

The 2D:4D ratio is associated with performance in the 'TEACCH program' of subjects with autism spectrum disorder

MARIA CRISTINA PETRALIA¹, ELISABETTA SAGONE², MARINELLA COCO³, RAFFAELE GUELI²,
GIULIA DI GREGORIO², LUCIO SALVATORE GIOVANNI COCO²,
ANDREA BUSCEMI^{4,5} and VALENTINA PERCIAVALLE²

¹Bonino Pulejo Neurolesi Center, IRCCS, I-98124 Messina; Departments of ²Educational Sciences and

³Biomedical and Biotechnological Sciences, University of Catania, I-95123 Catania; ⁴Horus Social Cooperative, I-97100 Ragusa; ⁵Department of Research, Center Studies of Osteopathy, I-95100 Catania, Italy

Received September 19, 2017; Accepted January 26, 2018

DOI: 10.3892/etm.2018.6834

Abstract. Problems arising on the autistic spectrum are more common in male individuals, leading scholars to attempt to determine whether there is a correlation with testosterone levels to which fetuses were exposed during intrauterine life. The aim of the present study was to investigate, through the digit ratio technique, the possible correlation between testosterone exposure during intrauterine life and the achievement of predetermined objectives during the educational program Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) in a group of subjects with different forms of autism. The results showed a positive correlation of the TEACCH program and 2D:4D ratio. Therefore, we hypothesize that a base screening may be useful to pinpoint the optimal teaching strategies to obtain the best possible performance from each subject.

Introduction

The term 'autism' has been extensively utilized both in specialist contexts, such as scientific, educational and pedagogic research, and by public opinion.

To thoroughly define the term autism, we employed the definition of the scientist Bonnie Evans, who affirms that: 'Autism is an essential concept used in the description of child development and its variances. Yet the phenomenal success of autism

diagnoses is relatively recent. Today, autistic spectrum disorder is regarded as a developmental condition with genetic and biochemical correlates that often persists into adulthood' (1).

Problems associated with being on the autistic spectrum are more common in male individuals. However, whether there is a correlation with the testosterone levels to which babies were exposed during intrauterine life is unclear (2).

The aim of the present study was to investigate, through the digit ratio technique, the possible correlation between testosterone exposition during intrauterine life and the achievement of predetermined aims during the educational program Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) (3,4) in a group of subjects with different forms of autism. The results showed that it is possible to measure the levels of prenatal testosterone exposition in a non-invasive manner thanks to the digit ratio technique, which involves measuring the ratio between the second finger (index) and the fourth finger (ring finger) of the left hand. Certain authors have previously observed that high levels of prenatal testosterone exposition are associated with specific competences (mathematics and academical performance) and physiological and pathological personalities (5-8).

Subjects and methods

Subjects. A total of 60 boys on the autistic spectrum with a mean age of 9 ± 2.1 years participated in the study. Of the 60 subjects, 32 had a diagnosis of autism and mild mental retardation and 28 had a diagnosis of high-functioning autism.

The parents of the subjects were informed about the protocol of the research and gave their informed consent. The study was approved and implemented by the organization 'A Future for Autism Onlus-Catania' (<http://www.autismo.net/>).

A hand photocopy was made of all the subjects and different activities were proposed to achieve the goals of the TEACCH program (3).

TEACCH program. The TEACCH program, created and designed in 1960 by Mesibov *et al* (3), has the aim of improving the personal, social and professional life of the autistic subject,

Correspondence to: Dr Maria Cristina Petralia, Bonino Pulejo Neurolesi Center, IRCCS, Contrada Casazza, SS113, I-98124 Messina, Italy
E-mail: m.cristinapetralia@gmail.com

Dr Marinella Coco, Department of Biomedical and Biotechnological Sciences, University of Catania, Via Santa Sofia 64, I-95123 Catania, Italy
E-mail: marinella.coco@unict.it

Key words: autism, digit ratio, TEACCH program

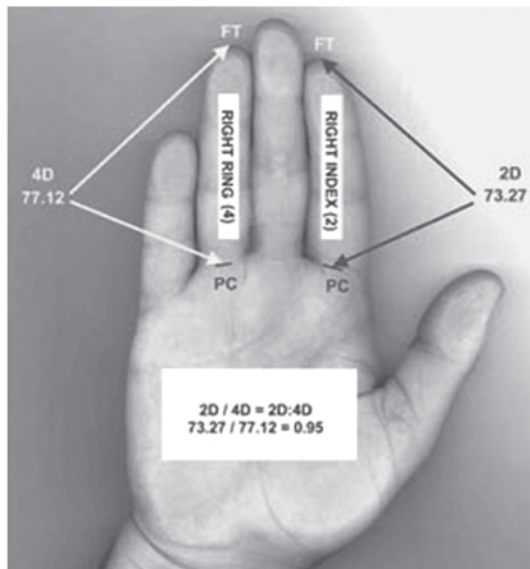


Figure 1. Method of measuring 2D:4D ratio.

by employing specific educational techniques to develop the individual's personal capacities.

