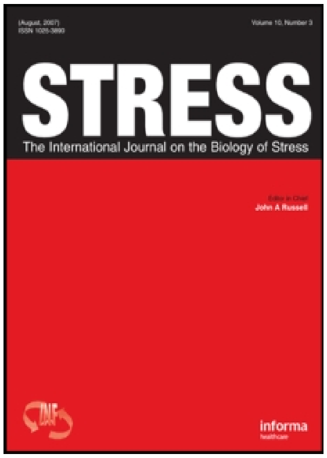

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Cold pressor stress reduces left cradling preference in nulliparous human females

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Cold pressor stress reduces left cradling preference in nulliparous human females

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Abstract

The left cradling preference refers to the finding that women hold their infants more frequently on the left side of their own bodies. Several observational studies showed reduced left cradling during stressful circumstances, such as mother–infant separation, or domestic violence. However, until now no experimental study was conducted to investigate the immediate impact of stress on cradling behaviour.

Half of the 64 female subjects participating were randomly assigned to a stressful bilateral cold pressor test. The remaining subjects performed a non-stressful control procedure. Before and after this intervention, cradling behaviour was assessed using a baby-like doll.

Subjects showed a left cradling preference prior to the intervention. The cold pressor test increased blood pressure and heart rate significantly. A repeated ANOVA revealed an interaction of intervention (cold pressor vs. control) X assessment period (pre- vs. post-intervention), indicating that cold pressor stress reduces left cradling behaviour in female volunteers.

Our data indicate that stress influences cradling preference. This may be of relevance for caregiver–infant interactions.

Keywords: *Autonomic arousal, lateralisation, caregiver–infant relationship, handedness, cold pain*

Introduction

Previous research has shown that approximately 70–80% of mothers cradle their infant on the left side of their body (Salk 1973; Bogren 1984; De Château 1991). A left cradling preference was also shown in nulliparous students (e.g. Saling and Tyson 1981; Lucas et al. 1993; Bourne and Todd 2004; Vauclair and Donnot 2004), children (de Château and Andersson 1976; Manning and Chamberlain 1991; Souza-Godeli 1996) and non-human primates (Manning and Chamberlain 1990). The holding preference is specific for infants and dolls. Several studies have shown a left cradling preference that is independent of whether a baby is real or imaginary and is not elicited by real or imaginary objects without typical baby features (Souza-Godeli 1996; Harris et al. 2000; Todd 2001; Almerigi et al. 2002; Erber et al. 2002). Numerous studies have indicated that the left cradling bias is manifested irrespective of handedness (Saling and Bonert 1983; Turnbull and Lucas 1996; Todd 2001) and prior experience with infants (Turnbull and Lucas 1991; Todd 2001).

Cradling plays a vital role in the mother–child relationship. Transportation, feeding, physical care, calming the upset infant, arousal and social integration of the child are tasks that take place in the cradling position (Rheingold and Keene 1965). As those examples show infants spend a lot of their waking time in the arms of their mothers and this makes cradling one of the main situations where mother–child interaction is taking place.

A widely discussed theory to explain the left cradling preference has its focus on the mother–child

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interaction. A mother expresses her feelings to her child through various sensory modalities by touch, gesture, facial expression and sound. Visual, auditory and somato-sensory nerves project to the contra-lateral cerebral hemisphere. Both hemispheres are involved in the processing of emotion but the right hemisphere is superior in decoding of facial expressions and emotional stimuli (Leventhal and Tomarken 1986). Cradling the baby on the left side in the left visual field therefore enhances the processing of its facial expressions and affective signals, resulting in an enhanced mother–child communication (Sieratzki and Woll 1996, 2002) and monitoring of the infant's well-being (Manning and Chamberlain 1990, 1991; Manning 1991). Yet, not only is the decoding of signals of the infant by its mother facilitated, but the child also has the advantage of being able to monitor the left side of its mother's face, which is more expressive than the right side (Manning and Chamberlain 1990, 1991). Thus, it was concluded (Sieratzki and Woll 1996) that mother–infant communication is facilitated by left sided cradling.

