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A CRITICISM OF MIRROR NEURON DYSFUNCTION AS AN ETIOLOGICAL HYPOTHESIS OF AUTISM

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ABSTRACT. This theoretical essay on screen presents itself as a contribution in the field of discussions about the etiology of Autistic Spectrum Disorder (ASD). To do so, it starts from the theoretical-methodological framework of Historical-Cultural Psychology as a lens for the investigation and analysis of the etiological hypothesis of the dysfunction of the Mirror Neuron System (MNS). The investigative process covered the historical trajectory of classification, description and main etiological hypotheses of ASD up to the current categorization of Neurodevelopmental Disorder in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), comprising a path that starts from the emotional conceptions to the search for neurobiological markers. In this sense, the hypothesis of MNS dysfunction, which results from the technological advancement of neuroimaging exams, is inscribed as an etiological explanation in the sphere of Neuroscience. The MNS was discovered from studies in apes leading to the observation of the relationship between action and perception, also seen in humans, thus, psychological functions such as language and imitation were attributed to the nervous activity of this neuron system. The Historical-Cultural Psychology presents itself in this discussion under the unmistakable understanding of typical and atypical development and its relationship with ASD, concerned with the periodization of development, and so to speak of the sociocultural character and foundation of psychological functions.

Keywords: Neurosciences; historic-cultural psychology; autism spectrum disorder.

UMA CRÍTICA À DISFUNÇÃO DOS NEURÔNIOS ESPELHO COMO HIPÓTESE ETIOLÓGICA DO AUTISMO

RESUMO. O ensaio teórico em tela apresenta-se como uma contribuição no campo das discussões acerca da etiologia do Transtorno do Espectro Autista (TEA). Para tanto, parte-se do arcabouço teórico metodológico da Psicologia Histórico-Cultural como lente para a investigação e análise da hipótese etiológica da disfunção do Sistema de Neurônios Espelho (SNE). O processo investigativo contemplou a trajetória histórica de classificação, descrição e principais hipóteses etiológicas do TEA até a atual categorização de Transtorno do Neurodesenvolvimento na quinta edição do Manual Diagnóstico e Estatístico de Transtornos Mentais (DSM-5), compreendendo um caminho que parte desde as concepções emocionais até a busca de marcadores neurobiológicos. Nessa direção,

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inscreve-se como explicação etiológica na alçada das neurociências, a hipótese da disfunção do SNE, que decorre do avanço tecnológico dos exames de neuroimagem. O SNE foi descoberto a partir dos estudos em símios conduzindo a observação da relação entre ação e percepção, vista também nos humanos, deste modo, funções psicológicas como linguagem e imitação foram atribuídas à atividade nervosa desse sistema de neurônios. A psicologia histórico-cultural apresenta-se nessa discussão sob a inadiável compreensão de desenvolvimento típico e atípico e sua relação com o TEA, versado sobre a periodização do desenvolvimento, e por assim dizer do caráter e fundamento sociocultural das funções psicológicas.

Palavras-chave: Neurociências; psicologia histórico-cultural; transtorno do espectro autista.

