Autism, Mirror Neurons and Being-in-the-World: An Approach from Neurophysiology to Neurophenomenology

[English Version]

Autismo, neuronas espejo y ser-en-el-mundo: una aproximación de la neurofisiología a la neurofenomenología

Autismo, neurônios-espelho e ser-no-mundo: uma abordagem da neurofisiologia à neurofenomenologia

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Viviana Andrea Arboleda Sánchez **
https://orcid.org/0000-0003-0051-0740
CvLAC https://scienti.minciencias.gov.co/cvlac/visualizador/generarCurriculoCv.do?cod_rh=0000082992
Colombia

Francia Restrepo de Mejía ***
https://orcid.org/0000-0002-0352-0234
CvLAC https://scienti.minciencias.gov.co/cvlac/visualizador/generarCurriculoCv.do?cod_rh=0000154016
Colombia

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** PhD student in Philosophy from the Universidad de Antioquia (Institute of Philosophy), Master in Clinical Psychology, Certified in Logotherapy and Existential Analysis. Professor and Researcher at the Universidad de Manizales. Email: vaarboleda81249@umanizales.edu.co

*** PhD in Social Sciences, Childhood and Youth, Master in Educational and Social Research and Development. Centro de Estudios Avanzados en Niñez y Juventud (CINDE). E-mail: francia46@gmail.com

Abstract

Autism has been conceptualized as a neurodevelopmental disorder and as a different form of human cognition. From a neurophysiological perspective, the mirror neuron system (MNS) in autism has been investigated, focusing on measurable data. Neurophenomenology proposes to integrate scientific evidence with subjective experience. **Objective**: to understand the relationship between subjectivity and the brain, covering the neural processes involved in autism and the first-person experience of a group of children and adolescents from the city of Manizales. **Methodology**: mixed research, descriptive and inferential, including qualitative information, approached from an interpretive phenomenological approach. 35 children between 6 and 16 years old and 19 control peers participated. **Results**: autistic participants demonstrated greater heterogeneity in the behavior of the MNS and in their relationship with the world, both with respect to control participants and among themselves. A proposal for inclusive education called "Neurodiversity" was built, which won second place in the Premio Cívico Retos con los ODS. **Conclusions**: the importance of integrating neurophysiological evidence with first-person experience was demonstrated, allowing a broad understanding of the object of study and its applications in context.

Key words: neurophysiology; mirror neurons; autism; diversity; inclusion (obtained from the DeCS/MeSH Multilingual Thesaurus – Health Sciences Descriptors).

Resumen

El autismo se ha conceptualizado como una alteración del neurodesarrollo y como una forma diferente de la cognición humana. Desde la neurofisiología, se ha investigado el sistema de neuronas espejo (SNE) en el autismo, centrándose en datos mensurables. La neurofenomenología propone integrar la evidencia científica con la experiencia subjetiva. **Objetivo**: comprender la relación entre subjetividad y cerebro, abarcando los procesos neuronales implicados en el autismo y la experiencia de primera persona de un grupo de niños, niñas y adolescentes de la ciudad de Manizales. **Metodología**: investigación mixta, de tipo descriptivo e inferencial, con inclusión de información cualitativa, abordada desde un enfoque fenomenológico interpretativo. Participaron 35 menores entre 6 y 16 años y 19 pares controles. **Resultados**: los participantes autistas demostraron mayor heterogeneidad en el comportamiento del SNE y en su relación con el mundo, tanto respecto a los participantes controles como entre ellos mismos. Se construyó una propuesta de educación inclusiva denominada «Neurodiversidad», ganadora del segundo lugar en el Premio Cívico Retos con los ODS. **Conclusiones**: se demostró la importancia de integrar la evidencia neurofisiológica con la experiencia

de primera persona, permitiendo una comprensión amplia del objeto de estudio y sus aplicaciones en contexto.

Palabras clave: neurofisiología; neuronas espejo; autismo; diversidad; inclusión (obtenidos del Tesauro Multilingüe DeCS/MeSH – Descriptores en Ciencias de la Salud).

Resumo

O autismo tem sido conceitualizado como uma alteração do neurodesenvolvimento e como uma forma diferente de cognição humana. A partir da neurofisiologia, o sistema de neurônios-espelho (SNE) no autismo tem sido investigado, com foco em dados mensuráveis. A neurofenomenologia propõe integrar a evidência científica com a experiência subjetiva. **Objetivo**: compreender a relação entre subjetividade e cérebro, abrangendo os processos neurais implicados no autismo e a experiência em primeira pessoa de um grupo de crianças e adolescentes da cidade de Manizales. **Metodologia**: pesquisa mista, de natureza descritiva e inferencial, com inclusão de informações qualitativas, abordadas a partir de uma abordagem fenomenológica interpretativa. Participaram 35 menores com idades entre 6 e 16 anos e 19 pares controle. **Resultados**: os participantes autistas demonstraram maior heterogeneidade no comportamento do SNE e na sua relação com o mundo, tanto em comparação aos participantes controle quanto entre eles próprios. Foi construída uma proposta de educação inclusiva denominada «Neurodiversidade», vencedora do segundo lugar no Prêmio Cívico Desafios com os ODS. **Conclusões**: foi demonstrada a importância de integrar a evidência neurofisiológica com a experiência em primeira pessoa, permitindo uma compreensão ampla do objeto de estudo e suas aplicações no contexto.

Palavras-chave: neurofisiologia; neurônios-espelho; autismo; diversidade; inclusão (obtidos do Tesauro Multilíngue DeCS/MeSH – Descritores em Ciências da Saúde).

Introduction

The concept of autism has undergone significant evolution since its formulation in the 1940s. Initially, both Leo Kanner and Hans Asperger referred to autism as a condition in which their patients had difficulties establishing emotional contact with other individuals and meaningful relationships with the world (Asperger, 1944; Kanner, 1943).

