Infant and Child Development
Inf. Child Dev. **16**: 267–276 (2007)
Published online 21 March 2007 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/icd.497

Gender-Related Differences in Neonatal Imitation

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Socio-emotional behaviour is in part sex-related in humans, although the contribution of the biological and socio-cultural factors is not yet known. This study explores sex-related differences during the earliest communicative exchange, the neonatal imitation in 43 newborn infants (3–96 hours old) using an index finger extension imitative gesture. Results showed that although the experimenter presented comparable stimuli to both sexes, and the total number of movements was similar in boys and girls, girls showed more fine motor movements, a higher number of specific imitative gestures, responded faster during the imitation and showed a higher baseline heart rate during the experiment. Newborn girls, with their faster and more accurate imitative abilities, may create a more responsive and interactive social environment, which in turn may lead to differences in socio-emotional and cognitive development between girls and boys.

Key words: neonates; imitation; heart rate

Sex-related differences in behaviour, abilities, personality, achievement and other psychological and psychopysiological functions have been extensively documented in adults and children (for review see Friedman, Richart, & Wiele, 1974; Kimura, 2000; Maccoby, 1979), but rarely studied in infants, with only a few studies involving newborns. Although behavioural studies on sex-related differences in human neonates are sparse, those published indicate that differences in interest and behaviour start very early. Conellan *et al*. reported that newborn boys looked longer at a mobile, whereas girls spent more time looking at faces (Collenan, Baron-Cohen, Wheelwright, Batki, & Ahluwalia, 2001). Hittelman and Dickes found that newborn girls engaged in eye-contact with their caretaker for a significantly longer duration than newborn boys (Hittelman & Dickes, 1979). However, Leeb and Rejskind (2004) were unable to

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replicate this finding, although, increased eye-contact was measured in girls aged 13–18 weeks old . Newborn girls were more sensitive to being uncovered (Bell & Costello, 1964), and at 2-weeks they reacted more sensitively to skin-to-skin contact than boys (Wolff, 1969). Newborn girls were also more sensitive to sweet taste and consumed more milk if it was sweetened (Nisbett & Gurwitz, 1970). In conclusion, of the few studies published, behavioural differences between newborn girls and boys have been observed, albeit some of the results are inconsistent and most of the studies were not designed to explore sex-differences (Korner, 1974).

Sex-related behavioural differences in newborns may also be the consequence of differential treatment by the mother or caretaker, starting as early as immediately after birth. Mothers tended to imitate their daughters while they rather initiated interaction with their sons (Moss, 1974). Thoman *et al.* (Thoman, Leiderman, & Olson, 1972) found that mothers spoke and smiled more to their newborn daughters than to their sons, but touched male babies more than female infants. Robin (1983), however, found the opposite; mothers had a tendency to touch their newborn daughters more than their sons and this sex-related difference reversed only at later ages, when mothers made more body contact with male infants than with females (Ling & Ling, 1974).

Besides the physiological and psychophysiological sex-related differences at birth (e.g. differences in base-line heart rate, temperature, Nagy, Loveland, Orvos, & Molnár, 2001), the differential effect of the early environment has also been suggested (Murray, Firoi-Cowley, Hooper, & Cooper, 1996). Disruptions in the early social environment, such as depression in the mother during the first year, affect boys' development more severely than that of girls, especially in families with a lower socio-economic status (Murray *et al.*, 1996a). Sons of postpartum depressed mothers have a higher prevalence of internalizing problems than girls (Essex, Klein, Cho, & Kraemer, 2003). Male infants have greater difficulties adjusting their behaviours, even if the disruption is only temporary. Six-month old male infants had a greater problem maintaining affective regulation than girls, and it took them longer to repair the errors that occurred in the interaction when exposed to the still-face paradigm (Weinberg, Tronick, Cohn, & Olson, 1999). It is not clear from current research whether such differences originate from the different handling of male infants by the mother. Biringen *et al.* (1999) found that in natural situations, mothers communicate very similarly with their sons and daughters and are equally available to them in the first 14 months. Other studies however, reported that male infants demonstrated a greater difficulty maintaining their affective regulation against even naturally occurring temporary adverse events. Infant boys fuss more than girls, smile less (Moss, 1974), are more irritable, are less attentive, are less stable emotionally (Call, 1978; Feldman, Brody, & Miller, 1980; Moss, 1974), are less able to regulate their arousal (Brazelton, Koslowski, & Main, 1974), show more startles (Korner, 1969) and are less able to calm themselves. Similar to the results of studies with children of postpartum depressed mothers, sex-related differences in some of the previous studies were more pronounced in firstborn males from lower socio-economic groups (Moss, 1974), suggesting that early socio-economic disadvantage may more easily disrupt the affective regulation of male but not female infants.