UNA CRÍTICA A LA DISFUNCIÓN DE LA NEURONA ESPEJO COMO HIPÓTESIS ETIOLÓGICA DEL AUTISMO

RESUMEN. El ensayo teórico en pantalla se presenta como una contribución en el campo de las discusiones sobre la etiología del Trastorno del Espectro Autista (TEA). Para ello, se parte del marco teórico-metodológico de la Psicología Histórico-Cultural como lente para la investigación y análisis de la hipótesis etiológica de la disfunción del Sistema de Neuronas Espejo (SNE). El proceso investigativo abarcó la trayectoria histórica de clasificación, descripción y principales hipótesis etiológicas de los TEA hasta la categorización actual de Trastorno del Neurodesarrollo en la quinta edición del Manual Diagnóstico y Estadístico de Trastornos Mentales (DSM-5), que comprende un camino que parte del concepciones emocionales a la búsqueda de marcadores neurobiológicos. En este sentido, la hipótesis de disfunción del SNE, que resulta del avance tecnológico de los exámenes de neuroimagen, se inscribe como una explicación etiológica en el ámbito de las Neurociencias. El SNE se descubrió a partir de estudios en simios que llevaron a la observación de la relación entre acción y percepción, también visto en humanos, por lo que funciones psicológicas como el lenguaje y la imitación se atribuyeron a la actividad nerviosa de este sistema neuronal. La Psicología Histórico-Cultural se presenta en esta discusión bajo la inconfundible comprensión del desarrollo típico y atípico y su relación con la TEA, preocupada por la periodización del desarrollo y, por así decirlo, del carácter sociocultural y fundamento de las funciones psicológicas.

Palabras clave: Neurociencias; psicología histórico-cultural; autismo.

Introduction

The present work proposed an investigation into the hypothesis of the dysfunction in the Mirror Neuron System as the etiology of Autism Spectrum Disorder (ASD). With the proposal of a theoretical/critical study, this research sought to explain the diagnostic and etiological path until the recent hypothesis of the dysfunction in the Mirror Neuron System (MNS). The present analyses are based on the theoretical/methodological framework of Cultural-Historical Psychology, an approach that engenders knowledge on the philosophical basis of historical-dialectical materialism. Through the historical analysis of the development of human consciousness and psyche, Vygotski (2012) states that these are products of social relations established through work and life in society. Based on these assumptions, we present general aspects of the clinical diagnosis, the first systematizations, and

conceptions of the characteristics and possible origins of autism. Later, we carried out analyses of ASD based on human development, and considerations regarding the hypothesis of MNS dysfunction.

The current edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) categorizes ASD into neurodevelopmental disorders. In this category, possible deficits are specific impairments in learning, control of executive functions, and changes in global development in social skills or intelligence (APA, 2014). Among these diagnoses is Autism Spectrum Disorder with impairments in social communication/social interaction and repetitive patterns of behaviors, interests, or activities, manifested from the first years of life (APA, 2014).

The diagnostic journey of autism follows a historical path of changes, going from psychosis to idiocy to current neurodevelopmental disorders. In DSM-III, schizophrenia is eliminated as a diagnostic criterion for autism. However, current changes between DSM-IV and DSM-5 stand out (Rosen, Lord, & Volkmar, 2021). In DSM-IV, Asperger's disorder, autistic disorder, Rett syndrome, childhood disintegrative disorder, and pervasive developmental disorder not otherwise specified were incorporated. These different diagnoses were part of the category of global developmental disorders. In DSM-5, the different diagnoses present in DSM-IV are incorporated into a single nomenclature called Autism Spectrum Disorder, except for Rett syndrome (Rosen et al., 2021). In this latest edition, we observed a comprehensive and less specific diagnosis compared to its previous version.

There is a consensus in the scientific literature on the topic that the paradigmatic changes regarding autism were carried out by the Austrians Leo Kanner and Johann Hans Friedrich Karl Asperger. The systematization of these authors, accidentally simultaneous, described a series of essential characteristics of autism that are currently relevant, mainly, to the DSM-5 and the 10th edition of the International Classification of Diseases and Related Health Problems (ICD-10) (Pallarés & Pérez, 2017).

Wing (1997) reports that the characteristics described by the two researchers showed similarities in the symptoms observed, including social isolation, difficulties in imaginative games, motor deficits, volatility to sensory stimuli, and the symptomatological condition of autism was more present in the male. Wing (1991), in fact, indicated that the set of symptoms present in the descriptions of Leo Kanner and Hans Asperger belonged to a continuum or spectrum, which could present varying degrees, as well as the presence or absence of one or another symptom.

