Mimicry as a tool for early screening of Autism Spectrum Disorder

Mimetismo como ferramenta para o rastreamento precoce do Transtorno do Espectro Autista

Daniela Ceron-Litvoc[1], Márcia Maciel Santiago[2]

[1] Psiquiatra. Presidente da Sociedade Brasileira de Psicopatologia Fenômeno- Estrutural. Docente do Curso de Especialização em Psicopatologia Fenomenológica da Faculdade de Ciências Médicas da Santa Casa de São Paulo. Pesquisadora em Estudos Qualitativos pela Universidade de São Paulo. E-mail: daniela@ceronlitvoc.com.
[2] Médica psiquiatra. Fellow of the Royal College of Physicians of Canada (FRCPC). E-mail: marciahmaciel@gmail.com

Abstract

This is a theoretical paper in which we address the question of mimicry, one type of imitation behavior, in the first year of life through a phenomenological perspective. We conceptualize imitation in the first year of life with an emphasis on intentionality and argue that there are two types of imitation phenomena in infants: non-intentional and intentional imitation. As a conclusion, we generate the hypothesis as to whether mimicry could be used to the screening of Autism Spectrum Disorders so that it does not rely solely on questionnaires or expensive structured interviews.

Keywords: Mimicry; Screening; Early detection; Autism Spectrum Disorders; Phenomenology.

Resumo

Abordamos, neste artigo teórico, a questão do mimetismo, um tipo de comportamento de imitação, por meio de uma perspectiva fenomenológica. Analisamos a imitação no primeiro ano de vida com ênfase na intencionalidade e argumentamos que existem dois tipos de fenômenos de imitação em bebês: imitação não intencional e imitação intencional. Como conclusão, levantamos a hipótese de que o mimetismo poderia ser usado para a triagem de Transtornos do Espectro Autista de forma que não dependa apenas de questionários ou entrevistas estruturadas de difícil acesso.

Palavras-chaves: Mimetismo; Rastreamento; Detecção precoce; Transtorno do Espectro Autista; Fenomenologia.

Introduction

Although Autism Spectrum Disorders (ASD) prevalence seems to be the same around the world (Elsabbagh et al., 2012), the vast majority of research on ASD has been carried out in high-income countries (Durkin et al., 2015). Advancements in early diagnosis of ASD have been put forward by biomarkers such as eye-tracking measures of social attention (Bradshaw et al., 2019). Nonetheless, the costs associated with it tend to perpetuate inequality in the screening of children for early interventions in low-income countries. In order to develop an autism surveillance program in low-income countries, a low-cost and feasible tool that could be used by front line health care workers would be the ideal instrument. Such a tool is important for primary care services to detect ASD earlier and plan for early intervention. The design and implementation of a screening program for ASD is beyond the scope of this paper. Our aim is to conceptualize mimicry as an early marker for altered social development in infants.

Interpersonal synchrony, imitation and mimicry are considered prosocial behaviors (Lakin et al., 2003). Imitation is a behavioral match in interpersonal coordination (Hove and Risen, 2009), an essential pro-social behavior to social-communicative function and it is expected to be present since the first steps of development (Bandura, 1969; Rochat, 2012; Meltzoff and Moore, 1977; 1983; 1989; Meltzoff 1988; Dijksterhuis and Bargh, 2001). Imitation parameters could be useful to assess infants who diverge in early stages of interpersonal response (Paukner at al., 2014). Imitation can be pre reflexive, unconscious; its neurobiological underpinnings may lie on the mirror neurons (Gallese et al., 1996; Gallese et al., 2004; Dimberg et al., 2000; Carr et al., 2003; Preston and De Waal, 2002). Imitation can be also conscious, intentional (an element to fulfill the needs of whoever performs the action), and self-initiated, encompassing self-awareness that the self is the one who is the author of the action (Haggard and Clark 2003). The conscious and intentional imitation is contingent on the ability to recognize the boundaries between the self and the other (Piaget 1999, 2000).

Intentional and non-intentional imitation

If we take in consideration the descriptions of Jean Piaget (1999, 2000) as well as of other important developmental theorists such as Bowlby (1951), Stern (1985), Mahler (1968), we can consider the end of the first semester of life as a benchmark to delimitate when infants will perceive themselves as separate from others. After this realization, an interpersonal relationship is truly possible as there is *I* and *you* (Gallese, 2014). This form of interpersonal

relationship *I-you* brings intentionality to the equation. Therefore, after the 6th month of life, in addition to the ability to imitate unintentionally (mimicry), comes the ability to imitate others intentionally (Piaget 1999, 2000) and both phenomena will continue throughout life.

