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Received cradling bias during the first year of life: A retrospective study on children with typical and atypical development

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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

Word count: 312

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

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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

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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 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.

1 **Author contributions statement**

2 GM, LT, DM and MLS conceived and created the experiment; GM, CA, FA and FM conducted the
3 experiment; LT, MLS, FM, GSF, FA and GV supervised all the phases of the study; GM, DM, LT
4 and MLS analyzed the results; GM wrote the paper.
5 All authors reviewed the manuscript.
6

7 **Conflict of interest statement**

8 The authors declare that they have no competing interests in relation to this work.
9 The authors declare that they have no conflicts of interest to disclose.
10

11 **Contribution to the field:**

12 Most of women (usually 60-90%) hold infants and dolls on the left (a lateral preference also known
13 as “cradling bias”), regardless of their handedness. Part research has focused mainly on the cradling
14 woman, showing that the laterality of the cradling bias can tell us something about her well-being.
15 In this study we looked at the cradling bias from the point of view of the cradled infant.
16 Specifically, we wondered whether different trajectories of cradling laterality in the first years
17 might reveal the presence/absence of socioemotional symptoms before its proper diagnosis in a
18 population of autistic children. Actually, we found a different pattern of laterality in cradling
19 behavior between autistic children and typically developing children during the second half of the
20 first year of life. This is suggested to occur either because of the role that the infant plays (or does
21 not play) in the mother’s lateral preference, or because of the lack of responsiveness and social
22 initiative unconsciously perceived by the mother. In any case, our results suggest that the infant's
23 mental health condition plays a role in the cradling bias of the mother, and that cradling behavior
24 represents an important index of socio-emotional attunement in the mother-infant relationship.
25

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1 Introduction

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

15 When a female cradles/holds an infant on the left side, the infant's face is positioned on the left of
16 her visual field and the visual information is processed dominantly by the right hemisphere of the
17 brain, believed to be specialized for the perception and expression of emotion [11, 12]. Manning
18 and Chamberlain [13] suggested that, from the mother's point of view, the left-cradling bias
19 facilitates the monitoring of her infant's well-being cues through her left visual and perhaps
20 auditory fields [14] by providing a direct communication projecting to her right hemisphere,
21 specialized for recognizing emotional facial expressions [12, 15]. On the other hand, given that
22 many studies showed that newborns are endowed with a predisposition to attend face-like stimuli
23 [16, 17], left-sided cradling would allow the infant to receive the more salient emotional
24 information by means of a constant access to the left side (i.e., the most expressive side [18]) of the
25 mother's face [19].

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

34 Using chimeric face tasks, many studies [23+253] have demonstrated that the left-cradling bias is
35 predicted by a typical right-hemispheric specialization in the perception of emotions (see ref [2426]
36 for a thorough examination of leftward perceptual and emotional asymmetries). Therefore, the left
37 bias has been assumed to be associated with better recognition of emotional stimuli presented to the
38 left visual and auditory fields, which are under right-hemispheric control [14]. Specifically,
39 Huggenberger and collaborators [2527] suggested that cradling side preference is determined by a
40 management of cognitive resources during monitoring emotional signals from the infant face.
41 Vervloed, Hendriks and van den Eijnde [2628] also investigated the effects of the "received" lateral
42 cradling bias, showing that healthy individuals who had been held in the right arm during childhood
43 exhibited in turn a significantly reduced left-bias for emotional faces compared to those who had
44 been held in the left arm. Additionally, Hendriks, van Rijswijk and Omtzigt [19] suggested that
45 reduced or sub-optimal exposure to face information during infancy (due to a reversed lateral
46 cradling position, i.e. on the right side) might have consequences for the ability to recognize faces
47 and facial expressions later in life. This is likely to occur because the early infant exposure to faces
48 is extremely important not only for fostering the bonding between newborn and caregiver [17], but
49 also for later visual cognitive development [2729, 2830]. Indeed, both male and female observers
50 seem to show an experience-dependent bias of the right hemisphere for the female face, possibly
51 because of the greater incidence of left cradling during the early stages of development, as

1 suggested by refs [2931] and [3032]. Furthermore, studies on non-human vertebrates seem to
2 confirm the presence of an evolutionary right-hemispheric predisposition to process social stimuli to
3 the benefit of an infant's left-sided positioning during interactions with the mother [3433] (see ref
4 [3234] for a review).