Despite the descriptions appearing almost simultaneously, two differences can be pointed out in the authors' descriptions. The first concerns the complexity of the cases described by Kanner, generally children with severe cognitive impairments, which differed from Hans Asperger's descriptions. The second difference was in the possible origin of the clinical condition; Kanner was ambivalent - while autism would arise from an innate condition, it could also be produced by dysfunctional family relationships. Hans Asperger understood the origin of his clinical descriptions based on the genetic/biological approach (Pallarés & Pérez, 2017).

Although Kanner and Hans Asperger are the pioneers in the description of autism, there is in current literature recognition of the role of the Soviet psychiatrist, Grunya Efimovna Sukhareva (1891-1981), as the first to systematize the aspects of autism a decade in advance – in addition, the Soviet researcher differentiated autism from schizophrenia and related its symptoms to the central nervous system (Manouilenko & Bejerot, 2015; Silberman, 2015; Pallarés & Pérez, 2017; Simmonds, 2019).

Autism Spectrum Disorder has proven to be a theoretical-practical challenge in the sciences that are concerned with studying it. According to Rivière (2007), the historical

conception of research on the topic was based on three periods: a) autism was understood and treated based on an emotional approach, influenced mainly by psychodynamic currents between 1943 and 1963. During this period, the 'refrigerator mother theory' emerged, that is, the unsatisfactory development of emotional bonds between caregivers and children that produced the characteristic symptoms, and there was a refusal to understand and study the possible biological aspects of the disorder, b) between 1963 and 1983, there was a decline in emotional theories, with the development of the first biological hypotheses and the first explanations of cognitive changes, and c) from 1980 onwards, autism began to be understood and associated with developmental theories and the deepening of biological hypotheses extending to multidisciplinary fields (Rivière, 2007).

The beginning of the 21st century was marked by an immersion of neurosciences[6] in the study of autism. The search for brain neurobiological markers through the application of new technologies such as neuroimaging studies, which include positron emission tomography (PET), functional magnetic resonance imaging (fMRI), and transcranial magnetic stimulation (TMS) (Hamilton, 2012).

Ramachandran (2000) was one of the pioneers in relating deficits in the Mirror Neuron System (MNS) with the symptoms of ASD (Ramachandran & Oberman, 2006). Mirror neurons were discovered in 1990 by Giacomo Rizzolatti and collaborators, who studied simians - the researchers discovered a set of neurons that showed neural firing when the animal observed a given action from the researchers or even from other animals. The intensity of this nervous activity was equivalent to the execution of the action of the animal that was observed (Caetano & Ferreira, 2018). For Iacoboni (2009), the discovery of mirror neurons meant understanding the relationship between action and perception. From this, other studies associated the nervous activity of mirror neurons with psychological functions such as language, imitation, understanding emotions, and the development of intersubjectivity (Di Cesare, Di Dio, Marchi, & Rizzolatt, 2015; Rizzolatti & Sinigaglia, 2016).

For Oberman, Pineda e Ramachandran (2007), what distinguishes the activity of mirror neurons is their differential response to imitation, theory of mind, empathy[7], and understanding of emotions. An abnormality in the physiological functioning of these cells produces a cascade of socio-cognitive deficits characteristic of ASD (Oberman, Hubbard, McCleery, Altschuler, Ramachandran, & Pineda, 2005; Ramachandran, 2000; Ramachandran & Oberman, 2006; Ramachandran, 2014).

In this sense, the hypothesis in question appears to be a fruitful path of investigation for cultural-historical psychology, especially considering that one of the consensual ways of understanding ASD is in human development.

Typical human development[8] based on cultural-historical psychology

Vygotski (2006) organizes developmental discussions on new bases. This attempt showed that maturationist, preformist, and environmentalist explanations did not satisfactorily explain the complexity of human development. For Vygotski (2012),

[6] Silberman (2015) highlights neurodiversity as the second current way of understanding autism. Under this discussion, subjects are understood from an autistic identity and not as a pathological/diagnostic condition present in neurosciences and psychiatry.