The majority of women exhibit a left cradling preference. There is, however, substantial between subject variability and a number of women cradle on the right or do not show any cradling preference at all. The proportion of women who have been observed to display no cradling bias to either side varies between 9 and 30% (Reissland 2000; Todd 2001; Weatherill et al. 2004). Furthermore, there is substantial within subject variability and most mothers at least sometimes change the side of holding (Todd and Butterworth 1998). Reissland (2000) examined in her study the consistency of the left cradling bias and the assumption that left cradling is associated with a lower pitched and more soothing voice quality, whereas right-cradling is associated with a higher pitched and more controlling voice quality. The results suggested that cradling behaviour is variable and might be related to the mothers' or the infants' emotional states.

There are several reasons for a reduced left cradling preference or a right cradling preference such as arm fatigue, feeding situations, or other manual activities. One of the most important reasons though, might be the influence of stress on cradling. Either no cradling preference, a right sided preference or a reduced left cradling preference was found in the following situations: In captive chimpanzees in a laboratory setting (Dienske et al. 1995), in mothers who experienced separation of their baby shortly after delivery (Salk 1973; De Château 1991), in mothers who started worrying a lot about delivery from the first months of pregnancy (Bogren 1984), in mothers with a mild to moderate depression and in mothers who reported experiencing domestic violence (Weatherill et al. 2004). Sieratzki and Woll (2004) reported that deaf mothers of hearing parents showed a rightward cradling bias with deaf children. They assumed that the experience of the insecurity of their hearing parents resulted in greater anxiety of these mothers with their babies, which might have caused the right cradling preference. De Château (1991) reported that women holding their infants on the right side more often experienced bodily changes during pregnancy as ugly and unattractive. Furthermore, Bogren (1984) found that women who had unplanned pregnancies or who had problems to conceive were more frequently right holders. He suggested that the psychological tension evoked by those situations was responsible for the right side preference. Overall, the common element in all those studies is that the subjects were in stressful circumstances, or perceived stress.

Stress is an important factor that may affect social interactions, especially the mother–child interaction (Assel et al. 2002; Crnic et al. 2005). Mothers during stressful life episodes were less sensitive (Muller-Nix et al. 2004), more irritable, critical and punitive (Webster-Stratton 1990). Moreover, stressed mothers showed less warmth and flexibility in interactions with their children. They also had lower levels of warm responsiveness, which was measured as sensitivity to the child's cues, amount of physical affection, praise, avoidance of negative comments about the child, maternal promptness and sensitivity in responding to children's cues and appropriateness of responses (Assel et al. 2002). Overall, stress seems to be a factor that has the power to disrupt parenting practices seriously and results in a lower quality of the mother–child interaction (Webster-Stratton 1990; Crnic et al. 2005), suggesting that stress may also affect the cradling position. However, until now no experimental study examined the direct impact of stress on cradling behaviour.

The current study was performed to examine the influence of a psychophysiological stressor on cradling behaviour. It was hypothesised that stress induced by a cold pressor test affects the female left cradling preference for holding a baby-like doll.

Methods

About 64 healthy nulliparous female undergraduate psychology students of the University of Basel participated voluntarily in this study. Two credit points were given as a modest incentive. The mean sample age was 21.8 years (SD 3.2). Subjects were randomly assigned to two groups: the cold pressor stress intervention group ($n = 32$), or the control group ($n = 32$). Procedures were approved by the ethical committee of the University of Basel. Subjects provided informed consent. All studies took place in rooms prepared for the behavioural exploration of adults at the Basel Institute of Psychology.

After participants entered the behavioural laboratory, they were told that the purpose of the study was to examine some aspects of bonding between mother and child. After this short introduction, they were asked to rate how intensively they experienced four mood adjectives (happy, angry, dull, aroused) depicted from the German short version of the "Profile of mood states questionnaire (POMS)" on a 7-point likert scale (Albani et al. 2005).

The total experiment consisted of three parts: the pre-intervention holding assessment period, the intervention phase and the post-intervention holding assessment period. Both holding assessment periods followed an identical protocol. All instructions were provided verbally using standardized scripts. Holding position was tested with a baby-like doll. The doll was a training instrument for nurses with a height of 53 cm purchased from Medela Company, Switzerland. To make it most similar to a real infant, its head and body were filled with gravel and wadding to achieve a total weight of 3.5 kg. The clothes were chosen to fit the image of a baby girl (white baby cap and socks, red pullover, red and white trousers).