Currently, there are two main views on autism. The first is the medical model, which is based on scientific evidence and continues to recognize dysfunctions in interaction with other individuals and with the world as a clinically significant characteristic of autism. Under this model, autism is called "autism spectrum disorder" (ASD), a neurodevelopmental disorder that presents difficulties in socialization and communication, stereotyped behaviors, restricted interests, sensory hypersensitivity or hyposensitivity (American Psychiatric Association [APA], 2014), as well as deficiencies in the understanding of symbolic language, in the theory of mind (ToM) and in imitation skills (Ramachandran, 2012).

The second approach is that of neurodiversity, an emerging model according to which autism does not constitute an alteration, but rather a diverse form of human cognition. It presents skills for specific aspects, such as visual-constructional tasks, learning of focused topics (Armstrong, 2012), attention to detail, systematic processing, and technical thinking (Baron-Cohen, 2013). From a social perspective, neurodiversity is the result of agitations and movements of people, mainly with autism, who have fought for inclusion in different contexts, such as education and work (Sánchez, 2020).

Although their conceptualizations are dichotomous, the medical model and neurodiversity share an idea: autism occurs within the framework of the individual's relationship with the world and with others. While the medical model considers that the person-world relationship is affected and neurodiversity sees it as a different way of relating to the environment, there is an inhabitation of the world implicit in autism that differs from the socially accepted view.

The relationship between the individual and the world has been a widely discussed philosophical problem. One of the authors who addressed this issue was Martin Heidegger, a German philosopher, who proposed the concept of "*Dasein*", a new ontological understanding that focuses on the individual's way of existing and places him in the world, with which he is in constant relationship. With the term "Dasein," which literally translates as "being-there" (Safranski, 1997), Heidegger emphasized a being whose essential constitution is that of being-in-the-world (*in-der-welt-sein*), that of being outside. In this sense, this is

a being immersed and active in a world with social and cultural characteristics, which he internalizes and transforms, while he also generates changes in his environment through his existence (Heidegger, 2003).

Etymologically speaking, the Greek word "*éxo*" (ἔξω), from which the verb to exist comes, means outside (Lidell & Scott, 1883). Thus, for Heidegger, *Dasein* is an entity, but it is more than something that merely is. *Dasein* is the being that asks about being. Unlike other entities whose character is categorial —such as the case of two entities that are in space as a being-inside or a being-there with something—, *Dasein* is not simply within the world or next to another entity, but its constitution is existential, so that its '*being next to*' implies an inhabitation, a being in relation to the world establishing a familiarity with that which is outside or, in other words, existing (Heidegger, 2003).

Quoting Parmenides' phrase "*τὸ γὰρ αὐτὸ νοεῖν ἐστίν τε καὶ εἶναι*" (in effect, perceiving [thinking] is the same as being), Heidegger indicated that being occurs in identity and that identity has its place in thinking, which allows him to be himself with himself (Heidegger, 1988). This process of identity is mediated by sensitive experiences with others, through which the being is constantly revised, assuming an attitude towards his own existence (Contreras, 2006).

In this sense, identity is a process in which the experiences given in a sociocultural context, in a world of life (lebenswelt) and in thinking are found. There is no living or existing without a being-in-the-world in relation to internal states. This is convergent with the position of Varela et al. (2009), who affirm that the meanings regarding the world are mediated by social, linguistic and bodily processes.

Francisco Varela, a Chilean biologist, was one of the pioneers of neurophenomenology. A research program developed from neuroscience, phenomenology and the philosophy of mind, which emerges from the need to generate a dialogue between the rigor of the scientific method and quantitative data, obtained through neurophysiological and neuroimaging studies, and the first-person subjective experience of the participant in a research process. Neurophenomenology studies the relationship between subjective experience and the processes of the nervous system. Gallagher and Fernández (2020) state: "While Husserl proposed a purely phenomenological consideration of the intrinsic temporality of consciousness, Francisco Varela formulates a naturalized approach that integrates phenomenological and neurophysiological elements" (pp. 17-18). In this way, the objective and subjective views come together to obtain a more comprehensive perspective of the object of study.

Among the leading figures in the phenomenological tradition are Edmund Husserl, Martin Heidegger and Maurice Merleau-Ponty. Phenomenology studies the phenomenon (*φαινόμενον*) as it appears to the subject's consciousness, taking

into account his first-person experience (Zahavi, 2000). Husserl, Heidegger's teacher and considered the father of phenomenology, proposed that every assumption or judgment could be suspended or "*epoche*" (*ἐποχή*) in order to be captured in a pure manner, in its essence (Husserl, 2012). According to Heidegger (2003), phenomenology allows "[…] to make visible from itself that which is shown, and to make it visible as it is shown from itself" (p. 54).

Unlike Husserl, for Heidegger it is not possible to put all assumptions in parentheses, since, as mentioned above, Dasein is in relation to a social context that shapes it, so, although it remains fundamental to go to the thing itself, it is not possible to grasp it in a pure way. For Merleau-Ponty, the body and the senses mediate the perception of subjective experience, so the understanding of the world is not free of assumptions either (Merleau-Ponty, 1994). Despite their differences, Heidegger, Husserl and Merleau-Ponty converged on the importance of first-person experience and on understanding things from the way the individual experiences them in their daily lives.

The meeting point among autism, being-in-the-world and neurophenomenology is seen in the need to understand the relationship between the processes of the nervous system involved in this condition and the subjective first-person experience of those who have it. In other words, it is about identifying the neurobiological substrate of autism in relation to the being-in-the-world of autistic people and the meanings they attribute to their relationship with the world, strengthening the understanding of their own experience.

