The Phenomena of “Self” and “Other” Within the Human Brain: a Developmental Perspective

Caleb Sponheim

Grinnell College

Abstract

Human society relies heavily upon the inference of others’ thoughts, intentions, emotions, and actions. Cognitive mechanisms such as empathy, intention, emotional understanding, and Theory of Mind develop at an early age to allow an individual to understand the perspective of another human being, enabling participation in complex social interaction. Research has found that the development of these social skills inhabit many of the same neural pathways used to understand one’s own behavior. This neural “shortcut” can lead to sensory confusion, mental disorders, and other examples of where the line between “self” and “other” becomes fuzzy. Facial expressions and motor actions are unintentionally mirrored, emotions are felt as one’s own, and, in some rare occasions, people literally feel each other’s pain. The current review will not only examine psychological phenomena such as mirror neurons and mirror-touch synesthesia, but will do so via a grounding in developmental psychology, providing a cohesive explanation of the systems controlling the representations of “self” and “other” within the human mind. Further research must use developmental psychology to conceptualize these phenomena; understanding how these disorders originate will enable new treatments and future research.

Keywords: Theory of Mind, Mirror Neurons, Developmental Psychology, Synesthesia

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Homo Sapiens are characterized by their construction and maintenance of large, complex societies (Effland, 1998). Humans are social animals, and have evolved to rely upon one another to survive. Interactions with other human beings are integral to culture. Because interactions are so important to human survival, over time, cognitive and cultural structures have evolved to facilitate easier co-interaction among individuals. These structures enable individuals to infer behavior, emotion, and intention in other humans, creating smooth contact and communication. Those who have a hampered ability to infer suffer in the social world; autistic individuals find themselves locked from complex social concepts, and individuals high in psychopathy fail to feel the empathy required to participate in the most basic human emotions (Myers & Johnson, 2007).

In reality, no human being begins life with the skills required to successfully navigate the social world. Infants, during their stages of rapid cognitive and physical development, develop a Theory of Mind, which allow them to differentiate their own goals, thoughts, and intentions from another's (Wellman, 1990). Theory of Mind and other cognitive concepts such as emotional development, intention, and empathy allow children to conceptualize others' thoughts, feelings, and perspectives as different from their own. This distinction between "self" and "other" is driven by mechanisms such as mirror neurons, empathy, and embodied cognition. These phenomena that allow humans to understand others' behavior in parallel to the same mechanisms that humans use to understand their own volitions. These cognitive mechanisms facilitate most social interactions (Gallese, 2009).

Once these tools have been established in early childhood, the foundation upon which they are built affords vulnerabilities to these systems (Lonigro, Laghi, Baiocco, & Baumgartner, 2014). Disorders such as mirror-touch synesthesia show that the mechanisms by which humans

understand others’ behavior inhabit the same space as their own personal experience. Modern neuroscience has identified structures such as mirror neurons that confirm the hypothesis that humans use the same pathways to simulate others’ experiences as their own. These shared mechanisms allow for deep inference of behavior and understanding of others, but run the risk of crossing the border between subconscious and conscious experience, causing some individuals to experience others’ sensations and emotions as their own.

Development of social skills like Theory of Mind inhabit many of the same neural pathways used to understand one’s own behavior. This “shortcut” can lead to sensory confusion and mental disorders. Further research must use developmental psychology to conceptualize these phenomena; understanding how these disorders originate will enable new treatments and future research. The current review will not only examine psychological phenomena such as mirror neurons and mirror-touch synesthesia, but will do so via a grounding in developmental psychology, providing a cohesive explanation of the systems controlling the representations of “self” and “other” within the human mind.

Development of “self” and “other”

Theory of Mind and its Associated Components

Theory of Mind is often described as the skill to infer and attribute intention, behaviors, thoughts, and emotion to individuals other than one’s self (Wellman, 1990). Although the exact age ranges wildly, researchers generally agree that typical children develop a Theory of Mind between four and seven years of age. The development of Theory of Mind is not a uniform process, either; some individuals continue to fully mature their conception of others and some may halt their development through lack of exposure or experience. It has been shown that children who develop a “nasty” Theory of Mind may exhibit antisocial or Machiavellian

behaviors. Conversely, children who develop a “nice” Theory of Mind show higher moral and emotional sensitivity (Lonigro, Laghi, Baiocco & Baumgartner, 2014).

