
LANGUAGE DEVELOPMENT OF CHILDREN WITH AUTISM SPECTRUM DISORDER: RELATIONSHIP TO THE RATIO OF HAND FINGERS LENGTH (2D:4D)

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Abstract: Communication between people, in all countries of the world, is carried out and ensured by language, which consists of a combination of systems, and varies from culture to culture and from one era to another. However, some children do not have the opportunity to develop their functional language skills to a satisfactory degree. Children with Autism Spectrum Disorder (ASD) present a delay and serious deficiencies in their speech and, by extension, in their language. Research findings have confirmed the effect of testosterone on the neurodevelopment of children, as well as on the language disorders which are directly related to ASD.

The aim of this article was to carry out a literature review, in combination with a brief critical overview of old and modern literature findings that use the 2D:4D hand finger ratio. And this for investigating the possible hormonal contributions to the manifestation of ASD, as well as to the differentiation of the language development of children with ASD.

The small number of studies, the different research designs, tools, size and composition of samples and methods for collecting and analyzing the data make it difficult for the studies to be compared and drawing reliable conclusions. So, the scientific community has not been able to reach clear positions on the understanding of the interdependence between the ratio 2D:4D of the length of the fingers of the hand and the language development of children with ASD.

The study of biological factors that interact and differentiate the language development of children with ASD is of scientific interest at a theoretical and applied level. At a theoretical level, the assumption that ASD is an etiologically, biologically and clinically heterogeneous disorder contributes to a more complete understanding of the individual and developmental differences observed in the learning, performance and behavior of children with ASD. The early identification of language deficits, combined with the assessment of the language performance of children with ASD, could create new perspectives in order to be launched the differentiation of the educational process. Consequently, early intervention, with the systematic and intensive implementation of appropriate learning programs, with the use of alternative teaching methods, as well as with the organization of supportive learning environments, in the various educational structures, can bring positive results in areas where children with ASD lag behind. More specifically, early detection and early intervention will make it possible to become useful changes that will concern the language development of children with ASD.

Keywords: Autism spectrum disorder, language development, hand fingers ratio, sex hormones and intervention.

1. INTRODUCTION

Sex hormones exert long-term organizational effects on the brain and behavior of humans (Collaer & Hines, 1995). Fetal testosterone has been found to be potentially associated with the presence of neurodevelopmental disorders (Schieve et al., 2018) and the appearance of features associated with ASD (Saenz & Alexander, 2013; Knickmeyer & Baron-Cohen, 2006). Their effects are evident during two sensitive periods of development, the prenatal/neonatal period and the postnatal period (Collaer, Reimers & Manning, 2007).

The data on these changes and their impact on human neurocognitive function are not easy to perceive. Therefore, the hand fingers ratio (2D:4D) has been proposed as a potential anthropometric indicator of prenatal testosterone exposure. In this context, this article refers to the existing literature on the 2D:4D hand fingers ratio, as a biological indicator, with the aim of investigating the existence of scientific interest regarding the effect of fetal testosterone on the language development of children with ASD.

2. CLARIFICATION OF TERMS

This chapter clarifies the terms mentioned in the international bibliography and related to the 2D:4D hand fingers ratio, the investigation of its possible hormonal effects on the manifestation of (ASD), as well as the differentiation of the language development of children with ASD.

Hand fingers ratio (2d:4d)

The 2D:4D ratio of hand fingers, i.e. the relative length of the 2nd finger (pointer) to the 4th finger (ring finger), was recognized as a biological characteristic in the last century (Phelps, 1952), with this ratio being comparatively

smaller in men than in women (Valla & Ceci, 2011). These differences appear to be universal and vary between different ethnicities (Manning et al., 2007). The genetic basis for finger length variation is relatively recent (Brosnan, 2006) and has been linked to several variables, including the influence of sex hormones during early embryonic development (Wang et al., 2016).

Specifically, high levels of testosterone facilitate the development of 4D in males, while high levels of estrogen contribute to the development of 2D in females. Therefore, low 2D:4D finger ratios in males are associated with high testosterone levels, while high 2D:4D finger ratios in females are associated with low testosterone concentrations (Manning et al., 2014). The 2D:4D finger ratio has been proposed as a potential anthropometric indicator of prenatal testosterone exposure, and recent research supports the relevance of this index in populations with ASD (Lee et al., 2021).