Not only humans, but also male rhesus infants (Sackett, 1974) and male rat pups (Ehlers, Kaneko, Owens, & Nemeroff, 1993; Lehmann, Pryce, Bettschen, & Feldon, 1999), demonstrate a more severe physiological and behavioural reaction

DOI: 10.1002/icd

to early parental separation and deprivation than females. Sackett (1974) explained this increased sensitivity in males to environmental disruptions with the 'bufferred females' theory. This theory suggests that females' behavioural regulation helps them to more flexibly adjust to adverse or changeable social environments by inhibiting the previously adaptive behaviours, which become maladaptive with environmental changes. In conclusion, although the findings of some of these studies may seem contradictory, a number indicate the presence of biologically based sex-related differences, in particular results on the greater vulnerability of males to early adverse environmental effects, and the stronger social orientation responses of females.

The aim of this study was to further explore whether early social interactions are influenced by the sex of the baby, while controlling for comparable handling of the babies by the experimenter. The study employed what might be considered the earliest form of communicative exchange, neonatal imitation (Meltzoff & Moore, 1977, Heimann, Nelson, & Schaller, 1989; Kugiumutzakis, 1985), and explored if sex-related differences existed during an interactive imitation experiment, using index finger extension gesture with a stranger (Nagy *et al.*, 2005).

A series of studies from the 1970s found that infants as young as a few hours old can imitate various gestures such as mouth, tongue, eye, hand, arm and leg movements (Heimann *et al.*, 1989; Kugiumutzakis, 1985; Maratos, 1973; Meltzoff & Moore, 1977; Reissland, 1988;). Since then, various theories have tried to explain why and how newborns and young infants imitate, including ethological (Jacobson, 1979) and learning theories (Miller & Dollard, 1941) intermodal matching (Meltzoff, 1988), self-other differentiation and conceptualization (Meltzoff & Moore, 1998), and the mirror neuron system model (Iacoboni *et al.*, 2001; Wohlschlager & Bekkering, 2002). Although all these theories successfully explained some aspects of imitation, they failed to explain why babies started to imitate and what the motivation is for their first imitations. Trevarthen (1982, 1998), Trevarthen and Aitken, (2001), Vinter (1986), Kugiumutzakis (1985) with their intersubjective approach, emphasized that imitation is not merely a reflexive isolated response to an experimental stimulus, but a meaningful social response as part of an early communicative behaviour (Arbib, 2006; Nagy & Molnar, 1994, 2004; Nagy, 2006).

Although most studies on neonatal imitation have been conducted using facial gestures (mainly tongue protrusion imitation), Nagy *et al.* (2005) reported that newborn infants are able to imitate fine motor movements, such as index finger protrusion gesture. Newborns specifically increased the frequency of index finger movements as opposed to general hand movements during the imitation periods, which suggests that babies indeed imitated the gesture. Moreover, babies started to imitate relatively quickly, and imitations progressed through an incomplete imitation stage before the attainment of accurate imitation. Kugiumutzakis (1993) analysed sex-related differences in vocal imitation in 21 mother–infant pairs from the 15th day of the baby and found no differences between boys and girls. No other studies analysing sex-related differences in imitation of gestures have however been reported. The aim of the current study therefore is to further analyse our dataset to investigate whether imitative capacities differ between female and male neonates. Should the result show sex-related differences in neonatal imitation, it may form a basis for sex-related differential treatment in everyday interaction immediately after birth.

DOI: 10.1002/icd

METHOD

Subjects

The study further analysed the dataset collected to establish the existence of index-finger imitation in human neonates (Nagy *et al.*, 2005). With the informed consent of the mothers, 43 healthy newborn infants (23 boys and 20 girls) were examined in the first 3–96 h after birth (mean age: 2.10 days, S.D. = 1.00). Two infants (one boy and one girl) were excluded by the coders because they were sleeping. Forty-one infants were included in the final analysis. Infants were born at an average of 38.4 gestational weeks (S.D. = 2.17; 33–43 weeks); average weight was 3273 g (S.D. = 560 g, 2450–4430 g), 26 were born by vaginal deliveries, and 15 were delivered by caesarean section.

