
Downloaded from:

Usage Guidelines:
Please refer to usage guidelines at contact lib-eprints@bbk.ac.uk. or alternatively
Received cradling bias during the first year of life: A retrospective study on children with typical and atypical development

Gianluca Malatesta1*, Daniele Marzoli1, Fabio Apicella2, Claudia Abiuso3, Filippo Muratori2, 3, Gillian S. Forrester4, Giorgio Vallortigara5, Maria Luisa Scattoni6, Luca Tommasi1

1Department of Psychological Sciences, Health and Territory, G. d'Annunzio University of Chieti and Pescara, Italy, 2Fondazione Stella Maris (IRCCS), Italy, 3Department of Clinical and Experimental Medicine, University of Pisa, Italy, 4Department of Psychological Sciences, School of Science, Birkbeck University of London, United Kingdom, 5Centre for Mind and Brain Sciences, University of Trento, Italy, 6Istituto Superiore di Sanità (ISS), Italy

Submitted to Journal: Frontiers in Psychiatry

Specialty Section: Child and Adolescent Psychiatry

Article type: Original Research Article

Manuscript ID: 458490

Received on: 05 Mar 2019

Revised on: 27 Jan 2020

Frontiers website link: www.frontiersin.org
Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest

Author contribution statement

GM, LT, DM and MLS conceived and created the experiment; GM, CA, FA and FM conducted the experiment; LT, MLS, FM, GSF, FA and GV supervised all the phases of the study; GM, DM, LT and MLS analyzed the results; GM wrote the paper.

All authors reviewed the manuscript.

Keywords

Autism Spectrum Disorder; ASD, Infant-holding biases, brain lateralisation, Retrospective investigation, neurodevelopment, epigenetics, Behavioral markers, mother-infant relationship

Abstract

A population-level left cradling bias exists whereby 60-90% of mothers hold their infants on the left side. This left biased positioning appears to be mutually beneficial to both the mother and the baby’s brain organization for processing of socio-emotional stimuli. Previous research connected cradling asymmetries and Autism Spectrum Disorders (ASD), entailing impairment in socio-communicative relationships and characterized by an early hypo-lateralization of brain functions. In this explorative study, we aimed to provide a contribution to the retrospective investigations by looking for early behavioral markers of neurodevelopmental disorders such as ASD. We hypothesized that an atypical trajectory in maternal cradling might be one of the possible signs of an interference in mother-infant socio-emotional communication, and thus of potential neurodevelopmental dysfunctions. To this aim, we examined photos depicting mother-child early cradling interactions by consulting family albums of 27 children later diagnosed with autism and 63 typically developing children. As regards the first half of the first year of life, no differences were shown between maternal cradling-side preferences in typical and ASD groups, both exhibiting the left-cradling bias in the 0-3 months period, but not in the 3-6 months period. However, our results show dissimilar patterns of cradling preferences during the second half of the first year of life. In particular, the absence of left-cradling shown in typical mothers was not observed in ASD mothers, who exhibited a significant left-cradling bias in the 6-12 months age group. This difference might reflect the fact that mother-infant relationship involving children later diagnosed with ASD might remain “basic” because mothers experience a lack of social activity in such children. Alternatively, it may reflect the overstimulation in which mothers try to engage infants in response to their lack of responsiveness and social initiative. However, further investigations are needed both to distinguish between these two possibilities and to define the role of early typical and reversed cradling experiences on neurodevelopment.

Contribution to the field

Most of women (usually 60-90%) hold infants and dolls on the left (a lateral preference also known as “cradling bias”), regardless of their handedness. Part research has focused mainly on the cradling woman, showing that the laterality of the cradling bias can tell us something about her well-being. In this study we looked at the cradling bias from the point of view of the cradled infant. Specifically, we wondered whether different trajectories of cradling laterality in the first years might reveal the presence/absence of socioemotional symptoms before its proper diagnosis in a population of autistic children. Actually, we found a different pattern of laterality in cradling behavior between autistic children and typically developing children during the second half of the first year of life. This is suggested to occur either because of the role that the infant plays (or does not play) in the mother’s lateral preference, or because of the lack of responsiveness and social initiative unconsciously perceived by the mother. In any case, our results suggest that the infant’s mental health condition plays a role in the cradling bias of the mother, and that cradling behavior represents an important index of socio-emotional attunement in the mother-infant relationship.