In the field of neuroscience, numerous studies have been conducted that have offered explanations regarding what happens in the brain of an autistic person. Some of these are neurophysiological studies that have explored the activity of mirror neurons or the mirror neuron system (MNS), a set of brain cells that are activated when an action is performed, as well as when it is observed by another individual (Rizzolatti & Craighero, 2004). The MNS circuits are said to be responsible for allowing human beings to mentally simulate the actions observed in others, learn through imitation, and establish connections from affective and emotional points of view (Gallese et al., 2004; Iacoboni, 2009). The MNS also allows us to create in our own mind a representation of what others feel and think, that is, the ToM (Ramachandran, 2012).

Various studies that have focused on MNS activity in autism using electroencephalography (EEG) have yielded conflicting results. Firstly, some studies (Bernier et al., 2007; Martineau et al., 2008; Oberman et al., 2005) suggest that the mu rhythm, an electrophysiological signal that occurs

between 8-13 Hz in the EEG (Palau-Baduell et al., 2011) and which has been considered a biomarker of mirror neurons that become desynchronised when performing and observing a movement performed by another individual (Ramachandran, 2012), is only suppressed when performing one's own movement, but not when observing it when the movement is performed by another person.

This would explain the difficulties that autistic people have in establishing a connection with an observed individual. On the other hand, studies also carried out with EEG (Bernier et al., 2013; Fan et al., 2010; Raymaekers et al., 2009) have revealed that participants with autism, in a similar way to control subjects, show a desynchronization or suppression of the mu rhythm when they observe another individual performing a movement, which concludes that they do establish some kind of connection with them. In the context of *Dasein*, they demonstrate that they exist, establishing a relationship with that which is in the world through inhabiting or familiarity with others.

Despite their divergent results, these investigations have two aspects in common: they all focused on the observable and measurable data obtained through neurophysiological recording, but none considered the subjective experiences of the participants regarding what it means to be-in-the-world as an autistic individual. While the rigorous study of the data allows us to understand how the brain works, allowing space for the individual's first-person experience broadens the understanding of the object of study, and facilitates its comprehension and subsequent intervention in the different contexts of life, such as the educational and social contexts.

Considering the above-mentioned background, this research had a neuro-phenomenological orientation. Its objective was to understand the relationship between subjectivity and the brain, covering the neural processes involved in autism and the first-person experience of a group of children and adolescents diagnosed with ASD from the city of Manizales, Caldas (Colombia). This study sought, on the one hand, to explore the functioning of the MNS in the participants and, on the other hand, to capture the subjective experience regarding their being-in-the-world as autistic people.

Methodology

Design

Mixed research. In quantitative terms, this study was descriptive and inferential. Qualitative information was included, approached from a Socratic procedure and an interpretive phenomenological approach.

Sample

35 children and adolescents diagnosed with high-functioning autism (ASD grade 1) participated in the study, linked to the *Instituto para el Desarrollo Integral del Niño en Condición de Autismo* (DINA) of the Universidad de Manizales, as well as 19 control peers. The participants were between 6 and 16 years old at the time the research was conducted. All the minors belonging to the autism group were diagnosed by an interdisciplinary team. Likewise, they had therapeutic support and were attending a public or private regular education institution in the city. It was verified that all participants had an intelligence quotient (IQ) equal to or greater than 85 points, through a prorating based on the Wechsler Intelligence Scale for Children, version IV (WISC-IV). Four participants were removed from the research due to having a psychiatric history that did not allow them to develop the cognitive tasks designed for the experimental conditions.

The research was approved by a bioethics committee, based on *Resolution 8430* (1993), which regulates the conduct of scientific studies in Colombia. Prior to the evaluation process, parents and minors were informed of the characteristics of the research, and their questions were answered. After the parents signed the respective informed consent and the minors gave their assent, the evaluation process was carried out.

Techniques and Instruments

To obtain quantitative data, an electroencephalogram (also called EEG) was used, a study that allows noninvasive exploration of the brain's electrical activity. Recording was done using frontal, central and parietal channels, as well as two headphones' references (A1 and A2) and a *ground* electrode. The channels used for recording were: F7, F8, F3, Fz, F4, C3, Cz, C4, P3, Pz and P4. The electrodes were placed on the scalp following the international reference system 10/20, which,

according to Iriarte et al. (2013) is called this way "[…] because the distances between the electrodes are 10% and 20% of the total distances measured, either in circumference or in a straight anteroposterior or transversal line" (p. 7). The impedance of each channel prior to electrophysiological recording was less than 5KΩ.

Event-related desynchronizations (ERD) of the EEG mu rhythm, considered biomarkers of the MNS (Ramachandran, 2012), located in the band between 8-13 Hz, were evaluated. Five experimental conditions were designed: baseline condition (BAS C), observation of movement performed by another individual or biological movement (OBS BIO), imitation of observed movement (IOM BIO), observation of a first non-biological movement (OBS NO BIO 1) and observation of a second non-biological movement (OBS NO BIO 2).

The qualitative information consisted of exploring the subjective first-person experiences reported by children and adolescents about their life and their being-in-the-world as individuals with autism. To do so, a Socratic style was used based on the proposal of Martínez (2009), according to which a conversational process begins from the phenomenal field of the interlocutor, from what interests him, reaching the essence of things themselves. This style of conversation does not have a rigid structure, but is flexible, and allows for the formulation of questions that follow the course of the conversation given by the interlocutor.

Since this is a conversational style with a phenomenological orientation, things are taken as they appear, such as the subjective first-person experiences related to a topic. In the case of this research, the questions were asked in a simple and concrete manner, without leaving room for ambiguity, especially in the case of participants with autism. It should be noted that not all individuals expressed a willingness to converse, so they were not pressured, but rather common ground was sought with them and dialogues were generated to the extent they allowed it.

