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NEUROBIOLOGICAL BASIS OF SOCIAL EMOTIONS – UNDERSTANDING EMPATHY AND COMPASSION

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Abstract

This article delves into the intricate realm of empathy, emphasizing its definition and exploring the underlying mechanisms from both psychological and neurobiological perspectives. Highlighting the evolutionary continuity of empathic behaviors across species, the study examines the multi-level conceptualization proposed by de Waal. The neurobiological foundations of empathy, including the mirror neuron system, insula, and anterior cingulate cortex, are discussed in relation to their roles in social bonding and emotional understanding. The article also addresses gender differences in empathy, shedding light on the stability of these differences from infancy to adulthood and the potential influences of both genetics and socialization. Overall, this comprehensive exploration contributes valuable insights into empathy's complex nature, offering implications for fostering compassion and understanding in society.

KEYWORDS: compassion, empathy, insula, neurobiology, neuroscience, psychology, social emotions

INTRODUCTION

Social emotions are more narrowly defined as subjective experiences that emerge during interaction with others, during recollection, and when reflecting on the behaviors, thoughts, intentions, or feelings of others.[1] Among a plethora of different social phenomena exists empathy, an intricate social phenomenon that has been characterized in various ways. While definitions may vary, they typically share common elements such as the capacity to understand and share the emotions of others. Empathy consists of two main forms: cognitive empathy, the ability to understand another's perspective (related to Theory of Mind), and affective empathy, which involves sharing the emotional experiences of others.[2] Adam Smith, for instance, defined empathy as "the ability to understand another's perspective and to have a visceral or emotional reaction".[3,4] Hastings et al.[4] similarly concentrate on emotions, aligning with Preston and de Waal[5] in underscoring empathy as a multistage process. They characterize empathy as "the recognition and sharing of another's emotional state".[3,5] Empathy has been a focal point of interest for philosophers and psychologists for an extended period, with comparatively less emphasis from neuroscientists. In recent times, the significant advancement of human brain imaging methods, particularly functional magnetic resonance imaging (fMRI), has spurred the systematic exploration of empathy through neuropsychological studies. The mentioned studies have established numerous connections with heightened psychological capabilities and have pinpointed the specific brain areas activated during the processing of intricate social cues associated with the sophisticated forms of empathic behaviors observed in humans.[2]

EVOLUTIONARY MECHANISMS OF EMPATHY

Many regard empathy as a distinctly human trait, overlooking the possibility of empathic behaviors in other species. However, accumulating evidence reveals pro-social behaviors across various species, including primates and rodents, suggesting that certain forms of empathy predate humans in evolutionary terms.[6] These findings strongly support the idea of an evolutionary continuity of empathic behaviors. Adopting such a perspective provides an experimental understanding of simpler forms of empathy and an opportunity to comprehend the neuronal processes underlying empathic behaviors.[2] Empathy is not merely a pro-social behavior but plays a fundamental role in the survival of species. By fostering cooperation, empathy ensures group cohesion, which is crucial for the survival and success of social species. This cooperative behavior enhances species' capacity to adapt, survive, and thrive.[22] Several empathy theories that incorporate an evolutionary viewpoint and broaden the research focus have been proposed. One influential theory is de Waal's multi-level conceptualization of empathy, which places the most basic forms, such as adopting another's emotional state (emotional contagion), at the core of all empathic behaviors. This is followed by a more complex continuum involving concern for another's

state and attempts to alleviate it, such as consolation (sympathetic concern). The most elaborate level involves attributing emotional states to others instead of oneself (empathetic perspective-taking). Emotional contagion has been observed in numerous animal species, while sympathetic concern and consolation have been documented in non-human primates and canines. The highest level of empathy in de Waal's model, which includes targeted helping based on a cognitive understanding of another animal's situation (perspective-taking), is predominantly seen in humans and apes.[2,6] Recognizing the presence of empathy in other animals enables the creation of relevant animal models. It was shown that yawning is highly contagious in humans, apes and monkeys and the frequency of such behavior is connected to the quality of the relationship between individuals, indicating a relationship between contagious behaviors and interpersonal emotional bonds. These results also imply that a fundamental aspect of empathic behavior involves the ability to mimic the actions of others. The ability to imitate the behaviors and emotions of others appears to originate from an ancient evolutionary capability that is evident at a very early stage in primate development. Attachment, especially between mother and child, plays a critical role in developing empathy, with mirroring behaviors during early interaction serving as precursors to other forms of social mirroring. This ability likely developed to align an infant's behavior with that of the mother, facilitating the mother-infant relationship and imitative exchanges.[6,7,8] Hence, it is not unexpected that, as suggested by various authors[5,10] the foundational components of empathy may be rooted in the early mother-infant relationship. The initial postnatal phase in both human and nonhuman primates is marked by a profound exchange of affective communication between infants and adults. Such communication involves a constellation of specific behavioral features that include close, sympathetic maternal imitation and elaboration of infant facial communicative and expressive signals which are unique in anthropoid species.[6,9,10]