Ethics statements

(Authors are required to state the ethical considerations of their study in the manuscript, including for cases where the study was exempt from ethical approval procedures)

Does the study presented in the manuscript involve human or animal subjects: Yes
Please provide the complete ethics statement for your manuscript. Note that the statement will be directly added to the manuscript file for peer-review, and should include the following information:

- Full name of the ethics committee that approved the study
- Consent procedure used for human participants or for animal owners
- Any additional considerations of the study in cases where vulnerable populations were involved, for example minors, persons with disabilities or endangered animal species

As per the Frontiers authors guidelines, you are required to use the following format for statements involving human subjects:
This study was carried out in accordance with the recommendations of [name of guidelines], [name of committee]. The protocol was approved by the [name of committee]. All subjects gave written informed consent in accordance with the Declaration of Helsinki.

For statements involving animal subjects, please use:
This study was carried out in accordance with the recommendations of ‘name of guidelines, name of committee’. The protocol was approved by the ‘name of committee’.

If the study was exempt from one or more of the above requirements, please provide a statement with the reason for the exemption(s).
Ensure that your statement is phrased in a complete way, with clear and concise sentences.

All participants provided written informed consent to participate in the study by signing an authorization form. Neither invasive nor risky procedures were involved, and the data were analyzed anonymously. The study was carried out in accordance with the principles of the Declaration of Helsinki and following the approval of the Italian ‘National Institute of Health’ (‘Istituto Superiore di Sanità’) ethical committee (Ethical Committee Approval Number: PRE 469/16).

**Data availability statement**

Generated Statement: All datasets generated for this study are included in the manuscript and the supplementary files.
Received cradling bias during the first year of life: A retrospective study on children with typical and atypical development

Running title: Received cradling in ASD infants

Gianluca Malatesta1*, Daniele Marzoli1, Fabio Apicella2, Claudia Abiuso2, Filippo Muratori2,3, Gillian S. Forrester4, Giorgio Vallortigara5, Maria Luisa Scattoni6**, Luca Tommasi1**

1Department of Psychological, Health and Territorial Sciences, University "G. d'Annunzio" of Chieti-Pescara, Chieti, I-66100, Italy
2IRCCS Stella Maris Foundation, Calambrone (Pisa), I-56128, Italy
3Department of Clinical and Experimental Medicine, University of Pisa, Pisa, I-56126, Italy
4Department of Psychological Sciences, Birkbeck, University of London, London, WC1E 7HX, United Kingdom
5Centre for Mind/Brain Sciences, University of Trento, Rovereto (Trento), I-38068, Italy
6Research Coordination and Support Service, Istituto Superiore di Sanità, Rome, I-00161, Italy

*Corresponding author: gianluca.malatesta@unich.it
**These authors contributed equally to this work

Abstract

A population-level left cradling bias exists whereby 60-90% of mothers hold their infants on the left side. This left biased positioning appears to be mutually beneficial to both the mother and the baby’s brain organization for processing of socio-emotional stimuli. Previous research connected cradling asymmetries and Autism Spectrum Disorders (ASD), entailing impairment in socio-communicative relationships and characterized by an early hypo-lateralization of brain functions. In this explorative study, we aimed to provide a contribution to the retrospective investigations by hypothesizing that an atypical trajectory in maternal cradling might be one of the possible signs of an interference in mother-infant socio-emotional communication, and thus of potential neurodevelopmental dysfunctions. To this aim, we examined photos depicting mother-child early cradling interactions by consulting family albums of 27 children later diagnosed with ASD and 63 typically developing children. As regards the first half of the first year of life, no differences were shown between maternal cradling-side preferences in typical and ASD groups, both exhibiting the left-cradling bias in the 0-3 months period, but not in the 3-6 months period. However, our results show dissimilar patterns of cradling preferences during the second half of the first year of life. In particular, the absence of left-cradling shown in typical mothers was not observed in ASD mothers, who exhibited a significant left-cradling bias in the 6-12 months age group. This difference might reflect the fact that mother-infant relationship involving children later diagnosed with ASD might remain “basic” because mothers experience a lack of social activity in such children. Alternatively, it may reflect the overstimulation in which mothers try to engage infants in response to their lack of responsiveness and social initiative. However, further investigations are needed both to distinguish between these two possibilities and to define the role of early typical and reversed cradling experiences on neurodevelopment.

Keywords: Autism Spectrum Disorders; Infant-holding bias; Brain lateralization; Retrospective investigation; Neurodevelopment; Epigenetics; Behavioral markers; Mother-infant relationship.
Author contributions statement
GM, LT, DM and MLS conceived and created the experiment; GM, CA, FA and FM conducted the experiment; LT, MLS, FM, GSF, FA and GV supervised all the phases of the study; GM, DM, LT and MLS analyzed the results; GM wrote the paper.
All authors reviewed the manuscript.

Conflict of interest statement
The authors declare that they have no competing interests in relation to this work.
The authors declare that they have no conflicts of interest to disclose.