[7] Theory of mind is a construct elaborated by cognitive sciences, used to explain how we attribute mental states, emotions, intentions, ideas, motivations, and presumptions about other people's thoughts based on our own mental state (Baron-Cohen, 2009).

[8] Development, in our conception, is marked by potential character; this means that whether it is typical or atypical, what stands out are the possibilities and how development takes place through a process of overcoming the current condition of both (Vygotski, 2012).

development is the result of the appropriation of human social history, which is mediated by physical instruments and psychological signs.

This process occurs integrally, i.e., the biological and the social make up a synthesis throughout human development; however, it is the social history that begins to subordinate the biological development of the species. This does not mean an abandonment of natural laws but that social development differs from natural evolution. What expresses the subordination of biological development to historical-social development is the transition and reorganization of elementary psychological functions into higher psychological functions. In general terms, the elementary functions are those typical of phylogenetic development, and the higher psychological functions are marked by exclusively human behaviors, such as language, writing, logical reasoning, and voluntary attention, among others (Vygotski, 2012).

The reorganization of the periodization of development, proposed by Vygotski (2006), does not link the main milestones of this process into chronological ages. The division is made up of stages that indicate radical and critical changes in the course of development and stages (or phases) that are stable periods in that same course.

Elkonin (2017) highlights that human beings are socially formed through activity, the driving force that drives development from one period to another. Thus, periods of development are marked by the main activity, which is how the child knows and appropriates the world. In this sense, the emotions, feelings, motives, and needs of each period are the results of the syntheses of the main activity. We also add that all human activity occurs in a given social situation of development, that is, in the totality of relationships in which the child is inserted. In this way, just as modifications in main activities generate changes in how the child appropriates the world, the social situation of development is the source that engenders the qualitative transformations that regulate the child's life and social existence (Vygotski, 2006).

Changes in the main activity will drive the transition of developmental periods and the formation of new connections of psychological systems. Psychic functions follow the law of general genesis of cultural development - that is, higher psychological functions develop on two planes, first on the interpsychological plane, through social exchanges between two or more individuals, and then on the intrapsychological plane, at which time the internalization of these functions occurs, previously observed and carried out externally, and which now occur on the child's own psychic plane (Vygotski, 2012). Following these principles, we highlight that the focus of exposing the developmental periods essential for understanding ASD will be on the changes between the connections of these functions and the main activities of each period.

The qualitative transition from one stage of development to another, described by Vygotski (2006) as a period of crisis, is characterized by a moment in which the activities that the child performed no longer contribute to their development, but they have not yet appropriated new ways of relating to the situations around them. Thus, there is a change in the guiding activity, a turning point, in which interest in what previously guided behavior is lost and is characterized primarily by the appearance of a new formation and reorganization of psychic processes in this new stage.

Therefore, the developmental phases that stand out in the analysis of ASD are the first year, early childhood, and preschool age, considering that symptoms appear in the early years of life.

Elkonin (2017) defines that, in the first year of life, direct emotional communication guides development. At this moment, the baby has the adult at the center of their actions, and to meet their needs, they need the attention and care of an adult. Regarding the

development of their psychological functions, the child is closer to elementary/natural conditions; however, it is in the adult's directed action on them that the first reactions are produced; the child recognizes people and differentiates the sounds of voices, among other examples. We highlight that affection is the child's first way of approaching the world, developing the basis of complex social feelings (Vygotski, 2006).

As communication with adults becomes a necessity together with the increased autonomy of their psychomotor system, perception takes the lead in psychological development. And so, at the end of the first year and the beginning of early childhood, we observe a change in the main activity, which is now defined as object activity of handling (Elkonin, 2017; Vigotski, 2018).

Early childhood and object activity of handling highlight the emergence of new relationships between the child and the world, both from the point of view of their psychic organization and their relationships with people and objects. Elkonin (2017) shows that, at this moment, the child is included in daily activities and interested in the outside world.