Not all Theories of Mind are created equal. There are a large number of complexities associated with the concept of Theory of Mind such as empathy, motor mirroring, and emotion understanding. Each of these aspects may develop in different ways and at different speeds. For example, Carleson & Moses (2001) show that establishing the difference between “self” and “other” is essential before one can begin replicating another’s actions, and that children ages three or below even have problems identifying when a belief may be false or true.

For example, there are some components of the “self” which develop much earlier. In Rochat & Hespos’ (1997) study, researchers discovered that babies as young as four weeks have the ability to discriminate between external and self-created stimuli. Babies differentiated between their own touch to their cheek and an experimenters touch by turning and facing an external stimuli. This research shows that although Theory of Mind has not been developed, infants have a strong aptitude for discriminating between “self” and “other” very early on in development.

An additional study completed by Wimmer and Perner (1983) focused on a child’s ability to understand another’s deception. Their study examined the crucial periods of time around which Theory of Mind is being developed: 3-4 years old, 4-6 years old, and 6-9 years old. Through their data, the authors were able to identify the point at which Theory of Mind emerges. Their task required children to understand a protagonist’s actions in relation to an antagonist, and predict the actions of the protagonist in response. In order to predict correctly, children had to understand the relationship between two persons’ states of being and consciousness. This skill emerged in those children ages between 4 and 6. Previous to the development of this predictive

skill, children could not understand the intention of either character in relation to the other. This study is particularly exemplary because it pinpoints the time when children start to develop the essential cognitive qualities that will eventually make up a Theory of Mind.

Once Theory of Mind has been developed, it is immediately put into use developing other important cognitive functions. For example, children often require Theory of Mind in order to achieve emotion comprehension and the ability to more accurately identify complex facial expressions (Weimer, Sallquist & Bolnick, 2012). Additionally, the development of Theory of Mind alongside Emotion Understanding predicts a greater appreciation for authority and higher amounts of acceptance-authority reasoning, potentially signaling an understanding of their desire to behave in a way society will approve (Lane, Wellman, Olson, LaBounty, & Kerr, 2010). Complexities of Theory of Mind can all be observed in children at different points in development, and the scrutiny of these phenomenon will reveal pertinent insights into the inner workings of humans' relationships between “self” and “other”. There are specific aspects this understanding that deem higher scrutiny than others, and that provide implications for adulthood and future research: Empathy, Intention and Emotion.

Empathetic Development

Children, before their development of Theory of Mind, have difficulty understanding the intentionality behind a given action and therefore empathizing with anything another individual might feel. If a child does not have the ability to create a remote connection to another individual’s emotions, empathy is extremely difficult to grasp. One aspect of Theory of Mind is the inference of thought and intention in other individuals; empathy quickly follows Theory of Mind development. Though a series of experiments with 18-month old children, Meltzoff (1995) showed that children can infer and imitate an adult’s intended action through the understanding

of goals and intention, even at a young age. They do not, however, understand the conceptual perspective that adult holds. There is also evidence to suggest that the development of empathy in children is essential to prosocial behavior. Those that do not develop it suffer in the long run (Lonigro, Laghi, Baiocco & Baumgartner, 2014). Bullies have lower levels of affective empathy, and children with high levels of empathy tend not to bully in the future.

The relationship between Theory of Mind and empathy is complex, as Lonigro and colleagues discovered. By implicating the previously mentioned models of Nice and Nasty Theory of Mind, the study found that children with a “nice” Theory of Mind attained the highest empathy scores, fostering prosocial behavior and inhibited antisocial behavior. The findings of this study not only suggest that Theory of Mind is implicated with empathy, but that empathy possibly strengthens the connection between Theory of Mind and social functioning. A child without empathy may create a Theory of Mind, but may have trouble interacting in a prosocial way, whereas a child with empathy will successfully exhibit their Theory of Mind through prosocial behavior.

