evidence points to the possibility of coping mechanisms that facilitate a spectrum of mindful behavior.[87] A binary view regarding theory of mind contributes to the stigmatization of autistic adults that do possess perspective-taking capacity, as the assumption that autistic people do not have empathy can become a rationale for dehumanization.[88]

Tine et al. report that autistic children score substantially lower on measures of social theory of mind in comparison to children diagnosed with Asperger syndrome.[89]

Generally, children with more advanced theory of mind abilities display more advanced social skills, greater adaptability to new situations, and greater cooperation with others. As a result, these children are typically well-liked. However, "children may use their mind-reading abilities to manipulate, outwit, tease, or trick their peers."[90] Individuals possessing inferior theory of mind skills, such as children with autism spectrum disorder, may be socially rejected by their peers since they are unable to communicate effectively. Social rejection has been proven to negatively impact a child's development and can put the child at greater risk of developing depressive symptoms.[91]

Peer-mediated interventions (PMI) are a school-based treatment approach for children and adolescents with autism spectrum disorder in which peers are trained to be role models in order to promote social behavior. Laghi et al. studied whether analysis of prosocial (nice) and antisocial (nasty) theory-of-mind behaviors could be used, in addition to teacher recommendations, to select appropriate candidates for PMI programs. Selecting children with advanced theory-of-mind skills who use them in prosocial ways will theoretically make the program more effective. While the results indicated that analyzing the social uses of theory of mind of possible candidates for a PMI program is invaluable, it may not be a good predictor of a candidate's performance as a role model.[31]

A 2014 Cochrane review on interventions based on theory of mind found that such a theory could be taught to individuals with autism but claimed little evidence of skill maintenance, generalization to other settings, or development effects on related skills.[92]

Some 21st century studies have shown that the results of some studies of theory of mind tests on autistic people may be misinterpreted based on the double empathy problem, which proposes that rather than autistic people specifically having trouble with theory of mind, autistic people and non-autistic people have equal difficulty understanding one-another due to their neurological

differences.[93] Studies have shown that autistic adults perform better in theory of mind tests when paired with other autistic adults[94] as well as possibly autistic close family members.[95] Academics who acknowledge the double empathy problem also propose that it is likely autistic people understand non-autistic people to a higher degree than vise-versa, due to the necessity of functioning in a non-autistic society.[96]

Schizophrenia

Individuals diagnosed with schizophrenia can show deficits in theory of mind. Mirjam Sprong and colleagues investigated the impairment by examining 29 different studies, with a total of over 1500 participants.[97] This meta-analysis showed significant and stable deficit of theory of mind in people with schizophrenia. They performed poorly on false-belief tasks, which test the ability to understand that others can hold false beliefs about events in the world, and also on intention-inference tasks, which assess the ability to infer a character's intention from reading a short story. Schizophrenia patients with negative symptoms, such as lack of emotion, motivation, or speech, have the most impairment in theory of mind and are unable to represent the mental states of themselves and of others. Paranoid schizophrenic patients also perform poorly because they have difficulty accurately interpreting others' intentions. The meta-analysis additionally showed that IQ, gender, and age of the participants do not significantly affect the performance of theory of mind tasks.[97]

Research suggests that impairment in theory of mind negatively affects clinical insight—the patient's awareness of their mental illness.[98] Insight requires theory of mind; a patient must be able to adopt a third-person perspective and see the self as others do.[99] A patient with good insight can accurately self-represent, by comparing himself with others and by viewing himself from the perspective of others.[98] Insight allows a patient to recognize and react appropriately to his symptoms. A patient who lacks insight does not realize that he has a mental illness, because of his inability to accurately self-represent. Therapies that teach patients perspective-taking and self-reflection skills can improve abilities in reading social cues and taking the perspective of another person.[98]

Research indicates that theory-of-mind deficit is a stable trait-characteristic rather than a state-characteristic of schizophrenia.[100] The meta-analysis conducted by Sprong et al. showed that patients in remission still had impairment in theory of mind. This indicates that the deficit is not merely a consequence of the active phase of schizophrenia.[97]

Schizophrenic patients' deficit in theory of mind impairs their interactions with others. Theory of mind is particularly important for parents, who must understand the thoughts and behaviors of their children and react accordingly. Dysfunctional parenting is associated with deficits in the first-order theory of mind, the ability to understand another person's thoughts, and in the second-order theory of mind, the ability to infer what one person thinks about another person's thoughts.[101] Compared with healthy mothers, mothers with schizophrenia are found to be more remote, quiet, self-absorbed, insensitive, unresponsive, and to have fewer satisfying interactions with their children.[101] They also tend to misinterpret their children's emotional cues, and often misunderstand neutral faces as negative.[101] Activities such as role-playing and individual or group-based sessions are effective interventions that help the parents improve on perspective-taking and theory of mind.[101] There is a strong association between theory of mind deficit and parental role dysfunction.