Contribution to the field:
Most of women (usually 60-90%) hold infants and dolls on the left (a lateral preference also known as “cradling bias”), regardless of their handedness. Part research has focused mainly on the cradling woman, showing that the laterality of the cradling bias can tell us something about her well-being.
In this study we looked at the cradling bias from the point of view of the cradled infant. Specifically, we wondered whether different trajectories of cradling laterality in the first years might reveal the presence/absence of socioemotional symptoms before its proper diagnosis in a population of autistic children. Actually, we found a different pattern of laterality in cradling behavior between autistic children and typically developing children during the second half of the first year of life. This is suggested to occur either because of the role that the infant plays (or does not play) in the mother’s lateral preference, or because of the lack of responsiveness and social initiative unconsciously perceived by the mother. In any case, our results suggest that the infant's mental health condition plays a role in the cradling bias of the mother, and that cradling behavior represents an important index of socio-emotional attunement in the mother-infant relationship.

Acknowledgements
The authors wish to thank all parents and their children participating in this study. Special thanks go to Dr. Costanzo Pinti (pediatrician in Termoli, CB, Italy) and Antonella D'Aloisio (Istituto Comprensivo Statale di Montelabbate, PU, Italy) for their help in collecting data, and to Rocco Cannarsa for drawing Figure 1.

Number of words: 44154287
Numbers of figures: 2
Number of tables: 1
Introduction

In contrast to right biased motor actions associated with motor sequences and environment-directed behaviors [1, 2], cradling behavior is associated with a bias to the left side of the body whereby an infant is held by an agent (usually the mother) close to her body by using arms and hands [3, 4], as shown in Figure 1. Indeed, 60-90% of mothers hold their infants to the left of the vertical midline of their body [5] almost independently of their handedness [6, 7], positioning the head against the chest and/or over the shoulder in their left peripersonal hemispace, and almost always bearing the weight using the left arm. Research shows that the left-cradling bias is strong and fairly stable in the first 18 months of life of the child for mothers. After this period, it was initially shown that left-cradling behavior starts to decline to the point that it is replaced, in some cases, by a right-cradling preference by the time the child is 2 or 3 years old [8]. However, in recent longitudinal studies, Scola and colleagues [9] found a slight decrease of left cradling only after 19 months from delivery in mothers, and Todd and Banerjee [10] showed that it was strongest when babies were aged less than 12 weeks.

When a female cradles/holds an infant on the left side, the infant’s face is positioned on the left of her visual field and the visual information is processed dominantly by the right hemisphere of the brain, believed to be specialized for the perception and expression of emotion [11, 12]. Manning and Chamberlain [13] suggested that, from the mother’s point of view, the left-cradling bias facilitates the monitoring of her infant’s well-being cues through her left visual and perhaps auditory fields [14] by providing a direct communication projecting to her right hemisphere, specialized for recognizing emotional facial expressions [12, 15]. On the other hand, given that many studies showed that newborns are endowed with a predisposition to attend face-like stimuli [16, 17], left-sided cradling would allow the infant to receive the more salient emotional information by means of a constant access to the left side (i.e., the most expressive side [18]) of the mother’s face [19].

Besides sleeping and being fed, the newborn life experience is nestled in a close relationship with the adult caregiver (in most cases, the mother), very often expressed in the context of cradling behavior. It would thus be reasonable to propose that cradling is a major framework for most of the neonate’s early social and communicative experiences, which provide the epigenetic foundations for the development of later social and communicative abilities [20, 21]. In this regard, a growing line of research on behavioral genetics questioned about whether and to what extent changes to the phenotype – especially as regards the occurrence of neurodevelopmental disorders – are under the epigenetic control of imprinting processes not yet fully understood [22].

Using chimeric face tasks, many studies [23-25] have demonstrated that the left-cradling bias is predicted by a typical right-hemispheric specialization in the perception of emotions (see ref [22] for a thorough examination of leftward perceptual and emotional asymmetries). Therefore, the left bias has been assumed to be associated with better recognition of emotional stimuli presented to the left visual and auditory fields, which are under right-hemispheric control [14]. Specifically, Huggenberger and collaborators [25,27] suggested that cradling side preference is determined by a management of cognitive resources during monitoring emotional signals from the infant face.