One of the ways for children to appropriate the social function of objects is through language. The child, previously restricted to rudimentary communication, which involved emotional and mimicry aspects, becomes a speaking being; the complexity of this communication allows for an ever greater insertion into the world of objects and their social functions. It is worth noting that the possibility of success in this development can only be guaranteed by teaching the function of objects by adults (Elkonin, 2017).

The end of early childhood is marked by the three-year crisis. Increased autonomy and mastery of language produce significant changes in the child's development regarding the structure of their functional system and knowledge of the world. The child recognizes that their actions have repercussions on the world, and this discovery indicates a contradiction between the reasons for their activity and what the adult demands (Vygotski, 2006). The emergence of this antagonism between the child and the adult produces a troubled social developmental situation during this period; reactions such as negativity, stubbornness, rebellion, and insubordination are common (Silva, 2017).

Although the child appears to be growing in opposition to the adult, this does not indicate a purely negative aspect, as it is precisely in this movement that new structures emerge. This antagonism promotes the beginning of self-awareness and the traits of a personality that are formed and will be built throughout development. The child begins to control their emotional impulses, even if this indicates a contradiction to their wishes. In this way, affective control indicates the first structures that will organize and hierarchize the child's motives (Vygotski, 2006; Elkonin, 2017).

The end of the three-year crisis marks the child's entry into preschool age. During this period, role-playing games stood out as the main activity involving the expression and reproduction of everyday human life. While in early childhood, we observe the child's mastery of the meaning of the function of objects, in preschool age, the child begins to acquire an understanding of human relationships (Elkonin, 2017).

Silva (2017) states that role-playing as a game (activity) enhances the child's psychic development as voluntary control of psychological functions begins to be established. One of the functions that gain prominence during this period is memory, as it starts to organize the psychological system, modifying previous inter-functional relationships.

Leontiev (1987) highlights that there is a reorganization of the child's motives through a hierarchy. The immediate motives (eating, sleeping, or responding to one's desires) present in previous periods become subordinate to motives mediated by the relationships the child establishes with the adult in the preschool period. That is, when the child

understands the limits of their action in the world, the antagonism of the three-year crisis is overcome, starting to act according to their relationship with the adult (Silva, 2017).

The possibility of prioritizing motives in preschool age produces in the child an understanding of the functioning of human relationships; isolated behaviors presented in previous stages of development fit directly onto a new basis. It is noteworthy that role-playing games develop an understanding of everyday life. Through play, the child represents life experiences, such as the world of work and its political/social relationships. Likewise, gaming activity influences the child's intellectual development concerning all functions, such as perception, verbal processes, imagination, and mainly the transition from concrete to abstract thinking (Leontiev, 1987; Silva, 2017).

One of the essential highlights in preschool age is the development of egocentric speech. Voluntary control of behavior, as well as the hierarchy of the child's motives, permeates the organization of speech. According to Vygotski (2017), language begins to play an important role in "structuring" the child's behavior to solve everyday tasks, "the child's behavior reaches a higher level, achieving relative freedom regarding the situation the child is attracted to, impulsive attempts are transformed into planned and organized behavior" (Vygotski, 2017, p. 29, our translation). Egocentric speech allows the child to organize their own behavior; then we observe a phenomenon called intellectualization of speech and verbalization of thought. This means that egocentric speech is a transitory condition for the internalization of thought, which at a later stage of development passes to the internal intellectual plane. Basically, at preschool age, speech becomes the way in which the child thinks.

This preschooler's way of thinking, in addition to being a milestone for the internalization of higher psychological functions, helps in the development and management of psychological signs and, consequently, in the development of the symbolic/abstract plane. Egocentric speech premeditates the child's actions and organizes the activity developed into operations, and with this, the first forms of planning originate. This is the genesis of the development of the symbolic plane and the more developed relationships the child will establish with language in later periods (Vygotski, 2017).