Although a child may develop a “nasty” Theory of Mind without empathy, certain mental disorders prevent children from developing any social connection to other humans at all. There are distinct differences in Theory of Mind in a developmentally delayed child, compared to one suffering from autism (Meltzoff, 1995). Using special screening procedures, research has been accomplished that shows a marked difference in the ways that infants with autism process empathy, attention, and imitation from a control population of developmentally delayed infants. Infants with autism would not express any facial concern when confronted with feigned distress, even though the facial expressions were “noticed” by the infants (Charman, Swettenham, Baron-Cohen, Cox, Baird, & Drew, 1997). The inability to internally register emotions at a young age

significantly hampers autistic infants’ ability to understand the world, setting them up for failure in the future. Research in autism is strongly grounded in development, and takes advantage of understanding the mechanisms by which autism might occur. The same does not occur when considering failures in broader systems that support “self” and “other” in the human brain. Empathy is a key component of not only Theory of Mind, but of development as a whole. Failure to understand the emotions of others can lead to future frustration, and can be caused by “shortcuts” the brain takes to enable empathy. Future research should examine the relationship between empathy and phenomena that cross the wires between “self” and “other”.

Development of Intention as a Precursor to Theory of Mind

Research has shown that many puzzle pieces are required to build a Theory of Mind and strong empathy, and that there are many points at which things can go wrong. Another central cornerstone of Theory of Mind is Intention. Considered an early developmental stage, understanding the intentionality of a motion or action is essential to human interaction. The understanding of intention, however, does not connote the deeper meaning of an action, of the perspective of the individual completing the action. There is no connection between the goals of people and the actions they take to complete those goals. The development of “why” is often made at a later point than the development of the understanding of the goal of an action. For example, babies as old as 14 months have the ability to understand the target result of goal-directed behavior, but they fail to understand why an action might be taken. Infants that observed two ways of interacting with a large button consciously chose to mimic actions that were most efficient and ignore inefficient actions, regardless of the order of presentation, denoting a mechanism of selective inference (Gergely, Bekkering, & Király, 2002). While infants see to

have the power of inference, the understanding of goals and ascribing action is a fundamentally more complex task.

In a series of experiments with children ages three to seven, researchers were able to examine the point at which intention and goal ascribing occurs in development. All children were able to identify the goal of a basic motor task, but found it more difficult to explain why the task might be completed. By the ages of six and seven, a majority of children could understand the meaning behind the action, signifying that certain mechanisms came into existence that previously did not exist (Bello, Sparaci, Stefanini, Boria, & Volterra, 2013). These results suggest that knowing the “what” of an action enables a child to eventually associate an outcome with the action and, therefore, an intention. Over time, children begin to make connections between the goals of people and the actions they take to complete those goals. At a certain point, the connection becomes clear, at which time the child has acquired a new advanced cognitive skill. Ascribing actions to goals and intentions allow a child to engage in complex social interactions, enhancing social development and leading to the eventual growth of a Theory of Mind.

Emotion as a Moderator of Theory of Mind

Some of the most interesting and complex mechanisms associated with the development of “self” and “other” in children are the mechanisms of emotional understanding. Although they often run side-by-side, researchers have identified Emotional Understanding and Theory of Mind as separate constructs, affected by different experiences and stimuli. Research has shown that only specific types of experiences advance an individual’s understanding of emotion in others; specifically, three influences rise to the top of conclusion made by research (Weimer, Sallquist & Bolnick, 2012). First, the ability for a child to understand the cause of emotion is key to age-

related development. Second, recognizing that a reminder or external stimuli can influence emotion is important in development; it also shows that the child is improving their ability to conceptualize another individual’s mental model. Third, the acknowledgement of hidden emotions and their potential effect on others creates a possibility to meaningful development over time. Children who had better emotion understanding also scored higher on Theory of Mind tasks, indicating that although they are separate constructs. Theory of Mind and Emotion Understanding are related, and when they are combined, greater understanding of the world is achieved. The combination of Theory of Mind and Emotional Understanding leads to the development of other complex cognitive skills, as discussed in research completed by Lane, Wellman, Olson, LaBounty, and Kerr (2010), in which researchers examined how these variables affected different types of reasoning in a social-cognitive context. Through a series of experiments, researchers discovered that children benefited the most from a combination of emotional understanding and Theory of Mind, which resulted in a higher appreciation for knowledge held by authority figures. This heightened aspect of cognition belies a deeper understanding of social mechanisms, and illuminates a child’s understanding of their place within society.