Based on the ability to recognize the self and the other as separate entities, we propose the definition of two types of imitation phenomena. The "Intentional Imitation" *(II)* occurs when infants can consider their own selves as separated from others in an interpersonal relationship *I-you*. This allows for an infant at this stage of development to appreciate that there is some intentionality in the relationship. Once a boundary is drawn between the self and another, it becomes possible for one to imitate another with an intention such as the intention to draw a response from another (Hamlin, 2007). Thereafter, infants will reproduce actions knowing that this imitation in itself has an impact in the social world (Tomasello and Carpenter, 2005). Imitation from now on implies an understanding of intentions and is not limited to an unconscious, unintentional reproduction of another person´s muscle movement (Call and Carpenter, 2002). Therefore, *II* can only appear when infants can perceive themselves as separate from others what occurs after the first semester of life as cited above.

The other type of imitation, defined in this article as "Non-Intentional Imitation" *(NII)* refers to the imitation phenomenon that occurs without a conscious intention to imitate, without intentionality in the act, being limited to an unintentional copying behavior (Call and Carpenter, 2002). Consequently, there is no need to perceive the other as separated to the self in order to *NII* to happen. The *NII* can occur in any moment of life and examples of it encompass the tongue protrusion observed since birth (Meltzoff and Moore, 1977; Field et al., 1982; Massen, 2017). If, by definition, mimicry is an unintentional reproduction of another person´s muscle movement, mimicry can be considered a paradigm of a *NII.*

As we postulated above, the first semester of life is characterized by a period when the infant cannot experience a boundary between the self and another, which makes intentional behavior impossible. So, in this period of time, the imitation phenomenon is restricted to its unintentional form *(NII)*. After the second semester of life, the imitation phenomenon acquires the ability to also perform its intentional form *(II)* in parallel with *NII*.

Mimicry

Mimicry is a specific imitation phenomenon restricted to unintentional reproduction of another person´s muscle movements at any age (Want and Harris, 2002), for example when

adults match postures, gestures, prosody and syntactic constructions (Chartrand and Bargh, 1999). According to Hess and Fischer (2013), mimicry can be considered a social behavior and is related to the roots of empathy (Chartrand and Bargh, 1999; Sonnby–Borgström, 2002; Lakin et al., 2003; Hove and Risen, 2009). Empathy occurs when the other person is experienced as another but, at the same time, as similar. An important component of similarity is the common experience of actions, grounded in our lived bodily pre reflexive experience, establishing an embodied interindividual link. "Whenever we look at someone performing an action, beside the activation of various visual areas, there is a concurrent activation of the motor circuits that are recruited when we ourselves perform that action. Although we do not overtly reproduce the observed action, our motor system becomes nevertheless active *as if* we were executing that very same action that we are observing." (Gallese, 2003, 174).

Such behavior can be observed since the first days of life as follow. Isomura and Nakano (2016) demonstrated that infants in the first semester of life respond to emotional expression on others by activating facial mimicry. Paukner at al. (2014) demonstrated neonatal imitation in one-week-old infant monkeys. Nagy et al. (2014) used an easy and feasible imitation test in order to show that neonates learn and imitate some gestures.

ASD is associated to altered brainstem function, limiting expressive movements of the eyes, face, and vocal muscles, which affects early development of preverbal social skills (Rodier and Arndt, 2005; Teitelbaum et al., 1998). We found few studies with preliminary data indicating that mimicry can be impaired in autistic subjects. Impaired imitation abilities have been observed in children over 24 months of age diagnosed with autism in a case-control study of 32 subjects (Carpenter et al., 2005). According to another case-control study, mimicry seems to be impaired in autistic teenagers and adults (McIntosh et al., 2006). Autism is associated with a deficit on spontaneous mimicry in children such as while passively observing certain movements on others (Oberman et al., 2009; Cattaneo, 2007). For instance, typically developed children activated mylohyoid muscles (which promote the movements that lower the jaw and raise the tongue for reaching-to-grasp-to-eat) when they watch another person eating, but in autistic individuals there was no anticipatory activation (Cattaneo et al., 2007).