Vervloed, Hendriks and van den Eijnde [26,28] also investigated the effects of the "received" lateral cradling bias, showing that healthy individuals who had been held in the right arm during childhood exhibited in turn a significantly reduced left-bias for emotional faces compared to those who had been held in the left arm. Additionally, Hendriks, van Rijswijk and Omtzigt [19] suggested that reduced or sub-optimal exposure to face information during infancy (due to a reversed lateral cradling position, i.e. on the right side) might have consequences for the ability to recognize faces and facial expressions later in life. This is likely to occur because the early infant exposure to faces is extremely important not only for fostering the bonding between newborn and caregiver [17], but also for later visual cognitive development [27,29,28,30]. Indeed, both male and female observers seem to show an experience-dependent bias of the right hemisphere for the female face, possibly because of the greater incidence of left cradling during the early stages of development, as
suggested by refs [2931] and [3032]. Furthermore, studies on non-human vertebrates seem to confirm the presence of an evolutionary right-hemispheric predisposition to process social stimuli to the benefit of an infant's left-sided positioning during interactions with the mother [3433] (see ref [4234] for a review).

Pileggi and colleagues [3335], assuming that the left-cradling bias is fostered by instinctive and right-hemisphere-localized attachment processes that allow individuals to relate to others, found that left-cradling bias is absent in children with Autism Spectrum Disorders (ASD), a population characterized by chronic and severe impairment in empathizing competencies and social relations [3436]. These findings were corroborated by Fleva and Kahn [3537], who showed a negative correlation between left-cradling bias and the presence of autistic traits in adults, and by Malatesta and colleagues, who showed positive correlations between left-cradling bias and both empathy [3638] and secure attachment [3739]. In this regard, it should be pointed out how, compared with typically developing individuals, those with autism are not biased to facial information from the left visual field, as shown by various studies using both eye-tracking and chimeric faces (e.g., see refs [3840, 3941]). These studies showed decreased right-hemispheric dominance for emotion processing in this population, different from the patterns of lateralization usually shown by typically developing individuals.

Much evidence has shown that decreased cerebral lateralization is associated with impaired cognitive functions, and it can also emerge behaviorally as mixed-handedness (e.g., see ref [4042]), given the crucial role that functional asymmetries play during cognitive tasks that require the use of both hemispheres. Hemispheric specialization provides the individuals with several advantages, such as the capacity to exploit in parallel the competences of the left and right hemispheres, to decrease the duplication of execution across hemispheres, and to reduce the initiation of simultaneous and incompatible responses [2, 4143]. In fact, the existence of a link between glitches in the typical separation of hemispheric functions during brain development and the occurrence of several mental disorders has been hypothesized, as in the case of the communicative shortcomings shown by patients with schizophrenia [44] or other instances of emotion dysregulation disorders in humans and animals (see ref [45] for a review). With regard to this, Forrester and colleagues [4246] assessed handedness as a marker of cerebral lateralization in different manual activities both in typical and autistic children, considering that reduced hemispheric specialization in motor behaviors might be an early marker of alterations in brain architecture related to autism onset. Indeed, the study showed that within the context of object manipulation and self-directed behaviors, children diagnosed with autism demonstrated decreased hand dominance compared with their typically developing counterparts. Moreover, Knaus and collaborators [4347] showed that ASD is associated with atypical language laterality in adolescents. Specifically, autistic children are characterized by an early hypo-lateralization of brain function compared to typically developing children.

Although Autism Spectrum Disorder (ASD) etiology is still unclear, we now know that such disorders have strong heritable and genetic underpinnings [4448] involving 300-500 different genes [4549]. Remarkably, in their study on relatives, Manning and Denman [4650] found that women's left cradling passed down to subsequent daughters and granddaughters, thus revealing genetic influences (through the female line) on lateral cradling tendencies. Along with cradling-side preferences, developmental instability (which in turn has been related to reduced left-cradling tendencies) seems to be passed down from mother – but not father – to children [4751], suggesting that genetic and environmental (see also ref [4852]) stressors could alter typical cradling asymmetries. Interestingly, a recent study showed that elevated levels of prenatal amniotic oestrogens (which could represent a hormonal stressor) are an important predictor of ASD in boys [4953].

To date, data gathered [20] hint at the importance of investigating associations between observations of cradling behavior received by the caregiver and later incidence of ASD, the early detection of which would have crucial implications for therapeutic success of clinical intervention [20, 21]. Currently, autism is usually not diagnosed until a child is at least 3 years old, with a mean
diagnosis age of 5.7 years \([540, 554]\). Therefore, most recent research used both prospective (e.g.,
the early observation of newborns "at risk" to develop autism because of previously affected
siblings \([562]\)) and retrospective (e.g., analyzing home-movies from the first months of life of
autistic children, and their caregivers \([573, 584]\)) methodologies in order to diagnose the condition
earlier. These studies indicated that autistic symptoms involve not only social communication and
repetitive behaviors, but also influence to some extent motor capacities and the regulation of
attention and emotion \([595]\). Analogously, previous findings seem to endorse the opinion that
empathy \([375, 386]\), social-attachment \([353, 397]\) and emotion lateralization \([13, 14]\) strongly
affect early lateral cradling preferences in females. Moreover, a recent study conducted by Forrester
and colleagues \([6056]\) suggested interesting associations between left-cradling bias and enhanced
social processing abilities in (typically developing) 5-6 years old children.