Procedures

The conversations about subjective experiences took place in the facilities of the Neurophysiology Laboratory of the Universidad Autónoma de Manizales, prior to the neurophysiological recording, fostering an environment that invited participants to express their ideas. This was done by avoiding furniture barriers, as well as structured questions that gave the impression of being in a clinical interview. The participants were asked what their life was like on a daily basis, what relationships with others meant to them, and what they liked most about

their lives. The concept of autism was not emphasized, but it was used as a starting point to formulate some questions associated with socialization with peers, friendship, and family.

For the neurophysiological recording, participants were placed in a room free of sensory stimuli that could affect the focus of their attention. The procedure of Oberman et al. (2005) was replicated, showing the experimental conditions on a screen placed 1 meter away from the participants. Table 1 lists these conditions.

Table 1. *Experimental conditions of the stimulation protocol.*

Experimental Condition	Description	Duration
C BAS	Baseline recording, in which participants remained in a resting state. Under this condition, no ERD of the mu rhythm is present, demonstrating that there is no activity of the MNS.	5 seconds.
OBS BIO	Participants are presented with a video clip of a person moving an arm in an extension-flexion direction. This is when, under expected conditions, the ERD or suppression of the mu rhythm occurs, demonstrating the activation of the MNS when observing a movement performed by another individual.	20 seconds.
IMI BIO	The video clip from the previous condition is repeated with a different aspect: this time, participants are asked to imitate the observed movement. Under expected conditions, the MNS becomes desynchronized or suppressed when the movement is imitated.	20 seconds.
OBS NO BIO 1	A video clip is projected on the screen in which, on a white background, a black circle appeared moving in the same direction as the arm. No desynchronization or suppression of the mu rhythm would be expected in this condition.	20 seconds.

OBS NO BIO 2	A video clip with a gradient blue background is shown on the screen with several colored spheres falling and jumping. Unlike the previous condition, in this case a greater response from the brain would be expected.	20 seconds.

Note. The experimental conditions were repeated three times in order to average the electrophysiological signal.

Cadwell Easy® III EEG software was used through one of its DC or channels to discriminate the conditions of the stimulation protocol.

Information Processing

The data were analyzed using MATLAB® software, through which filters were applied to eliminate noise from the signals. The maximum peaks were identified while the band between 8-13 Hz was defined for analysis and the characteristics of the signals were extracted, averaging them for each experimental condition executed. The extraction of the powers per channel and per experimental condition was compared with BAS C through an ANOVA with alpha of 0.05. The qualitative information obtained in the conversations with the participants was processed through the ATLAS.ti Software, version 23. Subsequently, it was analyzed under an interpretive phenomenological approach, based on the updated proposal of Duque and Aristizábal (2019).

Results

Qualitative Findings

The conversations held with the participants revealed the heterogeneity of their thinking and their way of narrating themselves, especially in the group with autism. In all the conversations with the autistic participants it was possible to identify a person-world relationship, but in a way that was different from the ways of inhabiting the world of the participants in the control group.

Unlike the control group, where participants were more homogeneous in the length of their speech, interactions with participants with autism revealed dichotomous points, with children and adolescents being very willing to express their ideas, while others responded in a monosyllabic manner. Participants

with autism also demonstrated having few shared interests with other autistic people, relating very specific topics and demonstrating, in some cases, a level of knowledge greater than expected for their age.

It was found that most participants with autism referred to aspects related to their school or educational institution. For example, when they were asked to describe what they liked, they not only referred to their specific interest, but in most cases, they associated it with situations experienced in their schools. Some also mentioned their families, mainly their brothers, sisters, fathers, mothers and grandparents.

Regarding family, dichotomous opinions were also observed in participants with autism. Some said they liked to hug their loved ones, while others only mentioned them to tell a story that allowed them to get to their topic of interest, for example, telling how their parents took them to play soccer or how, with their family, they had visited the planetarium where they had been able to see models of celestial bodies. Figure 1 shows the frequency of words derived from the conversations.

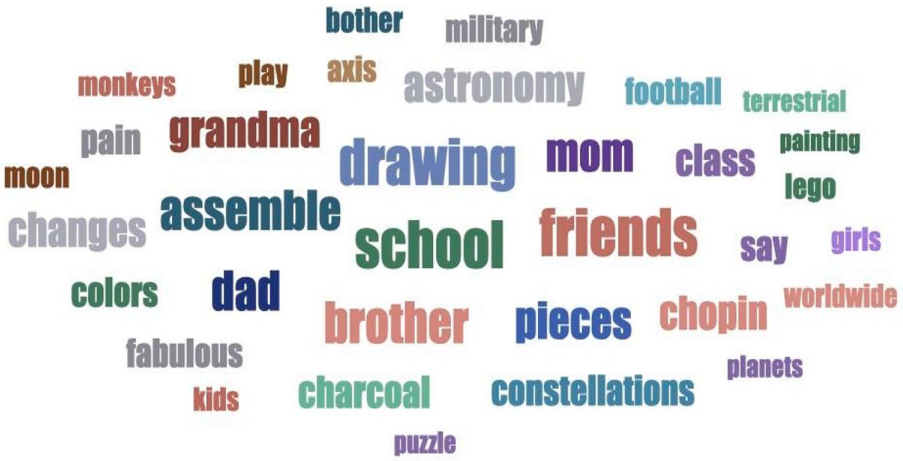

Figure 1. *Word cloud organized by frequency.*[1]

The question where the most divergences were found in the group with autism was the one about the meaning of the relationship with others, especially in friendship and social interaction with peers. Some participants with autism reported that they preferred to be alone at school, to work individually on their schoolwork, not to have many friends, and even to not care if others approached

1. Produced using ATLAS.ti, version 23.

them rudely. Before placing the electrodes on her scalp to perform the neurophysiological test, an autistic adolescent said: "I don't like to talk much, but if you have to press hard on the head to do that, do it. I like it when you press hard, it doesn't hurt at all" (personal communication, June 8, 2018).