In this paper we will argue that the assessment of mimicry can be used as a tool for screening of children with a high risk to develop autism. However, in order to use mimicry for this purpose, we still have one open question: what is the best moment during the first year of life to assess mimicry? Is there a golden period to use mimicry as a screening tool? The question

of timing is pertinent because mimicry is present throughout life and, most importantly, because autistic individuals with impaired mimicry can show normal responses when explicitly instructed to copy the expression, a behavior called emulation (McIntosh et al., 2006; Hamilton, 2008; Edwards, 2014). Autistic children can copy a behavior, but they fail to spontaneously initiate it (McIntosh et al., 2006).

Mimicry as a screening tool for ASD

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impairments in social interactions and communication and by the presence of restricted and repetitive behaviors (American Psychiatry Association, DSM-5, 2013). Although the diagnosis should be made with caution in children less than 18-month-old, early interventions make the greatest impact in those with ASD (Dawson et al., 2012; Dawson, 2009).

Early signs of autism can be included in the large group of imitative behaviors encompassing mimicry, imitation, and emulation (Want and Harris, 2002) as follows. Individuals diagnosed with ASD show since early age reduced ability to initiate joint attention to share interests or emotions (Osterling and Dawson, 1994; Bruinsma et al., 2004), excessive mouthing of objects and aversion to social touch (Matson et al., 2008), and weaker interpersonal synchrony in a dyadic interaction (Yun et al., 2012; Hari et al., 2013; Yirmiya et al., 2006). Longitudinal studies have showed that infants later diagnosed with autism begin to statistically diverge from typical development around the 12th month in regard to social reciprocity (Landa et al., 2012; Ozonoff et al., 2010). While typical developing infants show a preference for looking at faces in the first semester of life (Maestro, 2005), infants later diagnosed with ASD show less attention to a person or to a person's face at the age of 6-month-old (Chawarska et al., 2012).

The ability to look at another face seems to be intact at birth in infants who are later diagnosed with ASD, but it starts to diverge from typically developing infants between the second and sixth month of life (Jones and Klin, 2013). Feldman (2007a, 2007b) had indicated that from an evolutionary perspective, the transition from touch to vision around 2 to 3 months is a shift from maternal behaviors shared by all mammals to relational behaviors that are exclusively human and suggested that parents could accentuate mutual gaze in order to stimulate the emerging social brain. The importance of eye gazing in infant development cannot be overstated given that it is during face-to-face interactions in shared contexts that the

groundwork for social understanding is laid (Jaegher and Di Paolo, 2007; Fuchs and Jaegher, 2009; Gallagher, 2011).

Given that early interventions have been shown to affect the course of autism (Dawson et al., 2012; Dawson, 2009), the American Academy of Pediatrics has recommended that 18-and 24-month-old children be screened for ASD (Johnson and Myers, 2007). However, it is plausible that interventions before 12 months could have a role in mitigating or preventing the developmental delays and autistic behavior patterns even earlier (Rogers et al., 2014; Bradshaw et al., 2014; Estes et al., 2015; Zwaigenbaum et al., 2015) and it could also be more cost-effective than those interventions designed for toddlers (Cidav et al., 2017). Therefore, there is a large interest in the field to identify feasible tools for screening early signs of ASD.

After this brief discussion, we can return to our question: what is the best moment during the first year of life to assess mimicry as a screening tool for ASD? If we consider that *II* is less affect than *NII* in ASD, we should look for a period when imitation behavior is restricted to its *NII* form. Thereafter, we propose that the first semester of life is a golden period to evaluate mimicry as a screening tool for ASD, a period where the mimicry is restricted to *NII*. A potential bias caused by imitation behaviors with intention is naturally excluded in this period of life. Consequently, the only possible imitation phenomenon in the first semester of life is the *NII*. Considering mimicry a type of *NII* phenomenon, it follows that it could be a feasible screening tool for early social behavior.

Particularly in the first semester of life, when imitation is predominantly unintentional and represented by mimicry, the presence or absence of mimicry components (unintentional) can indicate early disruptions in *NII*. The first semester of life is a golden period to screen for the presence or absence of mimicry. In addition to these theoretical analyses, we have to emphasize that mimicry of facial muscle movements is considered a feasible measure (low-risk, low-cost), and has a long timeline research of reliable scoring options described (Bavelas et al., 1986; Lakin et al., 2008). Also, mimicry can be easily assessed, even at the neonate period (Nagy et al., 2014). The parameters more frequently cited as promising strategies to identify incipient ASD are MRI, EEG and eye metrics (Zwaigenbaum and Penner, 2018). Mimicry could be considered an interesting option to early identification of individuals with high risk of developing ASD, however, to our knowledge, there is no data about mimicry as a screening tool for ASD in first semester of life.