5 Pileggi and colleagues [3335], assuming that the left-cradling bias is fostered by instinctive and
6 right-hemisphere-localized attachment processes that allow individuals to relate to others, found
7 that left-cradling bias is absent in children with Autism Spectrum Disorders (ASD), a population
8 characterized by chronic and severe impairment in empathizing competencies and social relations
9 [3436]. These findings were corroborated by Fleva and Kahn [3537], who showed a negative
10 correlation between left-cradling bias and the presence of autistic traits in adults, and by Malatesta
11 and colleagues, who showed positive correlations between left-cradling bias and both empathy
12 [3638] and secure attachment [3739]. In this regard, it should be pointed out how, compared with
13 typically developing individuals, those with autism are not biased to facial information from the left
14 visual field, as shown by various studies using both eye-tracking and chimeric faces (e.g., see refs
15 [3840, 3941]). These studies showed decreased right-hemispheric dominance for emotion
16 processing in this population, different from the patterns of lateralization usually shown by typically
17 developing individuals.

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

37 Although Autism Spectrum Disorder (ASD) etiology is still unclear, we now know that such
38 disorders have strong heritable and genetic underpinnings [4448] involving 300-500 different genes
39 [4549]. Remarkably, in their study on relatives, Manning and Denman [4650] found that women's
40 left cradling passed down to subsequent daughters and granddaughters, thus revealing genetic
41 influences (through the female line) on lateral cradling tendencies. Along with cradling-side
42 preferences, developmental instability (which in turn has been related to reduced left-cradling
43 tendencies) seems to be passed down from mother – but not father – to children [4751], suggesting
44 that genetic and environmental (see also ref [4852]) stressors could alter typical cradling
45 asymmetries. Interestingly, a recent study showed that elevated levels of prenatal amniotic
46 oestrogens (which could represent a hormonal stressor) are an important predictor of ASD in boys
47 [4953].

48 To date, data gathered [20] hint at the importance of investigating associations between
49 observations of cradling behavior received by the caregiver and later incidence of ASD, the early
50 detection of which would have crucial implications for therapeutic success of clinical intervention
51 [20, 21]. Currently, autism is usually not diagnosed until a child is at least 3 years old, with a mean

1 diagnosis age of 5.7 years [540, 551]. Therefore, most recent research used both prospective (e.g.,
2 the early observation of newborns "at risk" to develop autism because of previously affected
3 siblings [562]) and retrospective (e.g., analyzing home-movies from the first months of life of
4 autistic children, and their caregivers [573, 584]) methodologies in order to diagnose the condition
5 earlier. These studies indicated that autistic symptoms involve not only social communication and
6 repetitive behaviors, but also influence to some extent motor capacities and the regulation of
7 attention and emotion [595]. Analogously, previous findings seem to endorse the opinion that
8 empathy [375, 386], social attachment [353, 397] and emotion lateralization [13, 14] strongly
9 affect early lateral cradling preferences in females. Moreover, a recent study conducted by Forrester
10 and colleagues [6056] suggested interesting associations between left-cradling bias and enhanced
11 social processing abilities in (typically developing) 5-6 years old children.

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

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

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

35 36 **Methods**

37 **Participants**

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

1 Procedure

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

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

15 Results

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

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

25 Within each age group, only participants who provided at least 4 maternal cradling photos were
26 included in the data analysis. Then, a cradling laterality quotient (CLQ) was computed for each
27 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
28 right photos). Data were analyzed with SPSS Statistics Version 20 (Armonk, NY, USA).