At the beginning of each holding assessment period the subject was seated in an armless chair opposite a table with a doll lying in a dorsal position with its feet pointing in the direction of the subject. The room was sparsely furnished. Two observers, who rated the subject's holding behaviour, were seated behind the table with the doll, facing the subject's chair. For each subject, one of the observers was alternately chosen to instruct and time the procedure with a stopwatch. The observers monitored alternate assessment periods. The participant was then given the instruction to imagine the doll was a real baby called "Anna" and was about 6 weeks old and to follow the continually given instructions throughout the whole procedure. The holding assessment protocol was divided into three identical trials. One trial consisted of a standing sequence and a sitting sequence. Trials were separated by 10 s intervals. The participant was first instructed to take "Anna" from the table and to remain standing with her there. After 10 s, the subject was asked to go back to the chair with "Anna" and to sit down comfortably. After 45 s, the subject was instructed to put the doll back on the table and to wait there a moment. Holding preferences were assessed during the standing and sitting sequences.

Both observers independently rated holding preferences. Holding was coded as right or left when the head of the doll was on the right or the left side of the subject's body midline. There was a very high agreement between the two observers. In the event of incongruent ratings, holding data of this particular sequence were set to missing (6.7% of all standing sequences; 10.6% of all sitting sequences). Previous research had revealed that only a few subjects changed the position of the doll within one holding sequence (Vauclair and Donnot 2004). Thus, holding was coded according to the initial holding position and whether subjects changed the holding position during the sequence was disregarded. Indeed, a change from left to midline or right position occurred only in 1% of all observations. Changes from a right position to a midline or left position (4%) also occurred rarely. Sequences in which the doll was held in the exact midline position were scored as missing (3% of all observations). According to the aforementioned criteria, there was no subject for who, in any single period, all standing or sitting sequences had to be scored as missing. Finally, a laterality index was calculated for each subject, separately for the standing or sitting sequences, and pre- and post-intervention by using a mathematical transformation suggested by Tomaszycki et al. (1998) according to the formula: $(R - L/R + L)$. R represents the number of observations of right-sided holding and L those of left sided holding. This transformation resulted in a scale ranging from -1 to $+1$ reflecting an extreme left to respectively right sided lateral bias.

The 32 subjects assigned to the experimental stress group were exposed to a bilateral cold pressor test. The unilateral version of this test is a standard procedure known to be perceived as stressful and painful. The cold pressor test provokes sympathetically mediated responses such as increases of blood pressure, total peripheral resistance and heart rate (Wolf and Hardy 1941; Hilgard 1969; Calhoun et al. 1993; Antony et al. 1994; Middlekauff et al. 2004). Subjects were asked to immerse both hands up to the wrist in a bucket containing crushed ice and water (4°C) for a period of 120 s. They were informed that for the experiment it was crucial to keep the hands in the bucket for the whole 2 min and that they should not take them out until it felt too uncomfortable to continue. The control procedure was identical to the cold pressor test, with the exception that the bucket contained 35°C warm water. Blood pressure was measured in both groups three times before the intervention and twice during the intervention. The first measurement during the intervention started after 30 s and the second after approximately 90 s. Blood pressure and heart rate were measured with an oscillometric non-invasive blood pressure cuff device (Dinamap 1486SX, Critikon, FL, USA). For calculations of blood pressure and heart rate, the three measures prior to the intervention (resting baseline) were averaged as well as the two measures during the intervention (stress level).

The intervention was followed by the post-intervention holding assessment period with a delay of 2 min to allow for detaching the blood pressure measurement apparatus and drying hands. Holding style was recorded according to the same protocol as in the first holding period. Then, volunteers were asked to complete the Edinburgh Handedness Inventory (Oldfield 1971).

A repeated measures ANOVA was employed to investigate the impact of the cold pressor stress on cradling behaviour and the interaction term between

Table I. Percentage of subjects with left or right hand preference (Edinburgh Handedness Inventory).