The line between “self” and “other”

The mechanisms that allow individuals to seamlessly interact with other people through emotional inference, empathy, and Theory of Mind are deeply integrated into humans' cognitive structures. These structures, although strong, often inhabit the same areas of the brain that humans’ self-conception inhabits (Bolognini et al., 2014). As a result, there are numerous examples of situations where the boundaries between “self” and “other” are ruptured, allowing signals from one side to pass to the other, fundamentally confusing how humans define

themselves in relation to others. Some of these examples involve the effect of viewing others’ actions through mirror neuron networks. Other examples show how a human’s perception tricks them into attributing sensations to the “self” that are not one’s own. Finally, the outward emotions of others have the potential to affect another human’s, often in ways they cannot control. Phenomena such as mirror-touch synesthesia and embodied cognition will be utilized to demonstrate how thin and precarious the line is between “self” and “other” really is.

The Motor Cortex and the Mirror Process

In the human brain, an important series of mechanisms exist that allow humans to infer others’ actions and intentions. Mirror neurons have been the subject of recent controversy, and have been used to explain a wide variety of cognition previously unattributed to any other mechanism. Mirror neurons are collections of neurons and pathways throughout the brain that activate when the organism experiences or views a certain action (Rizzolatti & Craghero, 2004). These mirror neurons fire, imitating the observed action, leading to potential “mirrored” activation in equivalent areas in the brain. This phenomenon has been observed in a number of different brain regions, but the large majority of research has centered on how mirror neurons serve to replicate observed motor actions. For example, research with non-human primates showed that disparate collections of neurons in the inferior parietal lobule fired when different actions were observed being completed by a human (e.g. eating, placing, or grasping) (Fogassi, Ferrari, Gesierich, Rozzi, Chersi, & Rizzolatti, 2005). These systems also exist in humans; mirror neurons serve as key component of how humans are able to understand intentionality and mimic motor movements through observation. These systems are trained early in life, as mentioned previously (Carleson & Moses, 2001; Rochat & Hespos, 1997, Weimer et al., 2012). Mirror systems enable the powerful tools we use to participate in social interaction; empathy,

emotional understanding, motor learning, observation, and Theory of Mind may all rely on mirror neurons to function

Not only do mirror neuron systems exist for basic motor areas of the brain, but they exist in areas dedicated to complex motor actions as well. Buccino et al. (2004) recognized that certain actions are categorized by the brain depending on their quality and content. When observing dogs bark, mirror systems activate based on basic visual properties, whereas seeing a speech read by a human elicits activation in a separate area of the brain. These results suggest that actions made by other individuals are diverted into a separate system from non-human signals. This separate “human” system is connected to the same areas of the brain that are dedicated to actions and thoughts. This means that when a motor action is observed in another individual, mechanisms exist that actively internalize that action, accepting it as the person’s own personal learning experience. In the experiment, participants also showed activation in the sulcus orbitalis, suggesting that they were attempting to not only imitate the action (speech reading), but actually apply and pull meaning from the observation. This natural process is a subconscious one, providing an example of a mechanism by which external stimuli can deeply affect they way humans view and process the world.

Natural systems exist to process and internalize others’ actions, making the human brain the perfect receptacle for the processing of others’ experiences. Sometimes, the line between others’ experiences and one’s own becomes blurred. In some cases, it is actually possible to artificially push the boundary between “self” and “other” using technology in order to discover new things about human cognitive systems. In 2014, Bolognini, Rosetti, Fusaro, Vallar, and Miniussi (2014) experimented with the capability of artificially enhance nascent subconscious brain activity to the level of consciousness, allowing for the scrutiny of empathy systems. The