Alcohol use disorders

Impairments in theory of mind, as well as other social-cognitive deficits, are commonly found in people who have alcohol use disorders, due to the neurotoxic effects of alcohol on the brain, particularly the prefrontal cortex.[8]

Depression and dysphoria

Individuals in a major depressive episode, a disorder characterized by social impairment, show deficits in theory of mind decoding.[102] Theory of mind decoding is the ability to use information available in the immediate environment (e.g., facial expression, tone of voice, body posture) to accurately label the mental states of others. The opposite pattern, enhanced theory of mind, is observed in individuals vulnerable to depression, including those individuals with past major depressive disorder (MDD),[103] dysphoric individuals,[104] and individuals with a maternal history

of MDD.[105]

Developmental language disorder

Children diagnosed with developmental language disorder (DLD) exhibit much lower scores on reading and writing sections of standardized tests, yet have a normal nonverbal IQ. These language deficits can be any specific deficits in lexical semantics, syntax, or pragmatics, or a combination of multiple problems. Such children often exhibit poorer social skills than normally developing children, and seem to have problems decoding beliefs in others. A recent meta-analysis confirmed that children with DLD have substantially lower scores on theory of mind tasks compared to typically developing children.[106] This strengthens the claim that language development is related to theory of mind.

Brain mechanisms

In neurotypical people

Research on theory of mind in autism led to the view that mentalizing abilities are subserved by dedicated mechanisms that can—in some cases—be impaired while general cognitive function remains largely intact.

Neuroimaging research supports this view, demonstrating specific brain regions are consistently engaged during theory of mind tasks. PET research on theory of mind, using verbal and pictorial story comprehension tasks, identifies a set of brain regions including the medial prefrontal cortex (mPFC), and area around posterior superior temporal sulcus (pSTS), and sometimes precuneus and amygdala/temporopolar cortex.[107][108] Research on the neural basis of theory of mind has diversified, with separate lines of research focusing on the understanding of beliefs, intentions, and more complex properties of minds such as psychological traits.

Studies from Rebecca Saxe's lab at MIT, using a false-belief versus false-photograph task contrast aimed at isolating the mentalizing component of the false-belief task, have consistently found activation in mPFC, precuneus, and temporoparietal junction (TPJ), right-lateralized.[109][110] In particular, it has been proposed that the right TPJ (rTPJ) is selectively involved in representing the beliefs of others.[111] Some debate exists, as the same rTPJ region is consistently activated during spatial reorienting of visual attention;[112][113] Jean Decety from the University of Chicago and Jason Mitchell from Harvard thus propose that the rTPJ subserves a more general function involved in both false-belief understanding and attentional reorienting, rather than a mechanism specialized for social cognition. However, it is possible that the observation of overlapping regions for representing beliefs and attentional reorienting may simply be due to adjacent, but distinct, neuronal populations that code for each. The resolution of typical fMRI studies may not be good enough to show that distinct/adjacent neuronal populations code for each of these processes. In a study following Decety and Mitchell, Saxe and colleagues used higher-resolution fMRI and showed that the peak of activation for attentional reorienting is approximately 6–10mm above the peak for representing beliefs. Further corroborating that differing populations of neurons may code for each process, they found no similarity in the patterning of fMRI response across space.[114]

Using single-cell recordings in the human dorsomedial prefrontal cortex (dmPFC), researchers at MGH identified neurons that encode information about others' beliefs, which were distinct from self beliefs, across different scenarios in a False-belief task. They further showed high specificity between cells based on the content of the others' beliefs and were able to accurately predict whether these beliefs were true or false.[115] These findings suggest a prominent role of distinct neuronal populations in the dmPFC in theory of Mmind complemented by the TPJ and pSTS.