	Left hand preference (score − 100–0) (%)	Right hand preference (score 0–100) (%)	Mean (SEM)
Total sample	9.4	90.6	63.117 (5.3425)
Cold pressor group	15.6	84.4	55.475 (9.0548)
Control group	3.1	96.9	70.759 (5.5002)

the between-factor (cold pressor stress vs. control) and the within-factor (pre- vs. post-intervention) was considered to reflect the effect of interest. Pre-intervention data were included in a covariance model to control for potential differences in initial values. *t*-Tests were used to investigate the significance of group holding preferences and Pearson correlations were computed to explore the associations between metric variables. Intra-class correlations were used to analyse congruity of holding behaviour between the two observers. All statistical analyses were performed by SPSS 11.0 (SPSS, Inc., Chicago, IL, USA). For statistical tests, an alpha level of $p < 0.05$ was used. Means and SD are reported in text and tables. Means and SE are presented in figures.

Results

Prior to the intervention the majority of participants cradled the doll on their left side. The corresponding laterality index of the total group was −0.27 (0.12) while standing, consisting of 62.5% left cradling positions, 1.6% midline positions and 35.9% right cradling positions. The laterality index for the sitting position was −0.32 (0.11) consisting of 65.6% left cradling and 34.4% right cradling positions. Laterality indices differed significantly from zero (paired *t*-test; standing: $p < 0.05$; sitting: $p < 0.01$).

The Edinburgh Handedness Inventory assesses handedness on a scale ranging from −100 (strict left hand user) to +100 (strict right hand user). As in previous studies there was no association between the subjects' handedness and their cradling behaviour. Also, there was no relation between handedness and cradling behaviour within the two groups. Detailed information about handedness are reported in Table I.

A group *t*-test showed that subjects in the cold pressor stress group did not significantly differ in their laterality indices from the control group prior to the intervention. Pre- and post-intervention holding data for both groups (cold pressor stress, control) and for both body positions (standing, sitting) are reported in Table II.

Self-reported ratings of mood items correlated positively ($p < 0.05$) with the pre-intervention laterality index of the standing position, indicating that subjects who reported higher "angry" ($r = 0.234$) or "dull" ($r = 0.256$) values more frequently exhibited a right sided cradling behaviour. The items "happy" and "aroused" did not correlate significantly with holding preferences.

Repeated measures ANOVA revealed a significant interaction ($F(1, 62) = 5.936$, $p < 0.05$) between intervention (cold pressor stress vs. control) X assessment period (pre- vs. post-intervention) for the laterality index during the standing position. Including the individual laterality indices prior to intervention as a covariate into an ANCOVA model did not affect this result, thus indicating that the significant impact of cold pressor stress on cradling does not rely on potential group differences prior to intervention. Differences between pre- and post-holding data during the standing and sitting position are illustrated in Figure 1.

There was no significant interaction effect between intervention (cold pressor stress vs. control) X

Table II. Laterality indices and percentage of right, left and midline cradling of pre- and post-intervention holding data of the stress and the control group during sitting and standing.

	Pre-intervention		Post-intervention	
	Laterality indices	Cradling behaviour (%)	Laterality indices	Cradling behaviour (%)
Standing				
Cold pressor	− 0.38 (0.15)	Left: 68.8 Midline: 3.1% Right: 28.1%	− 0.14 (0.17)	Left: 56.3 Midline: 3.1% Right: 40.6%
Control	− 0.15 (0.18)	Left: 56.3 Right: 43.7%	− 0.21 (0.17)	Left: 59.4 Right: 40.6%
Sitting				
Cold pressor	− 0.29 (0.16)	Left: 65.6 Right: 34.4%	− 0.21 (0.17)	Left: 59.4 Right: 40.6%
Control	− 0.35 (0.16)	Left: 65.6 Right: 34.4%	− 0.26 (0.17)	Left: 62.5 Right: 37.5%