study focused on the somatosensory cortex’s role in the mirroring of certain sensations. As mentioned before, the same areas of the brain activate when viewing an action as when actually completing the action. Utilizing brain stimulation technology called paired- pulse transcranial magnetic stimulation (ppTMS), researchers brought the base level of “mirrored” activity during observation to the level of conscious awareness. TMS utilizes a pair of electromagnets, programmed to oscillate a magnetic field rapidly at a targeted area in the brain, causing the area to activate. ppTMS relies on a stimulus to activate; in this case, it was the presentation of a video in which hands, in view, were touched from an angle. Participants found that they “felt a touch on my hand when I saw the hand being touched” on a computer screen when paired with brain stimulation (Bolognini et al., 2014). This sensation that participants felt was independent from any actual touch that was being administered to their body at this time, implying that by raising the level of their mirror neurons’ activation, participants actually felt the touch that they were observing in a video. These “phantom touches” were elicited from the mirror neurons, suggesting that the activation occurs in the same place as similar personal experiences.

In some rare cases, individuals find themselves actually feeling and experiencing others’ emotions and sensations without artificial assistance or stimulation; they feel a person hugging their significant other, they feel the happiness on another person’s face, and they internalize the pain of anyone who falls onto the pavement. This disorder, known as mirror-touch synesthesia, turns individuals into “tactile mirrors”, forcing them to physically feel another’s sensations as their own (Banissy, Kadosh, Maus, Walsh, & Ward 2009). This may be caused by overactivity in the same areas that generate empathy and motor mirroring; they bring the cognitively mirrored sensations to a conscious level such that they violently interfere with an individual’s life.

In fact, mirror-touch synesthesia is one of the small number of disorders that may be found in a reliable portion of the population. Bolognini (2014) mentioned the possibility of the replication or mirror-touch synesthesia in their experiment, and Banissy and Ward (2007) provided a foundation to enable their work through an examination of the symptoms of mirror-touch synesthesia. These authors completed groundbreaking work legitimizing the existence of mirror-touch synesthesia, showing that for some people with synesthesia, an observed touch on a different face can be literally felt on their own. Banissy and Ward (2007) also suggest a fundamental claim that mirror-touch synesthesia is variant of synesthesia that simply enhances empathy, and that the results of the study reinforce the idea that imitation and mirror neurons utilize the same circuits for actual feelings and movements. Individuals with mirror-touch synesthesia provide opportunities for innovative and groundbreaking research into the potential understanding of cognitive mechanisms of intention, Theory of Mind, and empathy. It is possible that signs of mirror-touch synesthesia can be found in children, who are developing these social mirrored systems. By identifying symptoms of synesthesia early, we may find certain development barriers or failures that cause or propagate this crossing of sensory and cognitive wires.

Impact of Others’ Emotion on the Self

The example of mirror-touch synesthesia allows researchers to solidify the connection between observation and actual movement, but far more interesting implications lie in the world of imitated emotion. In their review of motor neurons and social cognition, Sinigaglia and Sparaci (2010) show that the basis of emotional understanding comes from the observation of actions the and the inference of reasoning behind the action. By ascribing emotions to movements and actions, empathy may be enabled through this system of mirror mechanisms. In

their review, Decety and Sommerville (2003) also make a key distinction about the requirement for emotional understanding between humans: the self-awareness of one’s own conscious processes (the development of “self”) is required in order to understand and read the mental states of others.

Quick and accurate emotional understanding draws from previously mentioned cognitive “shortcuts,” which use the same “self” circuits to understand others’ emotions. Since these systems rely on one another, they have the potential to cross and interfere with one another (Banissy & Ward, 2007). It is extremely important that a human’s perceptions and understanding of others often cross the cognitive barrier into their own conscious experience. In her review, Knox (2006) provides additional evidence to suggest that the systems upon which humans rely to interpret their emotions and the systems that interpret others’ emotions lie next to each other, often inhabiting the same space in the brain. Because of their proximity, these systems cross over, causing individuals to experience another’s experience as their own. An example of the emotional cross-over that may occur is in a study conducted by Wicker, Keysers, Plailly, Royet, Gallese, and Rizzolatti (2003), which examined how disgust may be mirrored in the brain. The study found that when participants viewed a video of another individual acting disgusted, their brain activated the same area as when the participant smelled an oderant that produced a strong feeling of disgust. Based on these results, not only do humans mirror motor actions; they also mirror emotions.