We selected activities that were not previously conducted by the subjects, with the aim of excluding inferences from previous learning (routine, execution and automatism). The degree of achievement of predetermined aims was calculated by conferring a score from 0 to 10.

The chosen activities, which correlated with the objectives in the TEACCH program, are:

i) Recognition of colours and geometrical figures involved work aiming to recognize colours (the subject had to put the same colour cardboard inside the corresponding baskets of three different colours: yellow, red, blue). The second assignment was to pair up geometrical figures (triangle on triangle, square on square, rectangle on rectangle).

ii) Another objective was autonomy in purchasing a snack through social stories relating to the purchase of a snack in a small shop. To reach the aim, the subject had to comprehend the sequence of a social story regarding the purchase of a snack, and, later, was required to use it as an acquired skill and employ it in a natural context, such as a small shop.

iii) Refining manual skills, e.g., tying their own shoelaces was checked. Manual labour was carried out on a table as preparation for determining precision manual skill. The subject had to tie his shoes with different types of shoelace, differing in length and thickness, to arrive to the standard measure of tennis shoes.

iv) Autonomy in personal hygiene, such as hand washing and brushing of teeth was another objective. The aim was achieved if the subject, after working with social stories and after a 'training' with a tutor, could put soap on his hands, rub the hands in the typical manner of washing hands, dry off with a little towel and hang the towel back in its place, and then take the beauty case from the bag and open it, take the toothbrush out, remove the protective cap, take the toothpaste and twist off the cap, brush his teeth, rinse the toothbrush, put on again the protective cap, put the toothbrush in the glass, put on again the cap on the toothpaste, place everything back

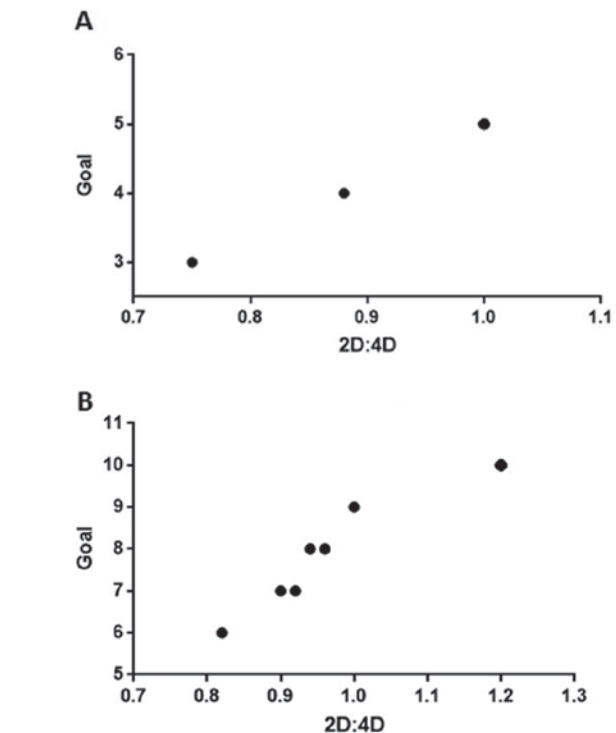


Figure 2. Correlation between achieved goals and digit ratio in subjects with (A) autism and mild mental retardation, and (B) high-functioning autism.

in the beauty case, and finally, place the beauty case back in the bag.

v) Recognizing road signs (pedestrian crossing, pedestrian traffic light, stop, no entry, one-way road, impasse, generic danger) only for the high-functioning autism group. The objective was achieved if the subject was capable of distinguishing the different road signs and at a later time could also use this capacity in an outdoor environment.

Digit ratio. At present, there is consensus on using the ratio between index and ring fingers (2D:4D), termed digit ratio, as an instrument to measure in the subject the exposure to testosterone during intrauterine life. We photocopied the left hands of the subjects and we measured the length of the fingers from the meta-carpo-phalanx crease to the tip of the finger (Fig. 1). This crease, the nearest between finger and palm, appears at approximately the ninth gestation week, and is one of the primary or regular creases of the hand. It was verified that finger length is directly associated with the exposition of fetus to testosterone: A bigger length of ring finger in comparison to index finger indicated a high quantity of testosterone to which the baby has been exposed during pregnancy (9).

Results

Both the autism and mild mental retardation and the high-functioning autism groups showed an improvement in the TEACCH program tasks.

The autism and mild mental retardation group obtained a mean score of 4.037 (± 0.80). The high-functioning autism group obtained a mean score of 6.47 (± 2.24).