Conclusion

To the best of our knowledge, this is the first attempt to address the different types of imitation phenomena in early development with a compelling argument for the experiential use of it as a marker for ASD. Our article explores the use of facial mimicry as an empirical representation of the imitation phenomenon.

ASD is a disorder characterized by a deviation in interpersonal relationships and earlier in this article, *II* seems to be less altered than *NII* in ASD adolescents and adults subjects. Although *NII* seems to be altered in ASD patients, its assessment in the second semester of life can lead to confusion because it is a period of infant development when the imitation phenomenon encompasses both intentional and unintentional features. In other words, the existence of intentionality towards another in the second semester of life associated with intentional imitation may conceal a deficit in *NII*. Given that the first semester of life is a period of the development in which a child conceives his/her self as blended to caregiver, that precludes the presence of intentionality in any imitation behavior in contrast to when imitation occurs in the second semester of life. Therefore, a pristine assessment of *NII* is only possible in the first semester of life which is when the *II* phenomenon has not emerged yet. Moreover, the assessment of facial mimicry, a type of *NII*, in the first semester of life could potentially become a feasible and inexpensive tool to be used for the screening of infants with high risk of ASD. This hypothesis should be trialed in community studies to determine its accuracy in detecting infants that deserve preventative interventions for autism.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders*. Washington, DC: American psychiatric Publishing.

Bavelas, J. B., Black, A., Lemery, C. R., Macinnis, S., & Mullett, J. (1986). Experimental methods for studying elementary motor mimicry. *Journal of Nonverbal Behavior, 10*(2), 102-119. doi:10.1007/bf01000007

Bowlby, J. (1951). Maternal care and mental health. *World Health Organization.* Geneva.

Bradshaw, J., Shic, F., Holden, A.N., Horowitz, E.J., Barret, A.C., German, T.C. et al (2019). The use of eye tracking as a biomarker of treatment outcome in a pilot randomized clinical trial for young children with autism. *Autism Research*, 12, 779-93.

Bradshaw, J., Steiner, A. M., Gengoux, G., & Koegel, L. K. (2014). Feasibility and *effectiveness* of very early intervention for infants at-risk for autism spectrum disorder: A systematic review. *Journal of Autism and Developmental Disorders, 45*(3), 778-794. doi:10.1007/s10803-014-2235-2

Bruinsma, Y., Koegel, R. L., & Koegel, L. K. (2004). Joint attention and children with autism: A review of the literature. *Mental Retardation and Developmental Disabilities Research Reviews, 10*(3), 169-175. doi:10.1002/mrdd.20036

Call, J., & Carpenter, M. (2002). Three sources of information in social learning. In K. Dautenhahn, & C. Nehaniv (Eds.), *Imitation in animals and artifacts* (pp. 21 1-228). Cambridge, MA: MIT Press.

Carpenter, M., Tomasello, M., & Striano, T. (2005). Role reversal imitation and language in typically developing infants and children with autism. *Infancy, 8*(3), 253-278. doi:10.1207/s15327078in0803_4

Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., & Lenzi, G. L. (2003). Neural mechanisms of empathy in humans: a relay from neural systems for imitation to limbic areas. *Proceedings of the national Academy of Sciences, 100*(9), 5497-5502.

Cattaneo, L., Fabbri-Destro, M., Boria, S., Pieraccini, C., Monti, A., Cossu, G., & Rizzolatti, G. (2007). Impairment of actions chains in autism and its possible role in intention understanding. *Proceedings of the National Academy of Sciences, 104*(45), 17825-17830. doi:10.1073/pnas.0706273104

Chawarska, K., Macari, S., & Shic, F. (2012). Context modulates attention to social scenes in toddlers with autism. *Journal of Child Psychology and Psychiatry, 53*(8), 903-913. doi:10.1111/j.1469-7610.2012.02538.x

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology,* 76(6), 893-910. doi:10.1037//0022-3514.76.6.893

Cidav, Z., Munson, J., Estes, A., Dawson,G., Rogers,S., Mandell,D.(2017).Cost offset associated with Early Start Denver model for children with autism. *Journal of the American Academy of Child & Adolescent Psychiatry,* 56(9), 777-783. doi:10.1016/j.jaac.2017.06.007.pmid:19403506.