An additional example of emotion mirroring comes from a popular phrase: “I feel your pain.” Although this common expression of empathy communicates understanding, there is evidence to suggest that viewing pain being delivered to others activated the portion of somatosensory cortex responsible for experiencing painful and tactile stimuli (Bufalari, Aprile,

Avenanti, Di Russo, & Aglioti, 2007). This effect has important implications for enabling social interaction and enhancing empathy. This study, combined with previously mentioned studies, shows that by using the same mechanisms as normal conscious emotions, the human brain enables deep emotional empathy, and allows for external stimuli to affect individuals in the same way as if they were experiencing it themselves, enabling social cognition (Goldman & de Vignemont, 2009). However, the failure of these mirror systems could possibly spell disaster for an individual attempting to interact with the world.

In fact, there is evidence to show that automatic mimicking and mirroring functions found in normal adults are not present in individuals on the Autism spectrum, leading to impairments in social function (McIntosh, Reichmann-Decker, Winkelman, & Wilbarger, 2006). Researchers found that when presented with happy and angry expressions and measured with electromyography (EMG), a technology which can measure muscle movements, normal participants immediately and subconsciously moved to physically replicate the faces presented to them. Autistic spectrum individuals did not automatically mimic the presented faces. As many other authors have pointed out, these results seem to suggest that autistic behavior may be due to the lack of activity in mirroring areas of the brain. This lack of activity leads to the inactivity of many key social processing areas of the brain, and consequently to inadequate activity in the main areas responsible for empathy and motor mimicking. However, findings such as these point to a potential area of future research, and links between autism and mirror neurons have been prevalent in the past decade (Oberman, Hubbard, McCleery, Altschuler, Ramachandran & Pineda, 2005). Not only should research continue into the connection between autism and mirror systems, but research should also focus on the relationship between “self” and “other” systems in

autistic individuals. By looking at how autistic individuals use these systems, deeper understanding may be reached.

Applications of Knowledge

Previous sections of the current review have established that not only is the ability to distinguish “self” and “other” extremely important to human interaction, but it has also developed in a way that reinforces many important social and cognitive mechanisms (Bello et al., 2014; Carleson & Moses, 2001; Gergely, Bickering & Király, 2002). Previous sections have also shown that due to imitation and mirroring, crossovers between “self” and “other” are common. Given the intimacy these two constructs share, there may exist possibilities for research that exploits this close relationship to help understand it further. In the following section, the use of technology enables art, neuroscience, and psychology to investigate the relationship between “self” and “other” in new, exciting ways.

A previously mentioned study deserves new light here. Bolognini et al. (2014)’s use of TMS is a prime example of the ability to induce a disorder to not only replicate previous findings, but also to examine the relationship between “self” and “other”. Mirror-touch synesthesia was also induced through the use of transcranial direct current stimulation (tDCS), a technology which delivers a small amount of electrical current through the skull into the brain using small pads, making them more excitable and ready to activate (Utz, Dimova, Oppenländer, & Kerkhoff, 2010). By simply lowering the base level of depolarization on the somatosensory cortex, researchers enabled a state of mind the brought subconscious processes of empathy and mirroring into consciousness. The potential of this technology to further understand these processes on a cognitive level is unprecedented; it is the opinion of the author that tDCS could

prove essential in understanding complex cognitive systems such as one’s representation of “self” and “other”.

A system such as tDCS could greatly assist disordered populations described in McIntosh et al. (2006), such as autistic populations, since individuals on the autism spectrum often fail to respond to normal social and emotional stimuli. Macintosh et al. (2006)’s work is essential by itself as well; this research is essential in understanding the representation of others’ feelings and emotions within one’s self in abnormal populations. Disorders like autism and psychopathy may be used as vehicles to uncover treatments for disorders. They will also improve the understanding of normal populations. But for examples of avant-garde approaches to understanding cognitive mechanisms of “self” and “other," one must turn to art.

In experiments completed with between eight and twenty individuals, researchers Petkova and Ehrsson (2008) used a combination of virtual reality and mannequins to effectively create a body-swapping experiences. The participant’s vision was replaced with a camera on the model’s head, while the mannequin was touched in certain areas with a brush. Not only did participants report to experience another’s body as their own, but they also reported that threats (a fake knife presentation) to a “new” body elicit physiological reactions in an “old” body. The tenuous grasp on the ownership of a body is clearly demonstrated with these findings. Even more relevant to the current discussion, these results show that a normal individual’s sensory and motor systems may be tricked by external stimuli such that another’s experience may be inferred as one’s own.