In contrast, other autistic participants, especially some girls, showed a lot of social sensitivity, stating that they had friends and shared time with them at school and outside of it. One of them mentioned:

> I have lots of friends. My school is fabulous, I love it. I can do what I like there and my friends like my ideas because I know a lot about fashion, and I tell them what looks good on them. They also love my dog and when they come to my house, they take pictures with her (Personal communication, June 8, 2018).

Another striking aspect of the discussions was that most participants in the autism group reported liking visual stimuli and visualconstructional tasks. In the control group, these interests were also found both in school activities and independently, but in the autism group, these interests proved to be more specific. For example, several autistic participants indicated that they liked drawing and painting. Some stated that they preferred gore anime and youth manga drawing, while others reported greater interest in figures with a lot of depth, three-dimensional effects, and optical illusions. Several participants with autism expressed an interest in puzzles, puzzle pieces, as well as models of machines and digital systems.

Quantitative Findings

The ERDs of the mu rhythm, located in the band between 8-13 Hz, proved to be negative both for the group with autism or ASD and for the controls. The channel that was of most interest among the central channels was the C3, considering the right laterality of the participants; as well as the mu rhythm, whose source is located in the sensorimotor cortex (Hamilton, 2013). The C3 channel was placed over this area, capturing its electrical signal.

Greater data dispersion was identified in the control group. However, it was in the group of participants with ASD that more atypical data were found, especially in channel C3, in the biological movement observation condition. Figure 2 illustrates this behavior.

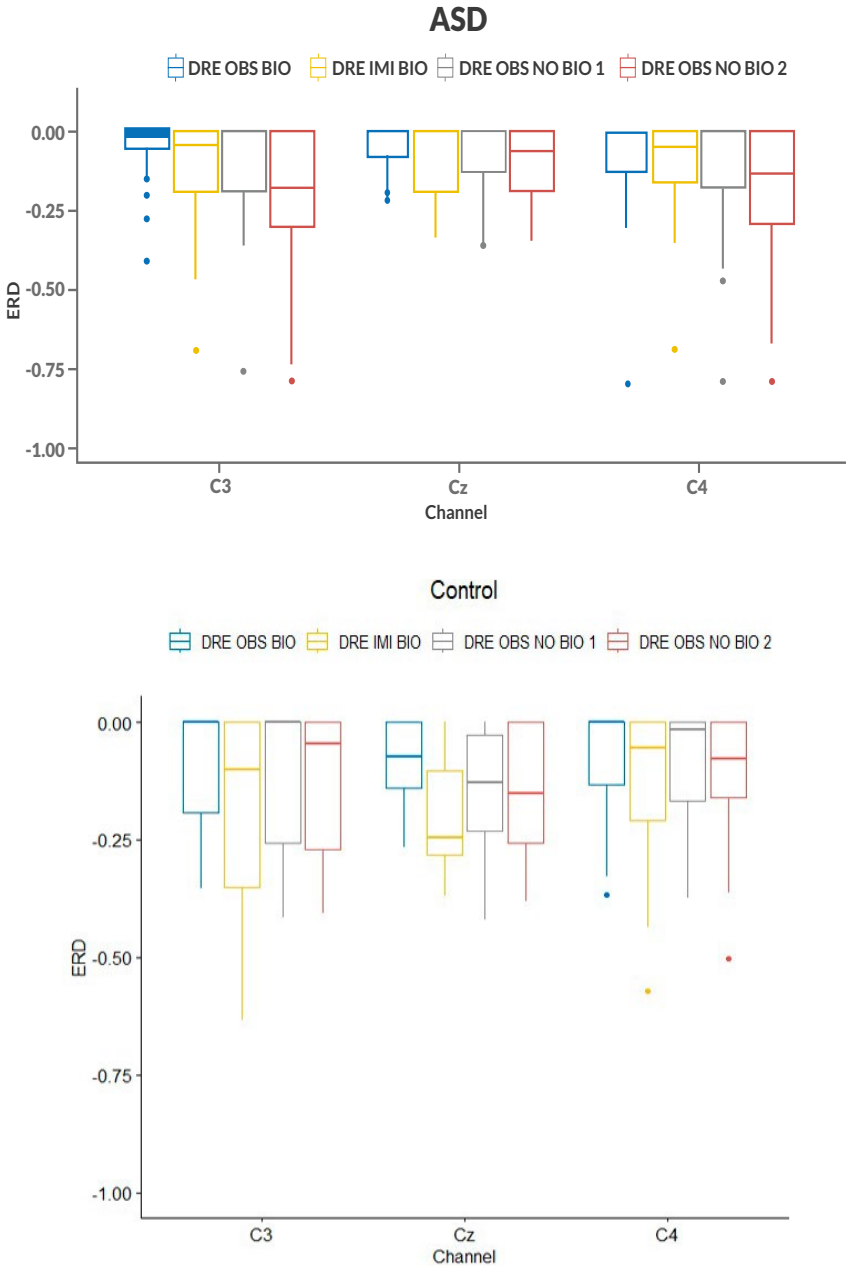

Figure 2. *Data relationship between ASD and control groups.*[2]

2 ERD for central canals in the four experimental conditions, compared with BAS C.

In the Cz channel, significant differences were identified between the two groups. In the IMI BIO condition (p = 0.000), the ERD was higher in controls than in participants with autism, which is compatible with the theory that states that people with this condition have lower imitation abilities (Ramachandran, 2012). In the OBS NO BIO 1 (p = 0.005), the group with autism obtained a ERD of 724% compared to 14% of the control group. In the same channel, for the OBS NO BIO 2 condition, the group with autism obtained a ERD of 1010% compared to 15% of the control group of participants.