Functional imaging also illuminates the detection of mental state information in Heider-Simmel-esque animations of moving geometric shapes, which typical humans automatically perceive as social interactions laden with intention and emotion. Three studies found remarkably similar patterns of activation during the perception of such animations versus a random or deterministic motion control: mPFC, pSTS, fusiform face area (FFA), and amygdala were selectively engaged during the theory of mind condition.[116] Another study presented subjects with an animation of two dots moving with a parameterized degree of intentionality (quantifying the extent to which the dots chased each other), and found that pSTS activation correlated with this parameter.[117]

A separate body of research implicates the posterior superior temporal sulcus in the perception of

intentionality in human action. This area is also involved in perceiving biological motion, including body, eye, mouth, and point-light display motion.[118] One study found increased pSTS activation while watching a human lift his hand versus having his hand pushed up by a piston (intentional versus unintentional action).[119] Several studies found increased pSTS activation when subjects perceive a human action that is incongruent with the action expected from the actor's context and inferred intention. Examples would be: a human performing a reach-to-grasp motion on empty space next to an object, versus grasping the object;[120] a human shifting eye gaze toward empty space next to a checkerboard target versus shifting gaze toward the target;[121] an unladen human turning on a light with his knee, versus turning on a light with his knee while carrying a pile of books;[122] and a walking human pausing as he passes behind a bookshelf, versus walking at a constant speed.[123] In these studies, actions in the "congruent" case have a straightforward goal, and are easy to explain in terms of the actor's intention. The incongruent actions, on the other hand, require further explanation (why would someone twist empty space next to a gear?), and apparently demand more processing in the STS. This region is distinct from the temporoparietal area activated during false belief tasks.[123] pSTS activation in most of the above studies was largely right-lateralized, following the general trend in neuroimaging studies of social cognition and perception. Also right-lateralized are the TPJ activation during false belief tasks, the STS response to biological motion, and the FFA response to faces.

Neuropsychological evidence supports neuroimaging results regarding the neural basis of theory of mind. Studies with patients with a lesion of the frontal lobes and the temporoparietal junction of the brain (between the temporal lobe and parietal lobe) report that they have difficulty with some theory of mind tasks.[124] This shows that theory of mind abilities are associated with specific parts of the human brain. However, the fact that the medial prefrontal cortex and temporoparietal junction are necessary for theory of mind tasks does not imply that these regions are specific to that function.[112][125] TPJ and mPFC may subserve more general functions necessary for Theory of Mind.

Research by Vittorio Gallese, Luciano Fadiga, and Giacomo Rizzolatti[126] shows that some sensorimotor neurons, referred to as mirror neurons and first discovered in the premotor cortex of rhesus monkeys, may be involved in action understanding. Single-electrode recording revealed that these neurons fired when a monkey performed an action, as well as when the monkey viewed another agent performing the same action. fMRI studies with human participants show brain regions (assumed to contain mirror neurons) that are active when one person sees another person's goal-directed action.[127] These data led some authors to suggest that mirror neurons may provide the basis for theory of mind in the brain, and to support simulation theory of mind reading.[128]

There is also evidence against a link between mirror neurons and theory of mind. First, macaque monkeys have mirror neurons but do not seem to have a 'human-like' capacity to understand theory of mind and belief. Second, fMRI studies of theory of mind typically report activation in the mPFC, temporal poles, and TPJ or STS,[129] but those brain areas are not part of the mirror neuron system. Some investigators, like developmental psychologist Andrew Meltzoff and neuroscientist Jean Decety, believe that mirror neurons merely facilitate learning through imitation and may provide a precursor to the development of theory of mind.[130] Others, like philosopher Shaun Gallagher, suggest that mirror-neuron activation, on a number of counts, fails to meet the definition of simulation as proposed by the simulation theory of mindreading.[131][132]

In autism

Several neuroimaging studies have looked at the neural basis for theory of mind impairment in subjects with Asperger syndrome and high-functioning autism (HFA). The first PET study of theory of mind in autism (also the first neuroimaging study using a task-induced activation paradigm in autism) replicated a prior study in neurotypical individuals, which employed a story-comprehension task.[133] This study found displaced and diminished mPFC activation in subjects with autism. However, because the study used only six subjects with autism, and because the spatial resolution of PET imaging is relatively poor, these results should be considered preliminary.