Cradling evidence seems to converge towards a link between reversed cradling behavior, decreased
handedness and atypical development \([21]\). An examination of the cradling bias as a possible early
behavioral marker of later typical or atypical development of the child seemed desirable at this
point. Thus, we hypothesized that an atypical developmental trajectory in maternal cradling,
indicating an interference in socio-emotional communication between mother and infant, might be
one candidate epigenetic behavioral marker of ASD in children, arising and already observable in
the first hours after delivery.

We present a retrospective longitudinal study capitalizing on the cradling-side preferences assessed
from pictures belonging to family albums. It is rather reasonable to expect that most parents keep a
rich collection of images depicting their children since immediately after birth, often including
photos depicting the children being cradled. This appeared to be a good proxy for measuring
cradling side preference in a sample of mothers of atypically developing children, especially
because the retrospective nature of such a survey would reflect the expression of cradling behavior
in the months preceding the diagnosis, in the assumption that — *a posteriori* — any behavior could
account as a potential marker predicting the later development of the disorder.

The "family photo album" methodology is not new, as witnessed by Manning \([5761]\), who
examined many photographs from his colleagues' family albums in which they were cradling their
infants. He examined photos dividing them according to the age of the cradled child and found that
the left-cradling percentage in females was strongest (the figure was between 60 and 70%) when the
children were 0-3 months old. In the other age groups (3-6 months, 6-12 months, 1-2 years, >2
years), females exhibited only a non-significant tendency to cradle on the left, the left-cradling bias
decreasing after the third month after child birth. These findings are consistent with Todd and
Benerjee's \([10]\) recent reports.

**Methods**

**Participants**

Mothers (age range at the time of evaluation: 29-50; \(M = 40.52; SD = 5.05\)) of 63 typical children
(age range at the time of evaluation: 1.4-16 years; \(M = 8.44; SD = 3.41\)) and mothers (age range at
the time of evaluation: 27-55; \(M = 38.59; SD = 6.12\)) of 27 children diagnosed with ASD (age
range at the time of evaluation: 1.9-16 years; \(M = 4.78; SD = 3.43\)) took part in the study. Mothers
in the typical group were recruited from pediatrics practices and primary and secondary schools of
Italian regions Molise, Abruzzo and Marche. Participants in the atypical group were recruited from
all over the country among parents whose children had been diagnosed with ASD at "Stella Maris
IRCCS" of Pisa (Italy). Only participants with a certified diagnosis of ASD according to medical
certification were recruited in the atypical group. All mothers participating in the study provided
written informed consent to participate in the study by signing an authorization form. Neither
invasive nor risky procedures were involved, and the data were analyzed anonymously. The study
was carried out in accordance with the principles of the Declaration of Helsinki and following the
approval of the Italian "National Institute of Health" ("Istituto Superiore di Sanità") ethical
committee (Ethical Committee Approval Number: PRE 469/16).
Procedure

Mothers of children were approached by the experimenter under the supervision of a psychologist/doctor/teacher, depending on the context in which they were recruited: schools or pediatrics practices in the case of the typical/control group; in the waiting rooms of "Stella Maris IRCCS" in the case of the atypical/experimental group.

Once recruited, mothers were asked to fill in a take-home survey concerning their child in which they were required to indicate preliminary information about both the child (sex; diagnosis; birth order; handedness) and themselves (age; handedness). Then, participants were asked to consult their family photo albums, specifically seeking photographs in which mothers were cradling their children, and to make a single entry on a first grid, for photos in which the child was under 12 months of age, or on a second grid, for photos in which the child was over 12 months of age. Using the baby’s head as a reference point, participants were required to indicate the side on which the child was being held in each photo, taking note of the age (in years and months) of the baby at the time of capture.

Results

We collected data from 1667 photos (range per participant: 3-101; M = 26.46; SD = 20.86) in which mothers were cradling their typical children (N = 63; control group) and 543 photos (range per participant: 0-51; M = 20.11; SD = 13.08) in which mothers were cradling their children later diagnosed with ASD (N = 27; experimental group). Two mothers belonging to the atypical group did not provide any photos in which they were cradling their children.