Cirelli, L. K. (2018). How interpersonal synchrony facilitates early prosocial behavior. *Current Opinion in Psychology, 20,* 35-39. doi:10.1016/j.copsyc.2017.08.009

Cirelli, L. K., Einarson, K. M., & Trainor, L. J. (2014). Interpersonal synchrony increases prosocial behavior in infants. *Developmental Science*, 17(6), 1003-1011. doi:10.1111/desc.12193

Dawson, G., Rogers, S., Munson, J., Smith, M., Winter, J., Greenson, J. et al. (2009). Randomized, controlled trial of an intervention for toddlers with autism: The Early Start Denver model. *Pediatrics, 125*(1). doi:10.1542/peds.2009-0958

Dawson, G., Jones, E. J., Merkle, K., Venema, K., Lowy, R., Faja, S et al. (2012). Early behavioral intervention is associated with normalized brain activity in young children with autism. *Journal of the American Academy of* Child *& Adolescent Psychiatry, 51*(11), 1150-1159. doi: 10.1016/j.jaac.2012.08.018

Dijksterhuis, A., & Bargh, J. A. (2001). The perception-behavior expressway: Automatic effects of social perception on social behavior. *Advances in Experimental Social Psychology Volume 33 Advances in Experimental Social Psychology*, 1-40. doi:10.1016/s0065-2601(01)80003-4

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological science, 11*(1), 86-89.

Durkin, M.S., Elsabbagh, M., Barbaro, J., Gladstone, M., Happe, F., Hoekstra, R.A. (2015) Autism screening and diagnosis in low resource settings: Challenges and opportunities to enhance research and services worldwide. *Autism Research*, 8, 473-6.

Edwards, L. A. (2014). A meta-analysis of imitation abilities in individuals with autism spectrum disorders. *Autism Research, 7*(3), 363-380. doi: 10.1002/aur.1379

Elsabbagh, M., Divan, G., Koh, Y-J., Kim, Y.S., Kauchali, S., Marcin, C., et al. (2012). Global prevalence of autism and other pervasive developmental disorders. *Autism Research*, 5, 160-79.

Estes, A., Munson, J., Rogers, S. J., Greenson, J., Winter, J., & Dawson, G. (2015). Long-term outcomes of early intervention in 6-year-old children with autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 54*(7), 580-587. doi: 10.1016/j.jaac.2015.04.005

Feldman, R. (2007)a. On the origins of background emotions: From affect synchrony to symbolic expression. *Emotion, 7*(3), 601-611. doi:10.1037/1528-3542.7.3.601

Feldman, R. (2007)b. Parent-infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *Journal of Child Psychology and Psychiatry, 48*(3-4), 329-354. doi:10.1111/j.1469-7610.2006.01701.x

Field, T., Woodson, R., Greenberg, R., & Cohen, D. (1982). Discrimination and imitation of facial expression by neonates. *Science, 218*(4568), 179-181. doi:10.1126/science.7123230

Fuchs, T., & Jaegher, H. D. (2009). Enactive intersubjectivity: Participatory sense-making and mutual incorporation. *Phenomenology and the Cognitive Sciences, 8*(4), 465-486. doi:10.1007/s11097-009-9136-4

Gallagher, S. (2011). In defense of phenomenological approaches to social cognition: interacting with the critics. *Review of Philosophy and Psychology, 3*(2), 187-212. doi:10.1007/s13164-011-0080-1

Gallese, V. (2014). Bodily selves in relation: Embodied simulation as second-person perspective on intersubjectivity. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1644), 20130177-20130177. doi:10.1098/rstb.2013.0177.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*(2), 593-609. doi:10.1093/brain/119.2.593

Gallese, V., Keysers, C., & Rizzolatti, G. (2004). A unifying view of the basis of social cognition. *Trends in Cognitive Sciences*, *8*(9), 396-403. doi:10.1016/j.tics.2004.07.002

Haggard, P., & Clark, S. (2003). Intentional action: Conscious experience and neural prediction. *Consciousness and Cognition*, *12*(4), 695-707. doi:10.1016/s1053-8100(03)00052-7