There were no differences between girls and boys in weight (t (39) = −0.52, ns), gestational age (t(39) = 0.46, ns) or type of delivery ($\chi^2 = 0.04$, ns). The study was approved by the Institutional Ethical Review Board of the Albert Szent-Gyorgyi Medical University.

Procedure

The examination room, which was a separate but integral part of the Neonatal Ward, had constant illumination and an ambient temperature (28°C), and the conditions and environment of the room were the same for every newborn. Newborns were examined 30–90 min after feeding, which proved to be the optimal time for examining them in an awake but quiet state.

Infants were placed on their back on an examination table with their heads turned towards the left side, facing a Panasonic 240 type video camera and the experimenter. A mirror was placed on the right side of the baby so that the experimenter could be seen by the video camera. The experimenter presented index finger protrusion gestures randomly with left and right hands. Experiments lasted for an average of 24.5 min (S.D. ± 4.56). The baseline period was an average of 4.29 min (S.D. ± 2.95 min; including the time needed to adjust the EKG electrodes and an approximately 2-min period when the baby was attentive), after which the experimenter showed an index finger protrusion movement to the baby. In the response period, the experimenter waited for an average of 49.64 (S.D. = 24.18) s and then administered the next gesture. An average of 25.44 (S.D. = 9.81) imitation periods were initiated by the experimenter. The frequency and the duration of the hand movements, both of the experimenter and the baby, were coded from time-stamped video records by a naive coder.

ECG Recording

Heart-rate of the babies was also recorded in order to explore the possible sex-related differences in heart-rate changes during imitation. R–R intervals of the babies were recorded using Primedic-Mobicard^{R} type ECG instrument within 2.5 ms accuracy, and heart rate values were calculated from the R–R intervals. All babies were dressed alike. After attaching disposable electrodes onto their chest and replacing their shirt, they were loosely swaddled. Data were stored in a computer for later analysis.

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Coding

All hand and finger movements on the video records were coded regardless of whether they occurred during the imitation (imitation period refers to the experiment after the experimenter's first modelling of the index finger extension gesture) or baseline period, and regardless of whether the movements were imitative or spontaneous. The coder was naive to the basic purpose of the experiment. Beginning and end times of every hand movement of the baby and the experimenter were coded. Babies' finger movements were coded using a 3-level coding system (1 = handmovements, i.e. baby raises hand; 2 = incomplete index finger extension movement or index finger extension movement accompanied by extensions of one or two other fingers; 3 = complete index finger extension movement with only the index finger raised). One hundred percent of the data were re-coded for reliability using frame-by-frame coding, and an 85% inter-rater reliability was attained.

Recorded Variables

The babies'hand movements (Code 1) and finger movements (Code 2 for incomplete and Code 3 for complete finger movements) were coded, as were the finger movements of the experimenter. Movements were measured in absolute numbers (i.e. how many movements were made), then percentages were calculated, given that the absolute length of the experiment varied from baby to baby. A 'percentage of time' variable was calculated using the formula: frequency/time(sec) (where 'time' was either the baseline period or the imitation period, depending on the nature of the variable). Mean heart rate was measured in beat/min to explore further psychophysiological differences during imitation. Data were examined using SPSS 10.0 Statistical software, and a $p < 0.05$ level of significance was accepted throughout.

Results

The experimenter's Behaviour

The number of finger movements by the experimenter was not different with boys and girls, either in absolute number ($t(2, 39)=0.99$, ns) or as a percentage of time ($t(2, 39)=-0.36$, ns).

Babies' Hand and Finger Movements

Results of a 2 (Condition [baseline/imitation]) × 3 (Movement [hand/incomplete index finger/complete index finger movements]) ANOVA with sex as the between-subject factor, yielded a main effect of Condition ($F(1,39) = 55.62$, $p < 0.01$), and Movement ($F(1, 39) = 34.63$, $p < 0.01$). There was a significant Condition × Movement interaction ($F(2, 39) = 3.49$, $p < 0.05$), and a significant Condition × Movement × Sex interaction ($F(2, 39) = 5.73$, $p < 0.01$).