A subsequent fMRI study scanned normally developing adults and adults with HFA while performing a "reading the mind in the eyes" task: viewing a photo of a human's eyes and choosing which of two adjectives better describes the person's mental state, versus a gender discrimination control.[134] The authors found activity in orbitofrontal cortex, STS, and amygdala in normal subjects, and found less amygdala activation and abnormal STS activation in subjects with autism.

A more recent PET study looked at brain activity in individuals with HFA and Asperger syndrome while viewing Heider-Simmel animations (see above) versus a random motion control.[135] In

contrast to normally-developing subjects, those with autism showed little STS or FFA activation, and less mPFC and amygdala activation. Activity in extrastriate regions V3 and LO was identical across the two groups, suggesting intact lower-level visual processing in the subjects with autism. The study also reported less functional connectivity between STS and V3 in the autism group. However decreased temporal correlation between activity in STS and V3 would be expected simply from the lack of an evoked response in STS to intent-laden animations in subjects with autism. A more informative analysis would be to compute functional connectivity after regressing out evoked responses from all-time series.

A subsequent study, using the incongruent/congruent gaze-shift paradigm described above, found that in high-functioning adults with autism, posterior STS (pSTS) activation was undifferentiated while they watched a human shift gaze toward a target and then toward adjacent empty space.[136] The lack of additional STS processing in the incongruent state may suggest that these subjects fail to form an expectation of what the actor should do given contextual information, or that feedback about the violation of this expectation doesn't reach STS. Both explanations involve an impairment or deficit in the ability to link eye gaze shifts with intentional explanations. This study also found a significant anticorrelation between STS activation in the incongruent-congruent contrast and social subscale score on the Autism Diagnostic Interview-Revised, but not scores on the other subscales.

An fMRI study demonstrated that the right temporoparietal junction (rTPJ) of higher-functioning adults with autism was not more selectively activated for mentalizing judgments when compared to physical judgments about self and other.[137] rTPJ selectivity for mentalizing was also related to individual variation on clinical measures of social impairment: individuals whose rTPJ was increasingly more active for mentalizing compared to physical judgments were less socially impaired, while those who showed little to no difference in response to mentalizing or physical judgments were the most socially impaired. This evidence builds on work in typical development that suggests rTPJ is critical for representing mental state information, irrespective of whether it is about oneself or others. It also points to an explanation at the neural level for the pervasive mind-blindness difficulties in autism that are evident throughout the lifespan.[138]

In schizophrenia

The brain regions associated with theory of mind include the superior temporal gyrus (STS), the temporoparietal junction (TPJ), the medial prefrontal cortex (mPFC), the precuneus, and the amygdala.[139] The reduced activity in the mPFC of individuals with schizophrenia is associated with theory of mind deficit and may explain impairments in social function among people with schizophrenia.[140] Increased neural activity in mPFC is related to better perspective-taking, emotion management, and increased social functioning.[140] Disrupted brain activities in areas related to theory of mind may increase social stress or disinterest in social interaction, and contribute to the social dysfunction associated with schizophrenia.[140]

Practical validity

Group member average scores of theory of mind abilities, measured with the Reading the Mind in the Eyes test[141] (RME), are possibly drivers of successful group performance.[142] High group average scores on the RME are correlated with the collective intelligence factor *c*, defined as a group's ability to perform a wide range of mental tasks,[142][143] a group intelligence measure similar to the *g* factor for general individual intelligence. RME is a theory of mind test for adults[141] that shows sufficient test-retest reliability[144] and constantly differentiates control groups from individuals with functional autism or Asperger syndrome.[141] It is one of the most widely accepted and well-validated tests for theory of mind abilities within adults.[145]

Evolution

The evolutionary origin of theory of mind remains obscure. While many theories make claims about its role in the development of human language and social cognition, few of them specify in detail any evolutionary neurophysiological precursors.

One theory claims that theory of mind has its roots in two defensive reactions—immobilization stress and tonic immobility—which are implicated in the handling of stressful encounters and also figure prominently in mammalian childrearing practices.[146] Their combined effect seems capable of producing many of the hallmarks of theory of mind, such as eye-contact, gaze-following, inhibitory control, and intentional attributions.

Non-human

An open question is whether non-human animals have a genetic endowment and social environment that allows them to acquire a theory of mind like human children do.[12] This is a contentious issue because of the difficulty of inferring from animal behavior the existence of thinking or of particular thoughts, or the existence of a concept of self or self-awareness, consciousness, and qualia. One difficulty with non-human studies of theory of mind is the lack of sufficient numbers of naturalistic observations, giving insight into what the evolutionary pressures might be on a species' development of theory of mind.