Hamilton, A. F. (2008). Emulation and mimicry for social interaction: A theoretical approach to imitation in autism. *Quarterly Journal of Experimental Psychology*, *61*(1), 101-115. doi:10.1080/17470210701508798

Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, *450*(7169), 557-559. doi:10.1038/nature06288

Hari, R., Himberg, T., Nummenmaa, L., Hämäläinen, M., & Parkkonen, L. (2013). *Synchrony* of brains and bodies during implicit interpersonal interaction. *Trends in Cognitive Sciences*, *17*(3), 105-106. doi:10.1016/j.tics.2013.01.003

Hess, U., & Fischer, A. H. (2013). Conclusion: Toward a better understanding of emotional mimicry. *Emotional Mimicry in Social Context*, 222-229. doi:10.1017/cbo9781107587595.011

Hove, M. J., & Risen, J. L. (2009). It's all in the timing: Interpersonal synchrony increases affiliation. *Social Cognition*, *27*(6), 949-960. doi:10.1521/soco.2009.27.6.949

Isomura, T., & Nakano, T. (2016). Automatic facial mimicry in response to dynamic emotional stimuli in five-month-old infants. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1844), 20161948. doi:10.1098/rspb.2016.1948

Jaegher, H. D., & Paolo, E. D. (2007). Participatory sense-making. *Phenomenology and the Cognitive Sciences*, *6*(4), 485-507. doi:10.1007/s11097-007-9076-9

Johnson, C. P., & Myers, S. M. (2007). Identification and evaluation of children with autism spectrum disorders. *Pediatrics*, *120*(5), 1183-1215. doi:10.1542/peds.2007-2361

Jones, W., & Klin, A. (2013). Attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism. *Nature*, *504*(7480), 427-431. doi:10.1038/nature12715

Lakin, J. L., Jefferis, V. E., Cheng, C. M., & Chartrand, T. L. (2003). The chameleon effect as social glue: evidence for the evolutionary significance of nonconscious mimicry. *Journal of Nonverbal Behavior*, *27*(3), 145-162. doi:10.1023/a:1025389814290

Lakin, J. L., Chartrand, T. L., & Arkin, R. M. (2008). I am too just like you. *Psychological Science*, *19*(8), 816-822. doi:10.1111/j.1467-9280.2008.02162.x

Landa, R. J., Gross, A. L., Stuart, E. A., & Bauman, M. (2012). Latent class analysis of early developmental trajectory in baby siblings of children with autism. *Journal of Child Psychology and Psychiatry*, *53*(9), 986-996. doi:10.1111/j.1469-7610.2012.02558.x

Maestro, S., Muratori, F., Cavallaro, M. C., Pecini, C., Cesari, A., Paziente, A. et al. (2005). How young children treat objects and people: An empirical study of the first year of life in

autism. *Child Psychiatry and Human Development*, *35*(4), 383-396. doi:10.1007/s10578-005-2695-x

Mahler, M. S. (1968). On human symbiosis and the vicissitudes of individuation. Infantile Psychosis, Volume 1.

Massen, J. J., & Gallup, A. C. (2017). Why contagious yawning does not (yet) equate to empathy. *Neuroscience & Biobehavioral Reviews, 80,* 573-585. doi:10.1016/j.neubiorev.2017.07.006

Matson, J. L., Wilkins, J., & González, M. (2008). Early identification and diagnosis in autism spectrum disorders in young children and infants: How early is too early? *Research in Autism Spectrum Disorders, 2*(1), 75-84. doi:10.1016/j.rasd.2007.03.002

Mcintosh, D. N., Reichmann-Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: Deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental Science*, *9*(3), 295-302. doi:10.1111/j.1467-7687.2006.00492.x

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science*, *198*(4312), 75-78. doi:10.1126/science.198.4312.75

Meltzoff, A. N., & Moore, M. K. (1989). Imitation in newborn infants: Exploring the range of gestures imitated and the underlying mechanisms. *Developmental Psychology*, *25*(6), 954-962. doi:10.1037//0012-1649.25.6.954

Meltzoff, A. N. (1988). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology*, *24*(4), 470-476. doi:10.1037//0012-1649.24.4.470

Meltzoff, A. N., & Moore, M. K. (1983). Newborn infants imitate adult facial gestures. *Child Development*, *54*(3), 702. doi:10.2307/1130058