1. The existence of imitation: Further analysing the significant Condition × Movement interaction, *post hoc t*-tests showed that while the hand movements did not change from baseline to imitation period (calculated as hand movements/all coded movements; $t(2, 39) = 1.49, p = 0.15$), the incomplete finger movements (calculated as incomplete finger movements/all coded movements; $t(2, 39) = -2.39$, $p < 0.05$) and complete finger movements (calculated as complete finger movements/all coded movements; $t(2, 39) = -2.52$, $p < 0.05$) increased

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during the imitation period. This analysis confirmed our previous results (using part of this dataset) on the existence of finger imitation in neonates (Nagy *et al.*, 2005).

2. *Sex-differences in finger movements:* There was a significant Condition × Movement × Sex interaction. Measured by the average scores (coded from 1–3) of all the hand and finger movements, girls scored significantly higher than boys in the baseline period (boys mean = 1.09 (S.D. = 0.41), girls mean = 1.40 (S.D. = 0.36), $t(2, 39) = -2.53$, $p < 0.05$). Girls also had a tendency to show 'higher score' movements during the imitation period (boys mean = 1.34 (S.D. = 0.15), girls mean = 1.47 (S.D. = 0.24), $t(2, 39) = -2.00, p = 0.05$). This means that girls tended to do more fine motor finger movements, incomplete index finger movements and complete index finger movements during the whole time.

Post hoc t-tests showed that girls had marginally higher percentage incomplete index finger movement ($t(2, 39) = -1.97, p = 0.056$) and complete index finger movements ($t(2, 39) = -1.57, p = 0.12$) during the baseline period compared to boys, and a significantly higher percentage of complete index finger extension movements ($t(2, 39) = -2.85, p < 0.01$) during the imitation period compared to boys.

When exploring the sample of girls and boys separately, boys significantly increased the percentage of incomplete finger movements during the imitation period ($t(2, 21) = -4.17, p < 0.001$) and showed a tendency to increase the percentage of complete finger movements during the imitation period ($t(2, 21) = -1.81$, $p = 0.08$). Girls did not change the percentage of incomplete finger movements ($t(2, 16) = 0.19$, ns), but showed a tendency to increase the complete finger movements ($t(2, 16) = -1.71, p = 0.105$) during the imitation period.

Baseline Heart Rate

Average heart rate throughout the experiment (baseline and imitation periods) was significantly higher for girls (girls *mean* = 133.19 beat/min, S.D. = 10.16; boys mean = 126.73 beat/min, S.D. = 9.65; $t(2, 39) = -2.08$, $p < 0.5$), thus replicating our previous finding, (Nagy, Orvos, Bardos, & Molnár, 2000). Moreover, the standard deviation of heart rate was also higher for girls (girls mean = 13.57 beat/min, S.D. = 4.63, $t(2, 39) = -2.05$, $p < 0.05$; boys mean: 11.21 beat/min, S.D. = 2.69).

This sex-related difference was not related to the imitation period. There was a tendency for a higher baseline heart rate in girls during the baseline period (girls mean = 134.98 beat/min, S.D. = 14.75; boys mean = 127.05 beat/min, S.D. = 9.65; $t(2, 39) = -1.95$, $p = 0.058$), while the heart rate difference during the imitation period was not significant (girls mean = 130.89 beat/min, S.D. = 12.21; boys mean = 126.71 beat/min, S.D. = 12.49; $t(2, 39) = -1.07$, ns).

Summary of the Results

In summary, the experimenter presented comparable stimuli to both boys and girls and the total number of movements (hand and all finger movements) were also similar in the two sexes during both the baseline and the imitation periods. When analysing the movements separately, girls showed more fine motor movements both in the baseline as well as in the imitation period than boys did. Girls showed a higher percentage of incomplete index finger extension movements during the baseline period, and a higher percentage of complete index finger extension movements in the imitation period compared to boys.

The higher percentage of finger movements in girls does not however mean that boys did not imitate. In fact, while neither sex increased the percentage of

DOI: 10.1002/icd

hand movements during the imitation period (which means both sexes were comparably active), the increase of incomplete index finger extension movements during the imitation period was significant for boys, while girls did not increase the percentage of this movement during the imitation period. Both boys and girls had a tendency to increase the percentage of complete finger movements during imitation.