Autism spectrum disorder (asd)

ASD is a pervasive developmental disorder with a heterogeneity of symptoms (Markou et al., 2017), which presents as key features the limited social interaction, quantitative and qualitative deficits in verbal and non-verbal communication, restricted interests, and repetitive patterns of behavior (Stepanova et al., 2017). The symptomatology of autism ranges from normal intelligence and minimal elements of autism to the most severe form that includes pronounced autistic elements and mental retardation (Antonioni & Daliana, 2017), with the result that some children with ASD show exceptionally high performance in some cognitive areas, such as art, music or mathematics (Happé & Frith, 2010).

The exact causes of ASD have not yet been clarified, as it is a multifactorial phenomenon (Happé, 1998). Genetic and environmental risk factors appear to interact and contribute to the development of ASD (Seretopoulos et al., 2020). Furthermore, the prevalence of ASD ranges from 1-3% in children and adolescents and affects approximately 7.6 individuals per 1000 births worldwide (Seretopoulos et al., 2020). Regarding gender, its incidence is 3 to 4 times higher in men than in women (Vermaat et al., 2018).

Sex hormones and atypical cognitive development

Sex hormones exert long-term organizational effects on the structure and functions of the brain, as well as on human behavior (Collaer & Hines, 1995), while also it was found that there is a connection between fetal testosterone and the occurrence of neuro-developmental disorders (Schieve et al., 2018). Increased prenatal exposure to sex hormones has been correlated with a higher likelihood of ASD development (Li et al., 2023). Studies report that there are negative effects of testosterone on children's neurodevelopment, including many features associated with ASD such as: lack of eye contact (Saenz & Alexander, 2013), limited vocabulary (Lutchmaya & Baron-Cohen, 2002), social deficits (Knickmeyer & Baron-Cohen, 2006), and lack of empathy (Chapman, et al. 2006). Also, high levels of fetal testosterone may compromise the development of regions of the left cerebral hemisphere, causing language disorders, left hand preference, and autism (Geschwind & Galaburda, 1985).

Furthermore, delayed or inadequate acquisition of empathy does not allow individuals with ASD to reason and provide logical explanations for other people's behavior (Shamsi et al., 2017). Systematic reviews confirm that androgen levels are often altered in autism (Wang et al., 2024). This results in children with ASD exhibiting social, behavioral, and communication deficits (Shamsi et al., 2017).

Language development in autism

Language is the main means of communication, it is an evolutionary process that begins from the prenatal period of human life (Tzouriadou, 1995), but not all children manage to develop functional language skills. Speech, and by extension language, is one of the areas that presents delays and serious deficiencies in people with ASD (Hojjati & Khalilkhaneh, 2014), as a result of which they significantly affect the way these people communicate and interact.

In more detail, some children with ASD present difficulty in language skills, in verbal and non-verbal communication (Floris et al., 2013), as well as obvious deficits in language acquisition, expression and use of language (Markou et al., 2017). Recent findings highlight significant variation in expressive language growth among individuals with ASD (Su et al., 2024). In addition to the inability to use language in the social environment, there is also a deficit in the paraverbal elements of language, such as e.g. is the timbre of the voice and the intonation (Kambouroglou & Papantoniou, 2003). Individuals with ASD are distinguished, at any age, by a lack of cognitive flexibility and understanding of body language, reduced use of gestures, absence of symbolic thinking and possible regression, either in language, or in other skills (Lukito et al., 2017).

As shown by the research, there is evidence that testosterone contributes to the development of ASD characteristics because high levels of prenatal testosterone negatively affect the structure and function of the left hemisphere of the brain of children with ASD, thus hindering the development of their language abilities (Geschwind & Galaburda, 1985).

3. LITERATURE REVIEW

The investigation of the relationship between the ratio of hand fingers length (2D:4D) and ASD has attracted the interest of modern neuropsychology and pedagogy since the last century. A review of the existing literature reveals a limited number of studies that refer to the relationship between this ratio and the language development of children with ASD. While the research results so far, which concern the relationship between the ratio of hand fingers (2D:4D) and the characteristics of ASD, are considered contradictory.

Since 2001, three major studies (Manning et al., 2001; Mackus et al., 2017; Kyselícová et al., 2021) have aimed to link the 2D:4D hand fingers ratio with the development of ASD traits, as follows:

The first of these (Manning et al., 2001) studied the relationship between the 2D:4D hand fingers ratio among children with ASD, their relatives, and a group of children from the typical population (control group). The ages of the sample ranged from 2 to 15 years, and the results showed a positive correlation between the 2D:4D finger ratios of children with autism and their relatives, and lower ratios compared to children in the control group.