NEUROBIOLOGY

ONTOGENY OF NEURAL SYSTEM

Empathy links neural circuits involved in social behavior, physical pain, and the capacity to comprehend both self and others. Through these neurological pathways, the brain facilitates the understanding of social distress or pain in others, experiencing this distress as if it originated within oneself. This neurobiological process encourages social connection and behaviors geared towards alleviating distress displayed by others.[3] The ontogenetic roots of empathy likely arose within the mammalian brain to support social bonds between a mother and child.[3,11,12] The rudimentary manifestation of affiliation and bonding emerged initially in mammals, characterized by the provision of nurturance and care for their offspring over an extended period. Unsurprisingly, the neurobiological foundations of the mother-child bond involve the limbic system, specifically the emotional circuitry (including the amygdala, hippocampus, and hypothalamus). Originally thought to be active primarily during pregnancy and lactation, certain components of this circuitry were established to facilitate the bonding between a mother and child.[3,4] Neurohormones such as oxytocin and vasopressin, along with peripheral steroid hormones like cortisol, play crucial roles in regulating limbic activity. The neural circuits governing affiliation and bonding play a crucial role in regulating responses to social stress and, in challenging situations, encouraging affiliative behavior towards offspring and friends. Both central and peripheral hormones, including cortisol, contribute to modulating limbic activity during stress. Consequently, empathy engages various brain regions, but its foundation in bonding and affiliation suggests a predominant instantiation in the limbic system.[3,13]

MIRROR NEURON SYSTEM

The fascination with understanding the neural basis of empathy gained momentum more than ten years ago when Di Pellegrino et al.[14] stumbled upon premotor neurons which are activated when a primate executes purposeful hand movements or when the primate simply watches the experimenter perform such hand movements.[3,6,14] This discovery held significance as it established a neurological foundation for imitation and offered insights into the mechanisms underlying observational learning. These neurons were termed “mirror neurons”.[3,15] While primarily motoric, the mirror neuron system offers a plausible mechanism for certain social and emotional behaviors. Mirror neurons, discovered in areas related to motor control, suggest that the actions of others can be converted into a motor code using one's own knowledge of cortical motor representations. This process enables individuals to match the actions or emotions of others to their own internal motor representation of those actions or emotions. Apart from motor imitation, the mirror neuron mechanism is involved in the perception of pain.[3] Many of the neural circuits activated during personal experiences of pain are also triggered when one envisions, foresees, or observes others undergoing pain. In those areas which are activated regardless of whether the self or another experience pain, the distinction between self and other is coded primarily by the degree of activation rather than having an anatomically distinct area of activation. For instance, Singer et al. conducted a study in which they examined how the neural responses varied when an individual personally underwent a painful stimulus compared to when they witnessed a loved one undergoing a similar painful experience. Their findings revealed significant overlap in the brain activity within pain pathways, regardless of whether the person directly experienced the pain or observed a close associate enduring it.[3,6,16]

INSULA

Along with many other important cognitive functions, such as processing feelings, decision making and risk prediction, the insular cortex has a great role in empathy and other similar complex social functions. In humans and other primates, the insula lies foleded deep within the

lateral sulcus of each hemisphere, hidden below parts of the frontal, parietal and temporal lobes, which form the so-called opercula. Due to its unique location, the insula is also called 'the hidden fifth lobe'.[17] The insula is commonly associated with adverse emotional states such as disgust, pain, and hunger. However, this region plays a crucial role in integrating emotional information with data from other cortical areas,including mirror regions. Carr et al. conducted a study comparing neural responses during the imitation and observation of complete facial displays of emotion.[18] They observed activation in premotor areas during the imitation of emotional expressions, with a notable emphasis on the preferential activation of the insula and amygdala during imitation. Another study conducted by Wicker et al. revealed that observing faces expressing disgust in others led to nearly as much insula activity as the experience of smelling a disgusting odor.[3,19] The anterior human insula is activated when a person experiences pain or observes pain in other people.[3] All of these data suggest a role for the insular cortex in mediating empathy. The phenomenon of alexithymia, a condition in which a person has difficulties understanding their own emotional and bodily states, corroborates the importance of insula for empathy, since people suffering from alexithymia show less insula activation compared to typical subjects trying to asses their own feelings or those of others.[17]

ANTERIOR CINGULATE CORTEX (ACC)

The anterior cingulate cortex (ACC) is engaged in tasks related to detecting errors, indicating the level of distress linked to errors. Additionally, it becomes active in tasks involving conflict detection, especially when performance requires significant effort or prompts an emotional assessment. Recent research has demonstrated heightened activity in this brain region during instances of physical pain.[16] Interestingly, similar neural signals are observed when individuals undergo social pain, such as feelings of rejection or exclusion.[20] An important conclusion is that in numerous studies highlighting the role of the ACC, there is often a simultaneous activation of the insula. This suggests that these structures commonly collaborate to facilitate functions related to empathy.[3]