Newborn girls had a greater tendency or capacity to show fine motor finger movements in general. During imitation, while boys increased both incomplete and complete index finger extension movements, girls seemed to show a specific response, a tendency to increase complete index finger extension movements. In addition, girls showed a higher heart rate during the experiment, unrelated to the imitation period.

In conclusion, girls showed more fine movements, more specific imitative gestures, and a higher baseline heart rate during the experiment, while boys seemed to show more effort during imitation based on their significant increase in incomplete finger movements and additionally, a tendency to increase complete index finger movements.

CONCLUSION

The results of this study suggest not only that independent, fine finger movements exist in human neonates (Nagy *et al.*, 2005), but also that female and male newborns exhibit these movements differently. Eyre *et al.* (Eyre, Miller, Cowry, Conway, & Watts, 2000) suggested that although the brain of human newborn infants is ready to coordinate fine motor finger movements, these movements do not actually appear until the second half of the first year. Trevarthen (1979) and Ronnqvist and von Hofsten (1994), however, demonstrated that newborn infants do use expressive individual finger movements. Recently, it has also been reported that not only expressive but also voluntary, imitative fine motor finger movements exist as early as in newborn age (Meltzoff & Moore, 1977; Nagy *et al.*, 2005). The differential increase of index finger protrusion movements during the imitation periods, as reported in our earlier study (Nagy *et al.*, 2005), suggest that this behaviour is not an automatic response triggered by general arousal, but instead is a true indicator of purposeful neonatal imitation.

Although the differences were subtle and the results will need further studies and replication, the fact that newborn boys and girls performed this fine motor finger extension movement differently both during the baseline period and also during imitations, is a potentially intriguing result. While baseline and imitative hand movements occurred with a comparable frequency in the two sexes, girls performed more fine motor index finger movements during the baseline period than did boys. This may mean, that fine motor finger movements belong more to the natural movement repertoire of newborn girls than that of boys'. If girls were just simply more active than boys, we could expect that girls perform hand movements at a higher rate too, which was not the case. The results that girls had a higher baseline fine motor activity, and at the same time an increased tendency for gesture-specific imitation, provide support for Meltzoff and Moore's (1997) theory that motor abilities of infants may influence their imitation performance.

Compared to baseline condition, boys increased the frequency of the incomplete index finger movements as unspecific imitative responses, and also

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showed a tendency to increase the frequency of the complete index finger extension movements. In contrast to boys, girls responded more specifically, increasing, as a tendency, only the frequency of the complete index finger extension movements, matching with the movements of the experimenter. The most plausible explanation for this result may stem from the previous one, i.e. if newborn girls were more skilled in producing fine motor movements during the baseline period, then imitating the specific movement could be easier for them. Another possible explanation could be that although boys do not show fine movements during the baseline period, they are more motivated to imitate with more effort, and succeed more with unspecific movements.

It was suggested earlier that mothers generally tend to imitate their newborn and infant daughters and arouse or stimulate their sons (Moss, 1974). As the neonates in our study were in their first days of life, it can be—although not entirely—, excluded that mothers have already shaped their behaviours, therefore girls were more skilled imitators. Boys, in contrast, showed a differential responsiveness, trying to increase both the incomplete and complete finger movements, which in real life may seem as to be an increased, even though slower, effort to communicate.

However, the present results on the natural communication abilities of human neonates must be taken with caution. The study, aimed at providing an objective description of neonatal imitation, employed an ethologically based coding system, which did not label the individual behaviours, and did not differentiate between imitations and spontaneous movements within the imitation period. It is possible that using labelled event-related coding would make a significant difference to the results. Also, mothers' subjective impression on newborn boys' and girls' communication styles can be very different from what was captured purely by this quantitatively based study. It may be that the greater efforts of boys (who increased the unspecific fine movements during the imitation period compared to the baseline period) will have a stronger impact on the interactive partner, and mothers may pay more attention to their sons' imperfect efforts than to their daughters' fast and highly skilled responses. Further fine-grained and time-line analysis of the imitations using interaction-based coding will be necessary to draw a full picture on the differences in the natural communication abilities of boys and girls immediately after birth.

ACKNOWLEDGEMENTS

Supported by the Nuffield Foundation (Grant No. 560 805678). The authors are grateful to Dr Imre Janszky and Dr Gyorgy Bardos for providing the computer software for coding.

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DOI: 10.1002/icd