In order to trace a cradling trajectory both in typical and in atypical development of children, we carried out an analysis splitting age groups on the basis of Manning’s [5761] photo-categories. We examined the following categories of photos collected per age group of the child: 0-3 months; 3-6 months; 6-12 months; 1-2 years. Table 1 shows the distribution of photos in each age group:

Within each age group, only participants who provided at least 4 maternal cradling photos were included in the data analysis. Then, a cradling laterality quotient (CLQ) was computed for each participant as \( \frac{\text{right photos} - \text{left photos}}{\text{right photos} + \text{left photos}} \) with participants scoring from -1 (all left photos) to +1 (all right photos). Data were analyzed with SPSS Statistics Version 20 (Armonk, NY, USA).

**Age group 0-3 months.** Thirty-seven participants of the typical group and 18 participants of the atypical group provided at least 4 maternal cradling photos in which infants were aged 0-3 months.

The CLQ of mothers of typical children significantly differed from 0, showing a left-cradling bias (N = 37; M = -0.231 [61.55% of left cradling]; SD = 0.616; \( t_{(36)} = -2.287; p = 0.028; d = -0.376; CI = [-0.437, -0.26] \)), and a similar pattern (albeit not significant) was observed for mothers of ASD children (N = 18; M = -0.208 [60.42% of left cradling]; SD = 0.442; \( t_{(17)} = -2.002; p = 0.062; CI = [-0.428, 0.011] \)).

Lateral cradling preferences in mothers of typical and ASD children did not differ significantly (\( t_{(53)} = -0.143; p = 0.887 \)).

**Age group 3-6 months.** Twenty-four participants of the typical group and 7 participants of the atypical group provided at least 4 maternal cradling photos in which infants were aged 3-6 months.

The CLQ of mothers of typical children significantly differed from 0, showing a right-cradling bias (N = 24; M = 0.245 [37.75% of left cradling]; SD = 0.573; \( t_{(23)} = 2.099; p = 0.047; d = 0.428; CI = [0.004, 0.487] \)), and a similar pattern (albeit not significant) was observed for mothers of ASD children (N = 7; M = 0.195 [40.25% of left cradling]; SD = 0.553; \( t_{(6)} = 0.930; p = 0.388; CI = [-0.317, 0.706] \)).

Also in this case, lateral cradling preferences in mothers of typical and ASD children did not differ from one another (\( t_{(29)} = -0.208; p = 0.837 \)).

**Age group 6-12 months.** Thirty-five participants of the typical group and 14 participants of the atypical group provided at least 4 maternal cradling photos in which infants were aged 6-12 months.

The CLQ of mothers of typical children did not differ from 0, showing a slight and no significant left-cradling bias (N = 35; M = -0.059 [52.95% of left cradling]; SD = 0.679; \( t_{(34)} = -0.514; p = 0.614 \)).
In this study, data did not show any difference between groups. mothers of typical children did not show any lateral preference. In the subsequent age group (1-2 years), mothers of ASD children showed a strong left-craddling bias (N = 14; M = 0.426 [71.29% of left craddling]; SD = 0.543; t(13) = -2.933; p = 0.012; d = -0.67; CI = -0.740, -0.112 [Figure 2]). Although the control and the experimental group showed a different pattern, this difference did not reach statistical significance (t(47) = -1.801; p = 0.078).

Age group 1-2 years. Thirty-four participants of the typical group and 12 participants of the atypical group provided at least 4 maternal craddling photos in which infants were aged 1-2 years (i.e., between the 12th and the 24th month of child's age). Both the CLQ of mothers of typical children (N = 34; M = -0.061 [53.05% of left craddling]; SD = 0.602; t(33) = 0.588; p = 0.561; CI = -0.150, 0.271) and that of mothers of ASD children (N = 12; M = 0.073 [53.65% of left craddling]; SD = 0.589; t(11) = 0.431; p = 0.675; CI = -0.301, 0.448) did not differ from 0, showing no lateral craddling preference for this age group. Moreover, no difference was observed between the control group and the experimental group (t(44) = 0.063; p = 0.95).

Figure 3-2 depicts the mixed cross-sectional longitudinal trajectory of received maternal left craddling in the first two years of life of both groups of children.

Discussion
The aim of this explorative study was to describe a retrospective longitudinal trajectory of maternal craddling side preference for children diagnosed with ASD — compared with that of typically developing children — in the first two years of life. Since it is impossible, at present, to observe autistic children before the second year of life (due to age of diagnosis), we decided to carry out an "indirect retrospective observation" of mothers using family photos in which they were craddling their children. Mothers were required to provide the age of the child for each photo in order to depict the longitudinal temporal craddling trajectory, according to the age groups used by Manning [5261].