Regarding the hypothesis of an altered MNS in autism, measurable through the absence of ERD or suppression of the mu rhythm in the OBS BIO condition through the C3 channel (Oberman et al., 2005), the data revealed heterogeneous behavior in the population, which generated its activation in some participants, but not in others. This could be demonstrated by the suppressed electrophysiological signal in the band between 8-13 Hz in some participants (MNS activation), while in others the voltage fluctuation continued as if they were in a resting state (absence of MNS activation). Figure 3 shows this behavior between two subjects diagnosed with ASD.

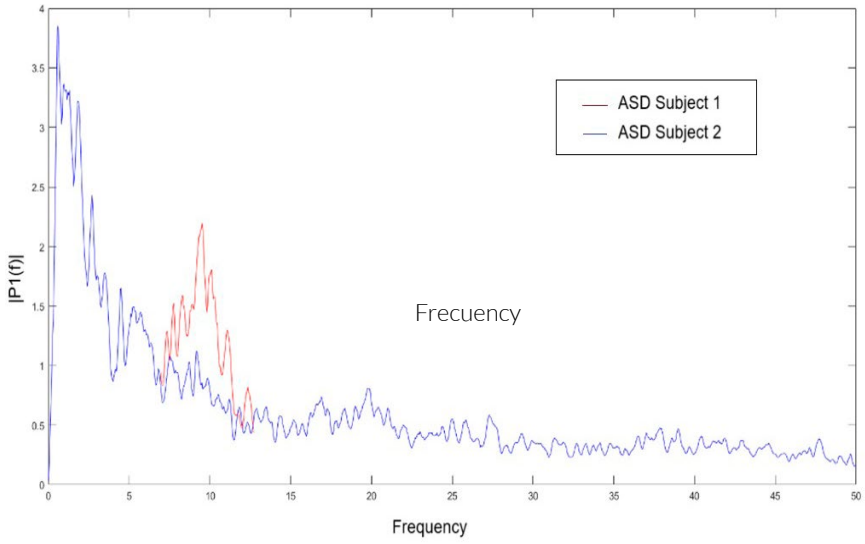

Figure 3. *ERD Channer C3 fon condition of biological movement observation Behavioral relationship of the MNS in two people with autism.*[3]

3 The electrophysiological signal of subject ASD 1 does not present suppression in the band between 8-13 Hz, while in subject ASD 2 it is observed.

Discussion

The systematic narration of autistic participants, as observed in this research, is relevant in terms of meaning. For people in the autistic group, recounting their daily life step by step proved to mean organization, tranquility and reduction of anxiety, which was of little relevance and even indifference for the control participants. In terms of Heidegger (2003), systematization is part of their existential constitution, being this their way of being together with other individuals, of inhabiting the world, of being connected and of becoming familiar with it.

Based on the accounts of autistic participants, it was identified that the lack of systematization, together with disorganization in the context, for example, the absence of patterns or defined agendas, as well as stimuli that for them constitute specific interests, would represent a difficulty for their person-world relationship. This systematization would be a way of inhabiting the world of the autistic individual, as well as a way of giving meaning to what is outside.

In this research, this was not only observed in terms of schedules, routines and anticipations of previously unestablished situations – such as changes in school activities, transport routes, food, home furnishings or playlists of audiovisual content – but also in meanings, such as colors and shapes; the color red was related to anger, for example, and green to tranquility. By acquiring these meanings, these patterns of the outside world would require continuity in the autistic person which, when altered, would generate high levels of anxiety, as well as feelings of incomprehension by other individuals, as observed in one of the stories.

Other relevant aspects in the accounts of autistic people were the greater presence of suspicion and the differences in the attitudinal disposition towards conversation. The Coffee Region, where the participants of this research and their parents stated that they reside, is a region of Colombia characterized by an attitude of trust, emotional reciprocity and a significant interest in conversation, even among children and adolescents. This contrasts with the suspicion and lesser disposition to conversation of some participants with autism.

In terms of meaning, socio-affective reciprocity would mediate differently in the construction of the identity of the autistic person, taking into account aspects such as the clinical picture of autism from the medical model - restricted interests and alterations in sensory modalities - and the differences raised from neurodiversity- preference for specific topics or diverse ways of integrating information received through the sensory organs. For some autistic people, as observed in the present research, it would be of little significance and even

annoying to talk with individuals recently met or who talk about topics that are not or are not interesting at all, as well as to talk with people who talk loudly, quickly or too much, or in spaces that are not or are very stimulating in sensory terms.

According to Heidegger (2003), *Dasein* in autism could be less susceptible than others to being absorbed in the world as a fallen being, taking into account the lower reciprocity with other individuals and the alerts that are turned on in sensorial terms and that intervene in not opening up to some experiences. Otherwise, the absorption would occur mainly through the elements of the world with which the individual resonates most, as is the case of his particular interests.

On the other hand, the present results demonstrate the importance of integrating neurophysiological findings with first-person experience for autism research. It is possible to consider that the divergent results found in previous research on MNS functioning in ASD (Bernier et al., 2007; Bernier et al., 2013; Fan et al., 2010; Martineau et al., 2008; Oberman et al., 2005; Raymaekers et al., 2009), could be due to the ontological heterogeneity of people with autism, represented in a wide spectrum of the person-world relationship. In this research, the atypical data presented in Figure 2 and found in channel C3 in the OBS BIO condition would correspond to the diverse characteristics of the participants, which include the different ways of seeing themselves, of relating to others and of being absorbed by the world.

It should be noted that the divergent results found in Figure 3 corresponded to two participants who narrated themselves differently. The participant who did not present the ERD of the mu rhythm in the OBS BIO condition in channel C3, indicating what would be MNS inactivity, demonstrated distant proxemics and an attitude unwilling to interact. On the contrary, the child in whom the ERD was observed, considering what would be MNS activation, showed greater openness to conversation, talking about his interests and his relationship with the world, but also demonstrating an attitude of openness towards the story of the researcher with whom he interacted. Likewise, his proxemics were less rigid, making gestures to converse, smiling and listening attentively when spoken to.