Conclusion

The human brain, though countless small iterations of evolution, has been created as the perfect vehicle for the inference of behavior and emotion. When individuals have conversations

and interact with another person, cognitive mechanisms are constantly at play that identify not only the intonation of the other’s words, but the meaning behind them. A person sees and mimics another’s facial expressions in an attempt to empathize. An individual may even subconsciously mirror the posture or actions the other person is taking. These myriad systems provide evidence to show that the human brain is a well-oiled machine, ready to understand the social world with a large collection of sensitive social and cognitive tools.

By researching the development of these tools, the mechanisms behind human empathy and self-conceptualization reveal themselves, and it is important. From a small period of time after birth, humans have the ability to recognize foreign input from their own, choosing to react in separate ways to external stimuli (Rochat & Hespos, 1997). As children grow, they attain the ability to ascribe intention to other’s actions and understand goal-directed behavior, allowing them to have knowledge of others’ actions (Bello et al., 2014) . In parallel, children develop a strong sense of emotional connection to other humans, allowing them to mimic and internalize another’s emotions to understand them more readily using the same pathways that they use to understand themselves (Meltzoff, 1995). At an important convergence point in time, children attain what is referred to at Theory of Mind, a skill conceptualized as the ability to infer another’s thoughts and feelings, imbuing them with independent goals and volition. This valuable tool, as it improves, proves useful for children and adults as they navigate the social world.

Many of the tools to understand others are used in personal function of the same emotions and actions. This means that the attributes that make a human’s understanding of others’ emotions and intentions so powerful also make them vulnerable to confusion due to the “shortcuts” that the human brain takes. Anomalies such as mirror-touch synesthesia and artificial

brain stimulation have shown that these inference tools lie just below the conscious experience, and they only require the smallest nudge to rise into an individual’s awareness, causing them to attribute others’ experiences as their own. These examples of “cracks in the foundation” are not detrimental, however; they provide opportunities to learn even more about the relationship between human self-representation and the representation of others’ experiences. By experimenting with brain stimulation and “body swapping”, a greater understanding of human internal cognitive mechanisms may be attained. Further research must use developmental psychology to conceptualize these phenomena; understanding how these disorders originate may not only provide new avenue for treatment of previously untouchable disorders, but it also opens up the door to future research in understanding how “self” and “other” live within the human mind.

References

Banissy, M. J., & Ward, J. (2007). Mirror-touch synesthesia is linked with empathy. *Nature neuroscience*, *10*, 815-816.

Banissy, M. J., Kadosh, R. C., Maus, G. W., Walsh, V., & Ward, J. (2009). Prevalence, characteristics and a neurocognitive model of mirror-touch synaesthesia. *Experimental Brain Research, 198*, 261-272.

Bekkering, H., & Neggers, S. F. (2002). Visual search is modulated by action intentions. *Psychological science*, 13, 370-374.

Bello, A., Sparaci, L., Stefanini, S., Boria, S., Volterra, V., & Rizzolatti, G. (2014). A developmental study on children’s capacity to ascribe goals and intentions to others. *Developmental psychology*, *50*, 504.

Bolognini, N., Rossetti, A., Fusaro, M., Vallar, G., & Miniussi, C. (2014). Sharing Social Touch in the Primary Somatosensory Cortex. *Current Biology*, *24*, 1513-1517.

Buccino, G., Lui, F., Canessa, N., Patteri, I., Lagravinese, G., Benuzzi, F., ... & Rizzolatti, G. (2004). Neural circuits involved in the recognition of actions performed by nonconspecifics: An fMRI study. *Journal of cognitive neuroscience*, *16*, 114-126.

Bufalari, I., Aprile, T., Avenanti, A., Di Russo, F., & Aglioti, S. M. (2007). Empathy for pain and touch in the human somatosensory cortex. *Cerebral Cortex*, *17*, 2553-2561.

Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child development*, *72*, 1032-1053.