No difference was found in lateral craddling preferences between the mothers of typical and autistic children in the first three months after delivery, that is the period in which left-craddling bias is particularly strong in healthy mothers [3, 4, 10] but not in mothers with affective symptoms such as stress, anxiety or depression [3638, 5862, 5963]. The left-craddling bias was clearly apparent from photos of the first age group (0-3 months) in both groups: significantly in typical children and trending towards significance in ASD children (probably due to the smaller sample size). In this regard, it is important to note that the photo laterality quotient is an index not coming from a direct observation, and is thus susceptible to many potential factors that might intervene on the bias detection. Indeed, photos can capture a given moment, but they might not be systematically indicative of the actual craddling behavior involving mother and child. However, scoring the family photo albums was successfully used by Manning [5261], and also in the present study a left-craddling bias (61.55%) was observed in the first three months, which confirms the usefulness of this method to obtain information not accessible otherwise.

As shown by Manning [5261] and, more recently, by Todd and Banerjee [10], after the third month of life of the child there is a remarkable decline of the left-craddling preference in mothers. The present data replicated such a decline from the 12th week, and also indicated a clear right-craddling bias observable in mothers of typical children in the 3-6 months age group. This right bias was also present in mothers of ASD children, albeit it was not significant. In this regard, it should be noted that only 7 participants of the ASD group provided an acceptable number of maternal craddling photos for this age group, thus making this comparison the least reliable of the study. Interestingly, in the second half of the first year of life (age group: 6-12 months), mothers of children with autism exhibited a strong and significant increase of left-craddling bias, whereas the mothers of typical children did not show any lateral preference. In the subsequent age group (1-2 years), data did not show any difference between groups.

In this respect, it should be noted how past research suggested that craddling lateral preferences might not be due exclusively to the right-hemispheric specialization for emotion processing [6, 6064]. Indeed, a significant relationship between hemispheric lateralization and...
cradling-side bias is observed only for “basic” holding relationships, in particular those in which the
held or cradled element (e.g., a doll) does not provide a feedback in response to the holding side or
position. On the other hand, “advanced” holding relationships are characterized by a considerable
involvement between the cradling and cradled individuals (e.g., a mother with her infant) [6, 6064].
In this case, the mother could gradually adjust her lateral preference in response to the infant’s
activity, and there might be more room for the effect of affective or psychological factors (e.g.,
insecure attachment, lack of empathy, depression; [3638, 3922]). Thus, it could be speculated that
mother-infant relationships involving children later diagnosed with ASD might remain “basic”
because mothers experience a lack of social activity in such children. Actually, many retrospective
and prospective studies have reported that infants later diagnosed with autism have social
difficulties in reciprocal interactions with their caregiver that were present since the first months of
life [6465]. Muratori and colleagues [6266] showed that infants later diagnosed with autism,
compared with children with typical development, exhibited significantly worse performance in
tasks that required the ability to shift attention from non-social to social stimuli, e.g. the orienting-
to-name ability that usually increases around the 9th month [6367]. The lack of socially motivated
engagement becomes an early specific signal of autism by 12 months of age of child, with respect to
other neurodevelopmental disorders [5457]. Furthermore, Dundas, Gastgeb and Strauss [6468]
showed a left bias for faces in typical children arising around 11 months, whereas children with
high risk of autism did not show such a bias [6569]. Similarly, Jones and Klin [6670] found that
ASD children showed a developmental decline in eye fixation from about 2 until 24 months of age,
despite appearing to begin at normative levels prior to this drop.
Parents of children later diagnosed with autism seem to perceive, long before diagnosis, the lack of
responsiveness and social initiative of their infants. Indeed, they engage themselves increasingly
more in a close relationship and stimulate their children more than parents of neurotypical children
[6771]. Many investigations reported that mother-child relationships involving ASD children
showed qualitative differences with respect to those involving typically developed children [6872].
Mothers of autistic children, actually, tend to engage more in physical contact with their infants and
perform more high-intensity child-directed behaviors [6973]. In general, compared with parents of
typical children, parents of autistic children show more positive strategies of parenting style,
probably in order to improve the attachment with their children [7074]. This over-responsive
engagement style may represent a reaction, implemented precisely in the second semester by
parents, to the atypical development exhibited by ASD infants [7475].
Such evidence seems to suggest that the significant increasing of the left-cradling bias we observed
in mothers of ASD children (during the 6-12 months period) might be an unconscious outcome of
the attempts carried out by parents, and especially by the mother, to recover their infants to a more
vivid emotional activity. A body of work, indeed, indicates that the defining features of autism are
not present at the first 6 months of age but begin to emerge later [7276]. For example, a decreasing
vocalization and an increasing of non-social babbling [7277] and more frequent and longer
repetitive movements [7478] have been described as characterizing this period.
The present results corroborate the idea that left cradling might be considered as an early marker of
the quality of the search for emotional closeness between the cradling and cradled individuals (or at
least, in the present case, of the parents’ efforts to improve such a “basic” relationship).
Although possible stressing factors linked to the mother seem to be involved in both ASD onset
[4953] and reduced left-cradling preferences [4751, 4852], the fact that these variables were not
related in the present study suggests that they result from different causes.
Finally, although our findings should be considered as preliminary, above all because of the small
sample, the results reported here might encourage further studies aimed at investigating whether
atypical patterns of cradling-side preferences in children with ASD might reflect either: i)
differences in the nature of the mother-infant relationship (“basic” or “advanced”) or ii) the indirect
overstimulation in which mothers try to engage infants in response to their lack of responsiveness
and social initiative, and iii) whether they can be used as a non-invasive behavioral marker for the
earlier identification (already in the first year of the infant’s life) of children at risk of ASD.