By correlating results of the TEACCH program with the digit ratio (Fig. 2), we observed a similar path in the two groups. This path indicated that the less the quantity of testosterone to which the subject has been exposed during intrauterine life is, the better is the performance.

In Fig. 2 we can observe how the results from the two groups, even if they start from different base scores, if correlated to 2D:4D ratio, show a similar path. Thus, an increase of the 2D:4D ratio also led to an increase in the score obtained in the TEACCH program.

Discussion

Autism as a concept is not easy or definitive, and is one that is constantly evolving, as evidenced by the constant changes in diagnostic manuals used to make a definitive diagnosis. The last version of the Diagnostic and Statistical Manual of Mental Disorders (DSM) (10) and of the International Classification of Diseases (ICD) (11), include differences between the diagnostic criteria of DSM-V and ICD-10, which were not previously incorporated.

Concordant with the conclusions of Guyatt *et al* (12), the subjects that participated in our research exhibited a variability in 2D:4D ratio.

The results obtained in the present study allow us to observe a positive linear correlation, statistically relevant, between index finger/ring finger and the capacity of achieving the predetermined goals.

These conclusions are in agreement with previous observations (5,6), which confirm that subjects with high levels of testosterone are more instinctive and have a reduced ability to concentrate during long performances, unlike subjects less exposed to testosterone during intrauterine life, who are capable of focusing on specific tasks with more regularity and concentration. However, Richards (13) differs in opinion, as he does not agree with the existence of a direct correlation between testosterone production in the womb and the digit ratio and argues that the studies demonstrating this have low statistical significance.

Therefore, we hypothesize that a base screening may be useful to pinpoint the optimal teaching strategies to obtain the best possible performance from each subject.

Acknowledgements

The authors wish to thank 'A Future for Autism Onlus-Catania' for providing the opportunity to partner with them.

Funding

The present study was supported by the current research funds 2016 of Bonino Pulejo Neurolesi Center - IRCCS (Messina, Italy).

Availability of data and materials

The data and the materials are available from the corresponding author on reasonable request.

Author's contributions

RG, MC, ES and AB conceived and designed the experiments. MCP, AB, ES, VP, MC, RG, GDG and LSGC performed the experiments. MC analyzed the data. MCP, AB, VP and MC wrote the paper.

Ethics approval and consent to participate

The parents of the subjects were informed about the protocol of the study and gave their informed consent. The present study was approved and implemented by 'A Future for Autism Onlus-Catania'.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

References

1. Evans B: The Metamorphosis of Autism. A History of Child Development in Britain. 1st edition. Manchester University Press, Manchester, UK, 2017.
2. Barona M, Kothari R, Skuse D and Micali N: Social communication and emotion difficulties and second to fourth digit ratio in a large community-based sample. *Mol Autism* 6: 68, 2015.
3. Mesibov GB, Shea V and Schopler E: The TEACCH Approach to Autism Spectrum Disorders. Springer US, New York, NY, 2004.
4. Hauth I, de Bruijn YG, Staal W, Buitelaar JK and Rommelse NN: Testing the extreme male brain theory of autism spectrum disorder in a familial design. *Autism Res* 7: 491-500, 2014.
5. Jeevanandam S and Muthu PK II: 2D:4D ratio and its implications in medicine. *J Clin Diagn Res* 10: CM01-CM03, 2016.
6. Coco M, Perciavalle V, Maci T, Nicoletti F, Di Corrado D and Perciavalle V: The second-to-fourth digit ratio correlates with the rate of academic performance in medical school students. *Mol Med Rep* 4: 471-476, 2011.
7. Perciavalle V, Di Corrado D, Petralia MC, Gurrisi L, Massimino S and Coco M: The second-to-fourth digit ratio correlates with aggressive behavior in professional soccer players. *Mol Med Rep* 7: 1733-1738, 2013.
8. Coco M: The brain behaves as a muscle? *Neurol Sci* 38: 1865-1868, 2017.
9. Paul SN, Kato BS, Hunkin JL, Vivekanandan S, Spector TD and Fields KB: The big finger: The second to fourth digit ratio is a predictor of sporting ability in women. *Br J Sports Med* 40: 981-983, 2006.
10. American Psychiatric Association (ed): Diagnostic and Statistical Manual of Mental Disorders. 5th edition. Washington, DC, 2013.
11. World Health Organization: ICD-10, International Statistical Classification of Diseases and Related Health Problems. Vol 2. World Health Organization, Malta, 2011.
12. Guyatt AL, Heron J, Knight BC, Golding J and Rai D: Digit ratio and autism spectrum disorders in the Avon Longitudinal Study of Parents and Children: A birth cohort study. *BMJ Open* 5: e007433, 2015.
13. Richards G: Digit ratio (2D:4D) and prenatal/perinatal sex hormones: A response to Manning and Fink (2017). *Early Hum Dev* 113: 75-76, 2017.