29 **Age group 0-3 months.** Thirty-seven participants of the typical group and 18 participants of the
30 atypical group provided at least 4 maternal cradling photos in which infants were aged 0-3 months.
31 The CLQ of mothers of typical children significantly differed from 0, showing a left-cradling bias
32 ($N = 37$; $M = -0.231$ [61.55% of left cradling]; $SD = 0.616$; $t_{(36)} = -2.287$; $p = 0.028$; $d = -0.376$; $CI =$
33 $-0.437, -0.26$), and a similar pattern (albeit not significant) was observed for mothers of ASD
34 children ($N = 18$; $M = -0.208$ [60.42% of left cradling]; $SD = 0.442$; $t_{(17)} = -2.002$; $p = 0.062$; $CI = -$
35 $0.428, 0.011$). Lateral cradling preferences in mothers of typical and ASD children did not differ
36 significantly ($t_{(53)} = -0.143$; $p = 0.887$).

37 **Age group 3-6 months.** Twenty-four participants of the typical group and 7 participants of the
38 atypical group provided at least 4 maternal cradling photos in which infants were aged 3-6 months.
39 The CLQ of mothers of typical children significantly differed from 0, showing a right-cradling bias
40 ($N = 24$; $M = 0.245$ [37.75% of left cradling]; $SD = 0.573$; $t_{(23)} = 2.099$; $p = 0.047$; $d = 0.428$; $CI =$
41 $0.004, 0.487$), and a similar pattern (albeit not significant) was observed for mothers of ASD
42 children ($N = 7$; $M = 0.195$ [40.25% of left cradling]; $SD = 0.553$; $t_{(6)} = 0.930$; $p = 0.388$; $CI = -$
43 $0.317, 0.706$). Also in this case, lateral cradling preferences in mothers of typical and ASD children
44 did not differ from one another ($t_{(29)} = -0.208$; $p = 0.837$).

45 **Age group 6-12 months.** Thirty-five participants of the typical group and 14 participants of the
46 atypical group provided at least 4 maternal cradling photos in which infants were aged 6-12 months.
47 The CLQ of mothers of typical children did not differ from 0, showing a slight and no significant
48 left-cradling bias ($N = 35$; $M = -0.059$ [52.95% of left cradling]; $SD = 0.679$; $t_{(34)} = -0.514$; $p =$
49

0.61; $CI = -0.292, 0.174$); in contrast, mothers of ASD children showed a strong left-cradling bias ($N = 14$; $M = 0.426$ [71.29% of left cradling]; $SD = 0.543$; $t_{(13)} = -2.933$; $p = 0.012$; $d = -0.67$; $CI = -0.740, -0.112$; **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 cradling 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 cradling]; $SD = 0.602$; $t_{(33)} = 0.588$; $p = 0.561$; $CI = -0.150, 0.271$) and that of mothers of ASD children ($N = 12$; $M = 0.073$ [53.65% of left cradling]; $SD = 0.589$; $t_{(11)} = 0.431$; $p = 0.675$; $CI = -0.301, 0.448$) did not differ from 0, showing no lateral cradling preference for this age group. Moreover, no difference was observed between the control 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 cradling 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 cradling 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 cradling their children. Mothers were required to provide the age of the child for each photo in order to depict the longitudinal temporal cradling trajectory, according to the age groups used by Manning [5761].

No difference was found in lateral cradling preferences between the mothers of typical and autistic children in the first three months after delivery, that is the period in which left-cradling 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-cradling 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 cradling behavior involving mother and child. However, scoring the family photo albums was successfully used by Manning [5761], and also in the present study a left-cradling 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 [5761] 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-cradling preference in mothers. The present data replicated such a decline from the 12th week, and also indicated a clear right-cradling 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 cradling 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-cradling 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 cradling 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