The second study (Mackus et al., 2017) investigated the 2D:4D finger ratio as a biomarker of autistic traits in a sample of 401 individuals aged 18 to 30 years. For women, the 2D:4D finger ratio of the left hand had a significant positive correlation with the score on the “communication” scale. For men, a significant positive correlation was found between the 2D:4D ratio of the left hand and the total score of the questionnaire. The result of the study showed that the 2D:4D finger ratio of the hands is not a biomarker of autistic traits in the typical study population (Mackus et al., 2017).

The third and final cross-sectional study by Kyselícová et al. (2021) investigated the relationship between hand fingers length ratio 2D:4D and ASD, through a cross-sectional study with 91 boys, 36 adults with ASD, and 379 neurotypical students with or without autistic features. The results of the study showed that the 2D:4D ratio may not be reliably associated with the autistic phenotype. No significant differences in finger ratios were found between autistic and neurotypical individuals, nor was the ratio associated with ASD characteristics (Kyselícová, et al., 2021).

More specifically, a positive relationship was found between the 2D:4D ratios of the fingers of the hands of children with ASD and their relatives, and lower ratios compared to that of the control group. Apparently, a low 2D:4D ratio may serve as a potential diagnostic marker for ASD and may implicate prenatal testosterone in its etiology (Manning et al., 2001). Low ratios also correspond to high prenatal testosterone levels and contribute to both the manifestation of autistic traits and the risk of possible ASD occurrence (Manning et al., 2001).

Furthermore, no relationship was found with the Baron-Cohen theory of the “Extreme Male Brain”, nor convincing differences in finger ratios between autistic and neurotypical individuals, nor an association of ratios with ASD characteristics. The results examined may reflect the results of recent longitudinal studies, which suggest that the 2D:4D ratio of the fingers of the hands is not stable during ontogenesis, nor is it reliably associated with autistic features in neurotypical adults (Kyselícová et al., 2021).

In summary, we would say that research results require special consideration and attention in their handling and evaluation. The small number of studies, the different research designs, the heterogeneity of research tools, the different size and composition of samples and the variety of methods for collecting and analyzing data cause serious problems. These problems especially concern the difficulty of comparing studies and drawing reliable conclusions. Therefore, the scientific community has not been able to reach clear positions on the understanding of the interdependence between the ratio of the length of the fingers of the hands 2D:4D and the language development of children with ASD.

4. CONCLUSION - RECOMMENDATIONS

The present literature review provides a brief critical overview of old and modern literature findings that use the 2D:4D hand fingers ratio to investigate possible hormonal contributions to the manifestation of ASD, as well as to the differentiation of language development in children with ASD.

Research data highlight the effects of fetal testosterone on the neurodevelopment of children, including language disorders associated with ASD (Schieve et al., 2018). It is hypothesized that the 2D:4D hand fingers length ratio is negatively associated with prenatal testosterone and that this ratio is comparatively lower in the ASD population than in the typical population. Consequently, this ratio may be a potential indicator of the diagnosis of ASD and prenatal testosterone may be involved in its etiology (Baharara, et al., 2014; Dey, et al., 2021). Therefore, the study of biological factors that interact and differentiate the language development of children with ASD is of scientific interest at a theoretical and applied level.

At a theoretical level, the assumption that ASD is an etiologically, biologically and clinically heterogeneous disorder contributes to a more complete understanding of the individual and developmental differences observed in the learning, performance and behavior of children with ASD.

At an applied level, the early recognition of individual differences in the language development of children with ASD can create prospects for improving the educational process. It is estimated that the role of the environment, in the sense of the experiences and education received by the individual, remains decisive for the severity with which the disorder manifests itself (Dawson, 2008). Consequently, early intervention, with the systematic and intensive implementation of appropriate learning programs, with the use of alternative teaching methods, as well as with the organization of supportive learning environments, in the various educational structures, can bring positive results in areas where children with ASD lag behind. The involvement and participation of parents of children with ASD in the intervention program, with the role of co-educator, can contribute decisively to the success of the program (Galanis, 2020).

In this light, intervention, as a means of education, acquires a different meaning and helps to change the attitude of specialists towards the way of dealing with the language and communication deficits of children with ASD. Thus, ASD should not be treated as a disease, but as a neurological variation which is considered normal and part of the great variety of neurological characteristics that characterize the human species (Jaarsma & Welin, 2012).

ACKNOWLEDGEMENTS

The selection of the topic and writing of this article on autism was done with scientific guidance, support and the valuable advice of Associate Professor Miglena Simonska, who is the supervisor of my doctoral thesis, and whom I would like to thank from the bottom of my heart. I would also like to thank my parents and family for their unwavering moral support.

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