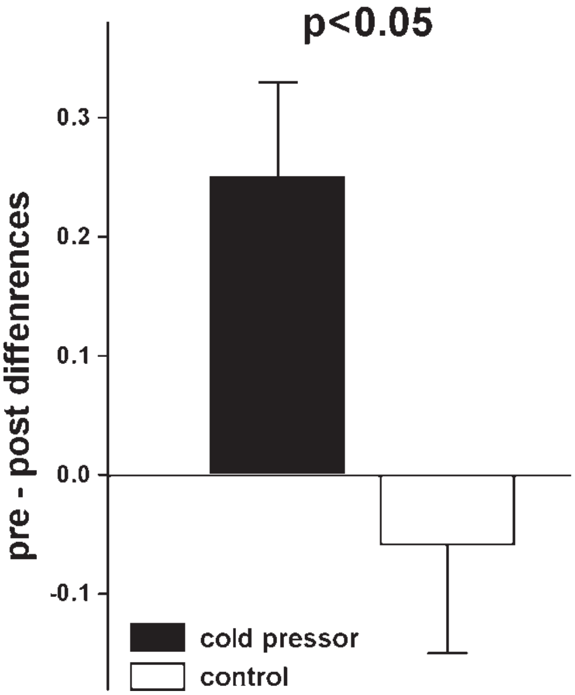

Figure 1. Pre- and post-intervention holding side differences for the cold pressor intervention group and the control group during the standing position. Cold pressor stress induced a significant change in cradling behaviour towards a right side holding. Data represent means and standard errors, negative values indicate a change towards left side cradling, positive values indicate a change towards right side cradling.

assessment period (pre- vs. post-intervention) for the laterality index during the sitting position ($F(1,62) = 0.005$, $p = 0.945$).

The cold pressor test is an aversive and painful test. Group averages of blood pressure and heart rate changes during the bilateral cold pressor procedure were as expected. Systolic blood pressure ($p < 0.001$), diastolic blood pressure ($p < 0.001$), mean arterial pressure ($p < 0.001$) and heart rate ($p < 0.001$) increased significantly (see Table III). However, 14 (41%) subjects took their hands out of the cold water before the 2 min were over, before the two physiological measurements could be completed. The average time in the cold water for those individuals was 72 s. Stress-induced blood pressure reactivity in this group was significantly higher than in the group of subjects who were able to leave their hands in the cold water for 120 s ($p < 0.05$). Stress-induced heart rate change did not differ between subjects who fully completed the test and those who did not.

Discussion

The current study examined the immediate impact of stress on cradling preferences of female students. The main finding of this study is that cold pressor stress reduces the left cradling preference in the standing position. Subjects of the intervention group exhibited a somewhat higher, albeit non-significant, tendency to cradle on the left side prior to stress. However, covariance adjustment by including initial holding data into the statistical model revealed that the cold pressor stress effect cannot be attributed to group differences in pre-intervention holding behaviour.

Table III. Group averages of blood pressure and heart rate changes during the cold pressor test and control procedure.

	Cold pressor	Control procedure
Systolic blood pressure (mmHg)		
Before intervention	118.64 (1.69)	114.10 (2.05)
During intervention	137.98 (3.18)	107.95 (2.35)
Diastolic blood pressure (mmHg)		
Before intervention	64.37 (1.38)	61.56 (1.52)
During intervention	85.69 (2.64)	55.00 (1.51)
Mean arterial blood pressure (mmHg)		
Before intervention	86.53 (1.38)	83.76 (1.81)
During intervention	109.59 (2.71)	76.59 (1.65)
Heart rate (beats per min)		
Before intervention	77.95 (2.58)	75.21 (2.59)
During intervention	91.88 (2.79)	76.02 (2.46)

In the present study, the majority of female students exhibited a left cradling preference during standing and sitting. Thus, we replicated earlier findings (Bourne and Todd 2004; Vauclair and Donnot 2004). We did not find a relation between cradling preference and handedness, which is also in accordance with the majority of previous reports (Todd 2001; Turnbull and Bryson 2001). However, conflicting results have recently been published (van der Meer and Husby 2006).