DEVELOPMENT AND GENDER DIFFERENCES

There is evidence indicating variations in empathetic capacity between males and females. Traditionally, females are often depicted as being more nurturing and empathetic, while males are portrayed as less emotional and more focused on cognition.[21] Perceived gender differences are suggested by some to be primarily attributable to cultural norms associated with gender roles. Nevertheless, empathy has roots in both evolutionary and developmental factors, and exploring it through implicit measures can provide insights into the interplay between culture and biology in shaping empathetic tendencies.[21] There are numerous works which suggest that there may be sex differences in emotional attunement and empathy beginning early in ontogenetic development. In summary, there is evident divergence in empathy between sexes from infancy, and these differences seem to remain consistent and enduring throughout life.[21] Females consistently exhibit higher levels of empathy compared to males, and individuals displaying greater empathy in early development tend to maintain this heightened empathy as they progress through later stages of development. This developmental stability implies that sex differences in empathy are unlikely to be solely attributed to postnatal experiences, such as maternal care. Instead, these differences likely stem from evolutionarily significant distinctions between males and females that are present, to some extent, from birth.[21] This aligns with findings indicating that empathy has a moderate heritability, reinforcing the notion that genetic factors play a role in shaping these differences.[21] As individuals age, disparities in empathy between sexes seem to magnify, particularly during puberty. This amplification may be linked to more pronounced age-related advancements in empathy among females compared to males. Several studies underscore the impact of social influences on empathy, suggesting that parents play a crucial role in nurturing empathy in their children.[21] This can be achieved either by serving as positive role models or by cultivating healthy and secure attachments with their children.[21] Divergences in social attention between male and female infants emerge early in development, preceding the influence of socialization. This distinction is observable even in newborns, as highlighted and likely contributing to the heightened sensitivity of females to the emotions of others in comparison to males.[21] While the exploration of this phenomenon has been limited, there is an emerging observation that the nature of the stimulus, such as the sex of the stimulus, significantly influences empathy in males, but not necessarily in females.[21] In essence, it's possible that males are not inherently less empathetic than females. Instead, they may show different levels of empathy toward different social partners. For instance, when it comes to empathy, female targets evoke similar behavioral responses from both male and female observers, whereas male targets trigger more empathy in female viewers compared to male viewers. Recent work in rodents suggests females have greater sensitivity to other's pain compared to males.[21] Langford et al. Have shown that in mice, for example, both males and females appear to increase their writhing when viewing a familiar individual in pain. However, when paired with an unfamiliar individual, males, but not females, show a decrease in their writhing, suggesting less sensitivity toward the pain of the unfamiliar mouse. These findings align with research in humans indicsating that males are more likely to have their empathetic responses influenced by contextual cues compared to females.[21]

CONCLUSION

In summary, this exploration digs into the intricate nature of empathy, highlighting its complex interplay of biological, developmental, and social factors. The definition of empathy as understanding and sharing others' emotions lays the foundation for an in-depth analysis of its neural mechanisms, encompassing mirror neurons, the insula, and the anterior cingulate cortex. Gender differences in empathetic capacity underscore the interplay between biology and culture, with females generally exhibiting higher empathy levels. Socialization and parental roles play crucial roles in shaping empathy, emphasizing its malleability from early experiences. The early divergence in social attention between male and female infants and the influence of stimulus type on male empathy further contribute to the nuanced understanding of this trait. Acknowledging these complexities challenges stereotypes and opens avenues for interventions to nurture empathy. In essence, this exploration underscores empathy as a vital aspect of human interaction. It helps us understand each other better and makes our society more caring and connected. By figuring out more about how empathy works, we can learn a lot about people and make the world a friendlier place.

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NEUROBIOLOŠKA OSNOVA DRUŠTVENIH EMOCIJA – RAZUMIJEVANJE EMPATIJE I SUOSJEĆANJA

Sažetak

Ovaj članak uranja u kompleksno područje empatije, naglašavajući njezinu definiciju i istražujući temeljne mehanizme s psihološkog i neurobiološkog stajališta. Ističući evolucijsku kontinuitet empatičkog ponašanja među vrstama, istraživanje ispituje višestruku konceptualizaciju koju predlaže de Waal. Vezano uz njihovu ulogu u društvenom povezivanju i emocionalnom razumijevanju, dotičemo se neurobioloških temelja empatije uključujući sustav zrcalnih neurona, insulu i prednji cingularni korteks. Članak također razmatra rodne razlike u empatiji, ističući stabilnost tih razlika od dojenaštva do odrasle dobi te potencijalne utjecaje genetike i socijalizacije. Zaključno, ovo sveobuhvatno istraživanje ističe vrijedne uvide u kompleksnu prirodu empatije, nudeći implikacije za poticanje suosjećanja i razumijevanja u društvu.

KLJUČNE RIJEČI: društvene emocije, empatija, insula, neurobiologija, neuroznanost, psihologija, suosjećanje