One aspect that also stands out is the difference in the ERD in the two groups in the OBS NO BIO 1 and OBS NO BIO 2 conditions in the Cz channel, where the group with autism obtained higher percentages (724% compared to 14% and 1010% compared to 15%). These divergences would indicate that autistic people are more oriented towards the details of objects and the identification of patterns in elements of the world where other individuals are not present; such as video games, computer programs, machines and other systems (Baron-Cohen, 2013).

However, establishing relationships between subjective experience and neurophysiological findings, it is observed that, despite sharing the same

diagnosis, people with autism - it should be remembered that this is autism grade 1 - adopt different ways of being-in-the-world; not only in relation to non-autistic individuals, but also among themselves, observed in the behavior of the MNS, in the way of narrating, in particular interests, as well as in the divergences in relationships with friends, family and classmates.

Based on Heidegger's proposal (2003), the greater connection with stimuli not coming from other individuals, observed in some autistic participants in this research, could be understood from the encounter of another entity with *Dasein*. In this sense, the conditions OBS NO BIO 1 and OBS NO BIO 2 as entities (things or elements that are) are not simple entities without more but are determined by the being of *Dasein* (corresponding to the participant with autism) as entities, which acquire a meaning from which they are seen and represented. Therefore, this *Dasein*, as a being that exists, arranges and takes care of the entity that it discovers in its surrounding world in a different way than other individuals (control participants) do. The two forms of relationship imply being outside, leaving their internal spheres to a different extent, one more than the other, but both being in relation and inhabiting the world.

Although the present findings may reflect the heterogeneous ways in which the MNS behaves in autism, they do not provide us with answers, but rather with questions about the differences among autistic people. The atypical data observed in Figure 2 for the group of participants with autism could also be mediated by subjective characteristics of individual and internal experiences that could not be observed using techniques for exploring brain bioelectrical activity. However, through the present results, it is possible to consider that the ENS, as a neuronal circuit, mediates the subjective experience of the autistic person situated in the world, while this experience influences the MNS, stimulating its functioning. Thus, the differences in the MNS could also be mediated by the identities that are constructed through the experiences lived within the framework of social and cultural processes.

Relationship with the Objectives

Considering that the objective of this research was to understand the relationship between subjectivity and the brain, covering the neural processes involved in autism and the first-person experience of the participants, it was considered that the results could have a significant impact on an educational institution or local

school, this being the space most referred to by the participants and the one in which they expressed having the most significant experiences.

Based on the neurophenomenological nature of this research, an integrative educational intervention initiative was designed, based on the first-person experiences of the children and adolescents evaluated, as well as on the neurophysiological findings. From the experience of the participants, the interests they reported in the laboratory were taken into account, such as visual stimuli and visual-constructional tasks when acquiring new knowledge. The initiative was called "Neurodiversity: neuropsychopedagogical intervention program for the inclusive education of children and adolescents with autism in the city of Manizales" (abbreviated "Neurodiversity"), led by one of the researchers.

The two objectives of this initiative were: first, to design an inclusive classroom that is friendly to cognition and to the ways of inhabiting the world of students with autism; second, to co-construct with classroom teachers and guidance teachers new teaching-learning strategies for students with autism and their peers. The initiative won second place in the *Premio Cívico Retos con los ODS*, organized by the *Manizales Cómo Vamos* Corporation, its partners and allies.

The money given as part of the award prize was invested in the adaptation of the fourth-grade classroom of the San Pío X Educational Institution (E. I.) in the city of Manizales, which is a public institution. The fourth-grade classroom is located in the *La Capilla* location of the *La Enea* neighborhood, first block. This is a regular classroom attended by both boys and girls with autism and other conditions, as well as students without any other diagnosis. The space was conditioned based on the qualitative and quantitative findings of the research, as well as Armstrong's thesis (2012) for the creation of the neurodiverse classroom.

The materials acquired were 3D anatomical models, 3D books, adhesive and buildable pieces, art materials, pictograms for the sequential completion of tasks, games to strengthen social skills, English phrases, models of the human face and body, 80 cm x 120 cm banner prints to learn topics from different subjects by jumping (Spanish, English, Natural Science, Social Studies and Mathematics), portable sheets to strengthen semantic skills and two pouf chairs to change places in class. Considering that the "Neurodiversity" initiative was developed during the COVID-19 lockdown period, teachers were suggested to lend the materials to the children. Figure 4 shows the conditioned classroom.

Figure 4. *Conditioned classroom at the E.I. San Pío X, fourth grade.*[4]

It should be noted that the second objective of the "Neurodiversity" initiative was to co-create with classroom teachers and guidance counselors new teaching-learning strategies for students with autism and their peers. For this reason, 10 workshops were held with five classroom teachers and the guidance counselor from the E.I. San Pío X. These workshops were based on a horizontal relationship, in which the phenomenological method and the Socratic style based on the proposal of Martínez (2009) were also used. On this occasion, the aim was to learn about and understand the first-person experience of teachers regarding their work in the classroom with students with autism, expanding their phenomenological field for the generation of new ideas that facilitate teaching-learning processes in this population.