Nagy, E., Pal, A., & Orvos, H. (2014). Learning to imitate individual finger movements by the human neonate. *Developmental Science*, *17*(6), 841-857. doi:10.1111/desc.12163

Oberman, L. M., Winkielman, P., & Ramachandran, V. S. (2009). Slow echo: Facial EMG evidence for the delay of spontaneous, but not voluntary, emotional mimicry in children with autism spectrum disorders. *Developmental Science*, *12*(4), 510-520. doi:10.1111/j.1467-7687.2008.00796.x

Osterling, J., & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. Journal of Autism and Developmental *Disorders*, *24*(3), 247-257. doi:10.1007/bf02172225

Ozonoff, S., Iosif, A., Baguio, F., Cook, I. C., Hill, M. M., et al. (2010). A prospective study of the emergence of early behavioral signs of autism. *Journal of the American Academy of Child & Adolescent Psychiatry*, *49*(3). doi:10.1097/00004583-201003000-00009

Paukner, A., Simpson, E. A., Ferrari, P. F., Mrozek, T., & Suomi, S. J. (2014). Neonatal imitation predicts how infants engage with faces. *Developmental Science*, *17*(6), 833-840. doi:10.1111/desc.12207

Piaget, J. (1999). *The Construction of Reality in the Child.* England: Psychology Press.

Piaget, J. (2000). *Play, Dreams And Imitation In Childhood.* International Library of Psychology.

Preston, S. D., & De Waal, F. B. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and brain sciences*, *25*(1), 1-20.

Rochat, P. (2012). Sense of "sameness" as foundation of infants' embodied subjectivity and intersubjectivity. In A. Fotopoulou, S. Pfaff, & M. A. Conway, *From the Couch to the Lab:* Psychoanalysis, Neuroscience and Cognitive Psychology in Dialogue (p. 427-438). Oxford: University Press.

Rodier, P. M., and Arndt, T. L. (2005). "The brainstem in autism," in The Neurobiology of Autism, 2 Edn., eds M. L. Bauman and T. L. Kemper (Baltimore, MD: Johns Hopkins University Press), 136-149.

Rogers, S. J., Vismara, L., Wagner, A. L., Mccormick, C., Young, G., & Ozonoff, S. (2014). Autism treatment in the first year of life: A pilot study of infant start, a parent-implemented intervention for symptomatic infants. *Journal of Autism and Developmental Disorders, 44*(12), 2981-2995. doi:10.1007/s10803-014-2202-y

Sonnby-Borgstrom, M. (2002). Automatic mimicry reactions as related to differences in emotional empathy. *Scandinavian Journal of Psychology*, *43*(5), 433-443. doi:10.1111/1467-9450.00312

Stern, D. N. (1985). *The interpersonal world of the infant:* A view from psychoanalysis and developmental psychology. Karnac Books.

Teitelbaum, P., Teitelbaum, O., Nye, J., Fryman, J., & Maurer, R. G. (1998). Movement analysis in infancy may be useful for early diagnosis of autism. *Proceedings of the National Academy of Sciences*, *95*(23), 13982-13987. doi:10.1073/pnas.95.23.13982

Tomasello, M., & Carpenter, M. (2005). Intention reading and imitative learning. In S. Hurley & N. Chater (Eds.), *Perspectives on imitation:* From neuroscience to social science (Vol. 2, p. 133-148). Cambridge, MA: MIT Press.

Want, S. C., & Harris, P. L. (2002). Social learning: Compounding some problems and dissolving others. *Developmental Science*, *5*(1), 39-41. doi:10.1111/1467-7687.00206

Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry*, *47*(5), 511-523. doi:10.1111/j.1469-7610.2005.01528.x

Yun, K., Watanabe, K., & Shimojo, S. (2012). Interpersonal body and neural synchronization as a marker of implicit social interaction. *Scientific Reports*, *2*(1). doi:10.1038/srep00959

Zwaigenbaum, L., Bauman, M. L., Fein, D., Pierce, K., Buie, T., Davis, P. A., et al. (2015). Early screening of autism spectrum disorder: Recommendations for practice and research. *Pediatrics, 136* (Supplement). doi:10.1542/peds.2014-3667d

Zwaigenbaum, L., Penner, M.(2018). Autism spectrum disorder: advances in diagnosis and evaluation. *British Medical Journal*. doi:10.1136/bmj.k1674