References

1. McManus C. Right hand, left hand: The origins of asymmetry in brains, bodies, atoms and
2. Vallortigara G, Rogers LJ. Survival with an asymmetrical brain: Advantages and disadvantages
3. Salk L. The effects of the normal heartbeat sound on the behaviour of the newborn infant:
Implications for mental health. World Mental Health (1960) 12:168-175.
4. Salk L. The role of the heartbeat in the relations between mother and infant. Sci Am (1973)
228:24-29. doi: 10.1038/scientificamerican0573
5. Donnot J, Vauclair J. Biais de latéralité dans la façon de porter un très jeune enfant: Une revue
6. Donnot J. Lateralisation of emotion predicts infant-holding bias in left-handed students, but not
7. Packheiser J, Schmitz J, Berretz G, Papadatou et al. Hand preference and handedness in cradling:
A longitudinal study. Philos T R Soc B (2013) 3095(91)90006
A longitudinal study. Philos T R Soc B (2013) 3095(91)90006
10.1080/17405629.2013.791230
11. Todd BK, Banerjee R. Lateralization of infant holding by mothers: A longitudinal evaluation of
variations over the first 12 weeks. Laterality (2015) 21:12-33. doi:
10.1080/1357650X.2015.1059434
12. Gainotti G. Unconscious processing of emotions and the right hemisphere. Neuropsychologia
13. Bourne VJ. How are emotions lateralised in the brain? Contrasting existing hypotheses using
10.1080/02699590903007714
15. Sieratzki JS, Wol B. Neuropsychological and neuropsychiatric perspectives on maternal
0005686
the visual, auditory and chemical modalities. Philos T R Soc B (2009) 364:895-914. doi:
10.1098/rstb.2008.0279
10.1038/nrn1766
18. Di Giorgio E et al. Filial responses as predisposed and learned preferences: Early attachment in
psychobiology of affective development (PLE: Emotion; 2014) 8:293-321 (Psychology Press)
20. Hendriks AW, van Rijswijik M, Omtzigt D. Holding-side influences on infant's view of mother's
10.1016/j.infbeh.2014.08.008
10.1016/j.mehy.2019.109442
10.1016/S0278-2626(01)80056-7
10.1016/j.neuropsychologia.2004.07.005
35-37. Fleva E, Khan A. An examination of the leftward cradling bias among typically developing adults high on autistic traits. Laterality (2015) 20:711-722. doi:
10.1080/1357650X.2015.1046881


**Figures**

**Figure 1.** Graphic representation of left-cradling behavior (courtesy of Rocco Cannarsa)

**Figure 2.** Left-cradling percentage based on CLQ of mothers of typical and ASD children in all age groups (the asterisks indicate significance of p < 0.05 [in blue as regards typical children; in red as regards ASD children]; the grey dashed line indicates the chance level [50%]; *error bars indicate standard deviations*)
Table 1. Number of collected photos depicting mothers cradling their typical (control group) and atypical (ASD; experimental group) per age group of the child

<table>
<thead>
<tr>
<th>Child development [N]</th>
<th>0-3 months (mean; SD)</th>
<th>3-6 months (mean; SD)</th>
<th>6-12 months (mean; SD)</th>
<th>1-2 years (mean; SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical [63]</td>
<td><strong>390</strong> (6.19; 5.63)</td>
<td><strong>262</strong> (4.19; 5.03)</td>
<td><strong>336</strong> (5.33; 4.85)</td>
<td><strong>380</strong> (6.03; 6.75)</td>
</tr>
<tr>
<td>Atypical (ASD) [27]</td>
<td><strong>166</strong> (6.15; 6.26)</td>
<td><strong>67</strong> (2.48; 2.46)</td>
<td><strong>119</strong> (4.41; 5.03)</td>
<td><strong>139</strong> (5.15; 6.68)</td>
</tr>
</tbody>
</table>