The workshops were held weekly for two hours using the *Google Meet* application. Although a researcher moderated and prepared a slide presentation for each meeting, the workshops were open to dialogue and the generation of ideas, based on the first-hand experience of the participants and on scientific evidence. The workshop topics were the following: 1) Generalities of autism:

4 The classroom seeks to adapt to the way students with autism inhabit the school world, which is why emphasis was placed on the purchase of visual-construction materials.

etiology, pathophysiology, sensory integration, emotion, cognition and behavior. 2) Neuropsychological and neurophysiological profiles of the child population with autism in the city of Manizales. 3) Children with autism in the school context: intervention strategies in the classroom, part 1. 4) Children with autism in the school context: intervention strategies in the classroom, part 2. 5) Work strategies by curricular areas with neurodiverse students. 6) Play as a tool for sensory integration and motor development. 7) How to create an inclusive and neurodiverse classroom. 8) Children with autism and their classmates. 9) Neurodiverse children, their families and their schools, part 1. 10) Neurodiverse children, their families and their schools, part 2. The workshops allowed teachers to share their understanding of their work in the classroom with their neurodiverse students, generating strategies with their classmates and acquiring new knowledge based on the results of the research.

Finally, four meetings were held with the parents, brothers and sisters of the students with autism from the E.I. San Pío X. These meetings were also based on the phenomenological method and on Martínez's proposal for Socratic dialogue (2009), questioning the interlocutors about being-in-the-world as a family member of a person with autism. The topics addressed scientific evidence but focused on the subjective experiences of the family members. The meetings, also held through *Google Meet*, were open and focused on the following aspects: 1) Generalities of autism. 2) Children with autism, their brothers and sisters. 3) Coping with stress in families of people with autism. 4) Children with autism in times of COVID-19: intervention strategies and care routes. During these meetings, parents expressed their feelings about their life world and the new ways of narrating themselves after the arrival of a child with autism in the family. Questions were asked that facilitated the identification of new possibilities to discover meaning in the face of the challenges that autism brings in childhood.

Conclusions

In the autistic person grade 1, as was the case of the participants in this research, a person-world relationship is observed, but given in a different way than that given in the person without this condition. From Heidegger's proposal (2003), the relationship in this research was between *Dasein* (way of existing of the participant with autism) and the entity (which is, in this particular case, conditions of observation of non-biological movements) that has a meaning for him; therefore, it does not constitute an entity without more, but it is shown and is represented

in his world, being determined by him and acquiring a particular meaning for him as an outstanding detail that follows a pattern or a systematic process.

In the educational context, it is essential to take this aspect into account, since it implies a recognition of the difference in the relationship between the autistic person and the world compared to the relationship between non-autistic person and the world. In a practical way, and as proposed by the "Neurodiversity" initiative, this underlines the need to create strategies that integrate the autistic student's being-in-the-world. Although the educational context seeks to strengthen relationships between peers, autistic people also require their differences to be recognized and learning scenarios to be fostered not always involving social interaction —much less forced— but that also facilitate the completion of individual tasks and the relationship with other elements, for example, animals, plants, minerals, as well as with objects of particular and significant interest for autistic people.

In the meantime, it is essential to respect the interests of autistic people in the educational context and to understand their subjective experience, for example, by allowing them to refer to their topics of interest in the development of academic activities, understanding their different ways of integrating sensory information, giving value to systematization in teaching-learning strategies and anticipating changes in previously established routines.

As indicated in the previous paragraph, the aspects described would apply to people with autism grade 1, the diagnosis corresponding to the children and adolescents in this study. However, this could not be said for cases of people with autism grade 2 or grade 3, where the psychophysical restrictors are greater and influence the person-world relationship. The present findings allow us to consider that the degree of autism could be directly proportional to the existential constitution of *Dasein*. However, both the imbalance of the evaluated sample of people with autism with respect to the control participants and the absence of people with other degrees of autism in this study constitute limitations to generalizing the present results. For this reason, it is necessary to carry out more studies with more balanced samples and that include participants with autism grades 2 and 3, making use of other methodologies that facilitate the evaluation of different cognitive, motor, emotional and affective processes in these other two groups, as well as the understanding of their subjective experience and their set of meanings.

The present research demonstrated the close relationship between mirror neurons and being-in-the-world. Aspects such as social interaction and the construction of bonds with other individuals would be conditioned by subjective characteristics of first-person experiences, mediated by mental processes linked to brain circuits, such as the MNS. In turn, the world of life, in which culture

and society participate, would provide feedback to this circuit, stimulating its functioning through interaction with others. It is considered that the different ways of being-in-the-world of individuals with autism could be integrated into the proposal of cognitive differences, as referred to by the neurodiversity model, also recognizing the impairments in aspects such as social interaction and imitation that are described from the medical model.

Autism would constitute a philosophical problem, considering that the concept used could influence the way in which the person with this condition thinks, identifies and, in effect, is himself. Autism, conceptualized only from the set of organic alterations, could condition the way in which the person narrates and identifies himself, excluding him from what is considered functional and influencing his way of inhabiting the world. Based on the results of this research, it is considered important to integrate the scientific evidence that supports the medical model with the arguments presented by the neurodiversity model, recognizing both the difficulties and the strengths of the autistic person.

Likewise, this research has also made it possible to understand that it is essential to focus on the person rather than on the data, within the framework of a horizontal relationship that promotes dialogue and understanding of the phenomenon under study from the perspective of those who experience it in their daily lives. One way to understand the differences between findings, as has been the case with some research that has studied the relationship between mirror neurons and autism, would be through the recognition of the subjective experience of the participants and the understanding of the meanings in the construction of their identities.

In future research, conducted from neurophysiology, neuropsychology and cognitive neuroscience, it is recommended to adopt a neurophenomenological approach, in which, in addition to the observable and measurable variables, the subjective first-person experience of the individuals evaluated is taken into account. It is also recommended to integrate other philosophical positions in the approach to subjective experience, such as narrativity and hermeneutics from Paul Ricoeur, as well as corporality from Maurice Merleau-Ponty. The comprehensive nature of philosophy would allow neuroscientists to expand their phenomenal field with respect to the object of research, integrating previously unconsidered perspectives to understand new realities. In this sense, neurophenomenology would constitute a research program that would facilitate this dialogue, making use of evidence and experience for the generation of new knowledge and social transformation.

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