Charman, T. Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with autism: an investigation of empathy, pretend play, joint attention, and imitation. *Developmental Psychology, 33,* 781.

Decety, J., & Sommerville, J. A. (2003). Shared representations between self and other: a social cognitive neuroscience view. *Trends in cognitive sciences*, *7*, 527-533.

Effland, R. (1998). The Cultural Evolution of Civilizations. *Buried cities and lost tribe, 2*, 1-50.

Fogassi, L., Ferrari, P. F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: from action organization to intention understanding. *Science*, *308*, 662-667.

Gallese, V. (2009). Mirror neurons, embodied simulation, and the neural basis of social identification. *Psychoanalytic Dialogues*, *19*, 519-536.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*, 593-609.

Gergely, G., Bekkering, H., & Király, I. (2002). Developmental psychology: Rational imitation in preverbal infants. *Nature*, *415*, 755-755.

Gilovich, T., Medvec, V. H., & Savitsky, K. (2000). The spotlight effect in social judgment: an egocentric bias in estimates of the salience of one's own actions and appearance. *Journal of personality and social psychology*, *78*, 211

Goldman, A., & de Vignemont, F. (2009). Is social cognition embodied?. *Trends in cognitive sciences, 13*, 154-159.

Kohler, E., Keysers, C., Umilta, M. A., Fogassi, L., Gallese, V., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: action representation in mirror neurons. *Science*, *297*, 846-848.

Keenan, J. P., Nelson, A., O'Connor, M., & Pascual-Leone, A. (2001). Self-recognition and the right hemisphere. *Nature, 409*, 305.

Knox, J. (2013). ‘Feeling for’and ‘feeling with’: developmental and neuroscientific perspectives on intersubjectivity and empathy. *Journal of Analytical Psychology*, *58*, 491-509.

Lane, J. D., Wellman, H. M., Olson, S. L., LaBounty, J., & Kerr, D. C. (2010). Theory of mind and emotion understanding predict moral development in early childhood. *British Journal of Developmental Psychology, 28*, 871-889.

Lonigro, A., Laghi, F., Baiocco, R., & Baumgartner, E. (2014). Mind reading skills and empathy: Evidence for nice and nasty ToM behaviours in school-aged children. *Journal of Child and Family Studies, 23*, 581-590.

McIntosh, D. N., Reichmann− Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental science*, *9*, 295-302.

Meltzoff, A. N. (1995). Understanding the intentions of others: re-enactment of intended acts by 18-month-old children. *Developmental psychology, 31,* 838.

Myers, S. M., & Johnson, C. P. (2007). Management of children with autism spectrum disorders. *Pediatrics, 120*, 1162-1182.

Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorders. *Cognitive Brain Research, 24*, 190-198.

Petkova, V. I., & Ehrsson, H. H. (2008). If I were you: perceptual illusion of body swapping. *PloS one*, *3*, e3832.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annu. Rev. Neurosci., 27*, 169-192.

Rochat, P., & Hespos, S. J. (1997). Differential rooting response by neonates: Evidence for an early sense of self. *Early development and Parenting*, *6*, 105-112.

Sinigaglia, C., & Sparaci, L. (2010). Emotions in action through the looking glass. Journal of *Analytical Psychology*, *55*, 3-29.

Umilta, M. A., Kohler, E., Gallese, V., Fogassi, L., Fadiga, L., Keysers, C., & Rizzolatti, G. (2001). I know what you are doing: a neurophysiological study. *Neuron*, *31*, 155-165.

Utz, K. S., Dimova, V., Oppenländer, K., & Kerkhoff, G. (2010). Electrified minds: transcranial direct current stimulation (tDCS) and galvanic vestibular stimulation (GVS) as methods of non-invasive brain stimulation in neuropsychology—a review of current data and future implications. *Neuropsychologia, 48*, 2789-2810.

Wellman, H. M. (1990). The child's theory of mind (Vol. 37). Cambridge, MA: MIT press.

Weimer, A. A., Sallquist, J., & Bolnick, R. R. (2012). Young children's emotion comprehension and theory of mind understanding. *Early Education & Development, 23*, 280-301.

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in my insula: the common neural basis of seeing and feeling disgust. *Neuron*, *40*, 655-664.

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13,* 103-128.