Stress affected holding behaviour in the standing position, but not in the sitting position. This disparity occurred despite a left cradling preference being present in both the standing and sitting positions, which might suggest that cradling behaviour is controlled by similar processes in both body positions. However, differences have been demonstrated previously (Todd 2001), suggesting that separable mechanisms may be involved in cradling behaviour in different positions. Until now, there were no data on whether one of these body positions is more likely to reveal stress-induced changes of holding preferences. It may, however, be argued that the sitting position allows for more comfort and represents a relaxed condition and consequently may reduce the likelihood of detecting stress effects. Such an interpretation is consistent with our findings that stress affects cradling only in the standing position.

The bilateral cold pressor test was chosen to avoid the possibility that unilateral peripheral stimulation may affect holding preferences. However, it may be that the left hand was more pain-sensitive, as suggested by previous studies investigating heat (Bar et al. 2003; Sarlani et al. 2003) and cold pain (Schiff and Gagliese 1994). There remains some controversy about this issue since not all studies have found such differences (Otto and Yeo 1993). We did not ask our subjects to rate left–right differences of pain perception, in order to avoid the priming of laterality effects. Therefore, we cannot exclude the possibility that increased left hand pain may have contributed to the observed effect. Clearly, this aspect needs to be addressed in greater detail in future research.

The cold pressor test effectively induced activation of the sympathetic nervous system, as evidenced by increases of heart rate and blood pressure. Moreover, the cold pressor test induced pain and discomfort such that 41% of subjects in the intervention group took their hands out of the ice-water before 2 min had elapsed. Stress-induced blood pressure and heart rate reactivity of those subjects was significantly greater as compared with subjects who were able to keep their hands in the water for the 2 min required. This finding might sufficiently be explained by individual differences in pain-sensitivity (Hodes et al. 1990).

There are several explanations for the disruptive effect of stress on left cradling behaviour. Attentional resources may be directed to the surrounding environment and at the same time the ability to concentrate on stress-irrelevant processes may be diminished (Arnsten 1998). This implies that in stressful situations attention might be dispersed from cradling and the infant to other factors, resulting in a holding behaviour more similar to that found for non-infant objects. Furthermore, self-preservation processes have been associated with left hemispheric function, while species preservation has been linked to the right hemisphere (Henry and Wang 1998). Under stressful circumstances self-preservational mechanisms of left hemispheric origin are increasingly needed. This process may interfere with advanced functioning of the right hemisphere, at the expense of the attachment system, which regulates intimacy, personal relevance and bonding (for review, see Henry and Wang 1998). Finally, the right hemisphere is dominantly affected by the feedback of bodily stress-induced arousal (Critchley et al. 2004), thereby disrupting right hemispheric processes which promote left cradling.

Several limitations of this study have to be discussed. Most important, standing vs. sitting differences should be interpreted with great caution. This study was not conducted to investigate the influence of body position, since we did not include any permutation of the standing and sitting sequences. It would have been preferable to use a split sample design, with half the group having the sitting task first. Furthermore, our data cannot be generalised to other populations, such as men, mothers, or non-student samples. Obviously, using a real infant instead of a doll, and parents instead of students might have revealed other insights. Furthermore, facilitated monitoring requires bi-directional communication, an aspect not possible to study with a non-responsive doll and so it is not possible to examine cradling behaviour fully with dolls instead of real infants. However, most subjects behaved as if the doll was a real infant. They patted, touched and stroked "Anna". Some greeted her by name before taking her up for the first time or talked to her. Many fumbled with her clothing, for example patted the material or adjusted the baby cap. For future research, it would be interesting to evaluate such affective behaviour and to determine whether it is related to cradling preferences. The correlation of the self-reported mood state items "angry" and "dull" with holding data suggests that emotional processes play a role for actual cradling preferences; further research is needed to investigate this interesting aspect. Another interesting point would be to assess the eye contact between subject and doll by the use of video techniques, which would also facilitate assessment of holding data. Cameras were not used in the present study in order to create a surrounding as natural as possible and to avoid distractions associated with video-recording that might distress or inhibit the subjects' spontaneous behaviour. In general, the cold pressor stress test proved to be an appropriate method to induce stress, pain and physiological arousal in our subjects. For further investigations however, it would be interesting to investigate other stressors, for example psychosocial stressors (Kirschbaum et al. 1993). Such tests provide an appropriate model for the stressors which typically affect a mother in her daily life.