Non-human research still has a major place in this field. It is especially useful in illuminating which nonverbal behaviors signify components of theory of mind, and in pointing to possible stepping points in the evolution of that aspect of social cognition. While it is difficult to study human-like theory of mind and mental states in species of whose potential mental states we have an incomplete understanding, researchers can focus on simpler components of more complex capabilities. For example, many researchers focus on animals' understanding of intention, gaze, perspective, or knowledge (of what another being has seen). A study that looked at understanding of intention in orangutans, chimpanzees, and children showed that all three species understood the difference between accidental and intentional acts.[26]

Individuals exhibit theory of mind by extrapolating another's internal mental states from their observable behavior. So one challenge in this line of research is to distinguish this from more run-of-the-mill stimulus-response learning, with the other's observable behavior being the stimulus.

Recently, most non-human theory of mind research has focused on monkeys and great apes, who are of most interest in the study of the evolution of human social cognition. Other studies relevant to attributions theory of mind have been conducted using plovers[147] and dogs,[148] which show preliminary evidence of understanding attention—one precursor of theory of mind—in others.

There has been some controversy over the interpretation of evidence purporting to show theory of mind ability—or inability—in animals.[149] For example, Povinelli *et al.*[150] presented chimpanzees with the choice of two experimenters from whom to request food: one who had seen where food was hidden, and one who, by virtue of one of a variety of mechanisms (having a bucket or bag over his head, a blindfold over his eyes, or being turned away from the baiting) does not know, and can only guess. They found that the animals failed in most cases to differentially request food from the "knower". By contrast, Hare, Call, and Tomasello found that subordinate chimpanzees were able to use the knowledge state of dominant rival chimpanzees to determine which container of hidden food they approached.[49] William Field and Sue Savage-Rumbaugh believe that bonobos have developed theory of mind, and cite their communications with a captive bonobo, Kanzi, as evidence.[151]

In one experiment, ravens (*Corvus corax*) took into account visual access of unseen conspecifics. The researchers argued that "ravens can generalize from their own perceptual experience to infer the possibility of being seen".[152]

Evolutionary anthropologist Christopher Krupenye studied the existence of theory of mind, and particularly false beliefs, in non-human primates.[153]

Keren Haroush and Ziv Williams outlined the case for a group of neurons in primates' brains that uniquely predicted the choice selection of their interacting partner. These primates' neurons, located in the anterior cingulate cortex of rhesus monkeys, were observed using single-unit recording while the monkeys played a variant of the iterative prisoner's dilemma game.[154] By identifying cells that represent the yet unknown intentions of a game partner, Haroush & Williams' study supports the idea that theory of mind may be a fundamental and generalized process, and suggests that *anterior cingulate cortex* neurons may act to complement the function of mirror neurons during social interchange.[155]

See also

- Attribution bias
- Cephalopod intelligence
- Cetacean intelligence
- Eliminative materialism
- Empathy
- Grounding in communication

- Intentional stance
- Joint attention
- Mental body
- Mentalization
- Mini-SEA
- Origin of language
- Perspective-taking
- Quantum mind
- Relational frame theory
- Self-awareness
- Social neuroscience
- Embodied cognition
- Space mapping
- *The Mind of an Ape*
- Turing test
- Type physicalism
- Interpersonal accuracy

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Further reading

- Excerpts taken from: Davis, E. (2007) "Mental Verbs in Nicaraguan Sign Language and the Role of Language in Theory of Mind." Undergraduate senior thesis, Barnard College, Columbia University.

External links

- Eye Test Simon Baron Cohen (https://huxta.com/theory-of-mind-eye-test/)
- The Computational Theory of Mind (http://plato.stanford.edu/entries/computational-mind/)
- The Identity Theory of Mind (http://plato.stanford.edu/entries/mind-identity/)
- Sally-Anne and Smarties tests (https://web.archive.org/web/20050502042438/http://www.psychology.nottingham.ac.uk/staff/plm/c81ind/lecture6.pdf)
- Functional Contextualism (http://www.contextualpsychology.org/functional_contextualism_0/)
- Theory of Mind (http://www.iep.utm.edu/theomind/) article in the *Internet Encyclopedia of Philosophy*