Atypical human development (Autism Spectrum Disorder) based on cultural-historical psychology

In cultural-historical psychology, there are no scientific productions on ASD from classic authors, as the diagnosis did not exist in that period, and there is currently little research based on this psychological approach (Castro, 2017). Vygotski (2006) stated that two major lines of research could help in the construction of general psychology: genetic and pathological. In this sense, we observe that ASD converges towards these two lines, which makes the study of development an interesting path for reflecting on this topic (Rivière, 2007).

As observed in Wing's synthesis (1991) and the behavior topography of the DSM-5, we can raise three central axes for the analysis of ASD - 1) difficulties in social interaction, 2) problems in language development, and 3) restricted patterns of interests and activities, including stereotypies. In general, ASD constitutes an atypical development of higher psychological functions, i.e., of characteristics that develop from the social level. Apparently, what appears as a set of symptoms actually constitutes a chain causal relationship.This means that, in the event of difficulties in the child's social interactions with the world, the relationship between language and activities will be compromised as a consequence.

The deficit in social interaction in ASD impairs the learning of its affective character concerning the people around these subjects. The role of adults in their care and the organization of emotional communication is directly associated with their elementary needs. If the deficits are structured in this way, spontaneous everyday forms of learning, such as the mother's conversation with the child, are not effective paths of development compared with the dynamics of typical development described by Vygotski (2019).

Given this aspect, one of the central impairments not included as a diagnostic criterion by the DSM-5 is language. Castro (2017) explains that atypical development in language harms the entire psychological system, which tends to be formed in the child and, consequently, their integral development (including motor development). This means that, throughout typical development, when the adult speaks to the child, they direct their attention to objects, organize the child's perception to understand the chain of actions of a given activity, and serve as the child's means of communication in the appropriation of knowledge about the world and objects during early childhood. In addition to assisting in integral development, language, more specifically the development of speech, helps children develop self-conduct control and the identification of their needs, which during the three-year crisis distinguishes itself from adults and marks the beginning of an individual consciousness (Vygotski, 2006).

Another factor that may arise from these difficulties in social interaction and language deficits is stereotypies. For example, in a child who does not speak, it can cause impairment of general activities specific to each period of development, as well as the unity between affective and cognitive. In other words, not talking is reducing the child's role in their social development situation, which can delay or even produce an atypical development of emotional and cognitive expressions and, consequently, generate stereotypical behaviors.

In summary, the notes made on this topic had a reflective purpose to understand the main developmental deficits in ASD. These possibly have their origin in atypical social development. In our analysis, autism is causal, as social relationships that cause harm to the global development of psychological systems are not established. In other words, the different behaviors are part of a set of developmental delays that cannot be analyzed in isolation. Furthermore, overcoming and improving deficient conditions must occur through social relationships that allow the subject to be understood beyond the negative aspect of their "disability."

Mirror neurons and ASD: solution or a dead end?

Ramachandran (2000) invested heavily in the discovery of mirror neurons, as the researcher believed that these cells could be the key to understanding mental abilities previously unknown to neuroscientists. This can be illustrated by the increase in research on the MNS - between 2000 and 2010, in which the number of publications doubled each year, going from four to 135 works (Hickok, 2014).

Nevertheless, Ramachandran's (2000) enthusiasm does not present reliable evidence. When we investigated the hypothesis of MNS dysfunction, one of the weaknesses was the lack of concrete evidence due to its investigation methodologies and controversial results. Hamilton (2012) analyzed 25 studies using different techniques to investigate the relationship between mirror neuron deficits and ASD. Among the techniques investigated, electroencephalogram (EEG) exams presented the most inconsistent results (Oberman et