1 cradling-side bias is observed only for “basic” holding relationships, in particular those in which the
2 held or cradled element (e.g., a doll) does not provide a feedback in response to the holding side or
3 position. On the other hand, “advanced” holding relationships are characterized by a considerable
4 involvement between the cradling and cradled individuals (e.g., a mother with her infant) [6, 6064].
5 In this case, the mother could gradually adjust her lateral preference in response to the infant’s
6 activity, and there might be more room for the effect of affective or psychological factors (e.g.,
7 insecure attachment, lack of empathy, depression; [3638, 397]). Thus, it could be speculated that
8 mother-infant relationships involving children later diagnosed with ASD might remain “basic”
9 because mothers experience a lack of social activity in such children. Actually, many retrospective
10 and prospective studies have reported that infants later diagnosed with autism have social
11 difficulties in reciprocal interactions with their caregiver that were present since the first months of
12 life [6165]. Muratori and colleagues [6266] showed that infants later diagnosed with autism,
13 compared with children with typical development, exhibited significantly worse performance in
14 tasks that required the ability to shift attention from non-social to social stimuli, e.g. the orienting-
15 to-name ability that usually increases around the 9th month [6367]. The lack of socially motivated
16 engagement becomes an early specific signal of autism by 12 months of age of child, with respect to
17 other neurodevelopmental disorders [5357]. Furthermore, Dundas, Gastgeb and Strauss [6468]
18 showed a left bias for faces in typical children arising around 11 months, whereas children with
19 high risk of autism did not show such a bias [6569]. Similarly, Jones and Klin [6670] found that
20 ASD children showed a developmental decline in eye fixation from about 2 until 24 months of age,
21 despite appearing to begin at normative levels prior to this drop.
22 Parents of children later diagnosed with autism seem to perceive, long before diagnosis, the lack of
23 responsiveness and social initiative of their infants. Indeed, they engage themselves increasingly
24 more in a close relationship and stimulate their children more than parents of neurotypical children
25 [6771]. Many investigations reported that mother-child relationships involving ASD children
26 showed qualitative differences with respect to those involving typically developed children [6872].
27 Mothers of autistic children, actually, tend to engage more in physical contact with their infants and
28 perform more high-intensity child-directed behaviors [6973]. In general, compared with parents of
29 typical children, parents of autistic children show more positive strategies of parenting style,
30 probably in order to improve the attachment with their children [7074]. This over-responsive
31 engagement style may represent a reaction, implemented precisely in the second semester by
32 parents, to the atypical development exhibited by ASD infants [7175].
33 Such evidence seems to suggest that the significant increasing of the left-cradling bias we observed
34 in mothers of ASD children (during the 6-12 months period) might be an unconscious outcome of
35 the attempts carried out by parents, and especially by the mother, to recover their infants to a more
36 vivid emotional activity. A body of work, indeed, indicates that the defining features of autism are
37 not present at the first 6 months of age but begin to emerge later [7276]. For example, a decreasing
38 vocalization and an increasing of non-social babbling [7377] and more frequent and longer
39 repetitive movements [7478] have been described as characterizing this period.
40 The present results corroborate the idea that left cradling might be considered as an early marker of
41 the quality of the search for emotional closeness between the cradling and cradled individuals (or at
42 least, in the present case, of the parents’ efforts to improve such a “basic” relationship).
43 Although possible stressing factors linked to the mother seem to be involved in both ASD onset
44 [4953] and reduced left-cradling preferences [4751, 4852], the fact that these variables were not
45 related in the present study suggests that they result from different causes.
46 Finally, although our findings should be considered as preliminary, above all because of the small
47 sample, the results reported here might encourage further studies aimed at investigating whether
48 atypical patterns of cradling-side preferences in children with ASD might reflect either: i)
49 differences in the nature of the mother-infant relationship (“basic” or “advanced”) or ii) the indirect
50 overstimulation in which mothers try to engage infants in response to their lack of responsiveness

1 and social initiative, and iii) whether they can be used as a non-invasive behavioral marker for the
2 earlier identification (already in the first year of the infant's life) of children at risk of ASD.

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In review

1 **Figures**

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

10 **Figure 2.** Left-cradling percentage based on CLQ of mothers of typical and ASD children in all age
11 groups (the asterisks indicate significance of $p < 0.05$ [in blue as regards typical children; in red as
12 regards ASD children]; the grey dashed line indicates the chance level [50%]; error bars indicate
13 standard deviations)

In review

1 **Tables**

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Table 1. Number of collected photos depicting mothers cradling their typical (control group) and atypical (ASD; experimental group) per age group of the child

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

9

In review

Figure 1.JPEG



Figure 2.JPEG