al., 2005); for Hamilton (2012), the measurement of *mu*[9] waves through EEG exams is not effective for localizing the MNS. The author also highlights that noise from other areas of the central nervous system can compromise the results of studies using these techniques. Functional Magnetic Resonance Imaging (fMRI) exams showed greater clarity in identifying brain areas such as the inferior frontal gyrus and inferior parietal lobule (areas with mirror neurons), but despite improving identification, the results are still inconsistent. In tasks involving social engagement, it is possible, through fMRI, to observe changes in nervous activity in areas such as the medial prefrontal cortex in subjects diagnosed with ASD, but none of the areas known to contain mirror neurons showed changes in their activity. The author concludes that the hypothesis of MNS dysfunction presents unreliable markers regarding its location and its relationship with the behavioral deficits presented in subjects diagnosed with ASD. Therefore, this hypothesis cannot be considered the main axis of autism symptoms (Hamilton, 2012).

Another vulnerability of the MNS hypothesis was reductionism and biological determinism when trying to explain psychic processes as complex as emotions, social relationships, imitation, empathy, and learning to a set of specialized neurons within the entire nervous system. The biological determinism in the discussion is evident when Ramachandran (2000) compares these cells to the discovery of DNA. “I predict that mirror neurons will do for psychology what DNA did for biology [...]” (Ramachandran, 2000, our translation). For the author, a set of cells can explain the complexity of human behaviors - he goes further when he states that the biological evolution of mirror cells possibly “played a decisive role” (Ramachandran, p. 117, 2014). Thus, mirror neurons would play a key role in the development of empathy and imitation. However, Hamilton et al. (2007) and Hickok (2014) described an experiment in which children diagnosed with ASD outperformed children in the control group by being able to imitate the movement of ironing a shirt based on sequential photographs. In other words, it is clear that mirror neurons do not play such a decisive role in imitation.

Furthermore, Southgate and Hamilton (2008) demonstrated that children with ASD may not present any impairment in terms of imitation, as some of them perform well in automatic imitation actions. For those who had difficulty imitating, when instructed correctly and explicitly, they tended to perform well on experimental tasks. Thus, in children diagnosed with autism who have difficulties in combining the actions of “self” and others, results were observed that are incompatible with the hypothesis of mirror neuron dysfunction.

The deficit or even the absence of empathy was placed as a central issue to explain ASD, which is not justified. To support our argument, we refer to the review by Heyes (2018), based on research with animals, babies, adults, and robots, aiming to investigate the aspects that determine empathy. The results showed that although the scientific community establishes empathy as an innate and phylogenetically inherited mechanism, the evidence shows the opposite. For the author, empathy is an emotion that is socially shaped and learned throughout development. It is formed by associative mechanisms that relate exteroceptive and interoceptive emotional states, mainly in the relationship between caregivers and the child. The author still does not deny the possible role of mirror neurons in understanding these processes, as some emotions express motor changes; however, it is not the mirror neurons that determine the learning of the feeling of empathy but the

[9] According to Ramachandran (2014) and Oberman et al. (2005), *mu* waves can be a way of indirectly measuring the activity of mirror neurons since their suppression occurs during the execution of an action, as well as when observing an action.

learning of the feeling of empathy that determines how the neurons mirror will respond to stimuli (Heyes, 2018).

Hickok (2014) states that reducing the complexity of human behaviors to motor acts is not new. This simplification of phenomena generates some implications or conclusions based on non-concrete evidence. The generalization of the dysfunction of these cells to a series of other conditions distinct from ASD, such as schizophrenia, obesity, phantom limbs, and stuttering - and even in extreme conditions, has made it possible to understand political attitudes (Hickok, 2014). How can dysfunction or deficits in the functioning of the MNS serve as an explanatory basis for such diverse conditions? To affirm this would be to say that there is a single cause for understanding very different manifestations.

Furthermore, MNS dysfunction would lead to the irreversibility of the behavioral conditions of ASD. In this sense, Oberman et al. (2005) describe “The additional lack of any significant correlation between age and *mu* wave suppression also suggests that this dysfunction is not something that improves throughout life” (p. 195, our translation). The affirmation of these results is based on the diversity of ages (6 - 47 years) of the subjects who participated in the experiment. Therefore, MNS dysfunction is assumed to be chronic in subjects with ASD. Given the results, we observed a contradictory premise in this study because, according to Vigotski (2018), in the development of the nervous system there are behaviors that may coincide: for example, we can observe the Babinski reflex in a newborn child, and the same reflex in an adult. However, there is a crucial difference because, in the first case, the child is in a developmental process that is expected, whereas in the second case, we see the expression of a possible pathology of the nervous system. Likewise, a lesion in the same brain region can trigger different symptomatological conditions in children and adults (Vygotski, 2018). This indicates theoretical and methodological problems in the hypothesis of MNS dysfunction, as it is not possible to compare subjects in such different developmental periods.

Fletcher-Watson et al. (2014), Sacks (2015), and Doidge (2016) demonstrate, through a literature review and concrete examples, evidence that makes it possible to question the role of MNS dysfunction in subjects diagnosed with autism, as it was possible to understand that the interventions enabled the development of deficits associated with theory of mind, empathy, imitation, shared attention, and emotion recognition. In this sense, there are two possible conclusions when we analyze the hypothesis of MNS dysfunction - either these subjects had the possibility of developing these skills, even with MNS dysfunction, following the hypothesis proposed by Oberman et al. (2005), or mirror cells do not have a determining factor in the behaviors associated with their activity, as credited by Ramachandran (2000) and Ramachandran & Oberman (2006).

Human development is the starting point for understanding that the term **dysfunction** is problematic for the analysis of ASD, mainly referring to a system of neurons apparently responsible for complex human behaviors. Huang (2017) adds that all brain dysfunction must present evident biological markers, as occurs in injuries, tumors, and toxic-metabolic disorders, among others.

In the conception of dysfunction, there is a linear association of the nervous activity of mirror neurons and, consequently, of the respective psychic functions (imitation, understanding of intentions, empathy). However, when we recall the review of **function** proposed by Luria (2017), the need for the central nervous system is notable, but human psychological processes are not directly related to nervous activity. Every psychological process is, by nature, psychophysiological, and what changes the course of development of these functions considered natural is the social reality. Vygotski (2012) draws attention to

the fact that new connections occur at a cortical and psychological level throughout human development. When appropriating the instrument, for example, there is an increase in the possibilities of connections between psychological functions that enable new ways for the subject to deal with reality. It should be noted that, just as it is not possible to locate a higher psychological function in a region of the brain (e.g., writing area), the functions that form this new psychological system in man cannot be separated. New connections make it impossible for distinct functions such as attention and memory to be separated during human activity. This plastic formation of human psychological processes guarantees that the development of brain connections is structured in different ways during ontogenesis, and in the same way, it guarantees that in the case of a pathological condition, other cortical centers can reestablish lost functional connections (Luria, 2017).

Vigotski (2019) defends the fundamental premise that the disability presented by a child, regardless of their diagnosis, must be understood in light of development. This means that, even when faced with a pathological process, children with atypical development also respond to this difficulty, as their lives are beyond gaps or deficits.

In conclusion, the hypothesis of MNS dysfunction does not present satisfactory evidence to date to be considered a safe etiological assumption regarding the explanation of ASD. We argue based on its questionable, reductionist, and anti-developmental methodology. In this way, the hypothesis discussed constitutes the expression of this historical period, which emphasizes the tendency to subordinate and equalize social behaviors in explanations restricted to the biological.

In opposition to this conception, cultural-historical psychology shows a fruitful methodological path for investigating ASD. We should also highlight that our position on mirror neurons is not a denial of the existence of these cells but rather their association with the etiology of ASD. These understandings allow the creation of conditions for a complete understanding of the phenomenon of autism without succumbing to the biological reductionism present in the fields of psychiatry and contemporary neuroscience.

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