Conclusion

Although much research has been done in the past decades on the left cradling preference, no previous study has examined the immediate influence of acute stress on cradling behaviour. This study is the first to show that stress reduces left cradling preference in nulliparous female volunteers. Our data indicate that stress influences cradling preference. This may be of relevance for caregiver–infant interactions under stress.

References

Albani C, Blaser G, Geyer M, Schmutzer G, Brähler E, Bailer H, Grulke N. 2005. The German short version of "Profile of Mood States" (POMS): Psychometric evaluation in a representative sample. Psychother Psychosom Med Psychol 55:324–330.

Almerigi JB, Carbary TJ, Harris LJ. 2002. Most adults show opposite-side biases in the imagined holding of infants and objects. Brain Cogn 48:258–263.

Antony I, Aptecar E, Lerebours G, Nitenberg A. 1994. Coronary artery constriction caused by the cold pressor test in human hypertension. Hypertension 24:212–219.

Arnsten AFT. 1998. The biology of being frazzled. Science 280:1711–1712.

Assel MA, Landry SH, Swank PR, Steelman L, Miller-Loncar C, Smith KE. 2002. How do mothers' childrearing histories, stress and parenting affect children's behavioural outcomes? Child Care Health Dev 28:359–368.

Bar KJ, Greiner W, Letsch A, Kobele R, Sauer H. 2003. Influence of gender and hemispheric lateralization on heat pain perception in major depression. J Psychiatr Res 4:345–353.

Bogren LY. 1984. Side preference in women and men when holding their newborn child: Psychological background. Acta Psychiatr Scand 69:13–23.

Bourne VJ, Todd BK. 2004. When left means right: An explanation of the left cradling bias in terms of right hemisphere specializations. Dev Sci 7:19–24.

Calhoun DA, Mutinga ML, Collins AS, Wyss JM, Oparil S. 1993. Normotensive blacks have heightened sympathetic response to cold pressor test. Hypertension 22:801–805.

Critchley HD, Wiens S, Rotshtein P, Öhman A, Dolan RJ. 2004. Neural systems supporting interoceptive awareness. Nat Neurosci 7:189–195.

Crnic KA, Gaze C, Hoffman C. 2005. Cumulative parenting stress across the preschool period. Infant Child Dev 14:117–132.

De Château P. 1991. Clinical application of asymmetrical behavioral communication in parent–infant interaction. In: Fitzgerald HE, Lester BM, Yogman MW, editors. Theory and research in behavioral pediatrics, Vol. 5. New York: Plenum Press. p 185–208.

De Château P, Andersson Y. 1976. Left-side preference for holding and carrying newborn infants. II: Doll-holding and carrying from 2 to 16 years. Dev Med Child Neurol 18:738–744.

Dienske H, Hopkins B, Reid AK. 1995. Lateralisation of infant holding in chimpanzees: New data do not confirm previous findings. Behaviour 132:801–809.

Erber NL, Almerigi JB, Carbary TJ, Harris LJ. 2002. The contribution of postural bias to lateral preferences for holding human infants. Brain Cogn 48:352–356.

Harris LJ, Almerigi JB, Kirsch EA. 2000. Side preference in adults for holding infants: Contributions of sex and handedness in a test of imagination. Brain Cogn 43:246–252.

Henry JP, Wang S. 1998. Effects of early stress on adult affiliative behavior. Psychoneuroendocrinology 23:863–875.

Hilgard ER. 1969. Pain as a puzzle for psychology and physiology. Am Psychol 24:103–113.

Hodes RL, Howland EW, Lightfoot N, Cleeland CS. 1990. The effects of distraction on responses to cold pressor pain. Pain 41:109–114.

Kirschbaum C, Pirke KM, Hellhammer DH. 1993. The trier social stress test-A tool for investigating psychobiological stress responses in a laboratory setting. Neuropsychobiology 28:76–81.

Leventhal H, Tomarken AJ. 1986. Emotion: Today's problems. Annu Rev Psychol 37:565–610.

Lucas MD, Turnbull OH, Kaplan-Solms KL. 1993. Laterality of cradling in relation to perception and expression of facial affect. J Gen Psychol 154:347–352.

Manning JT. 1991. Sex differences in left-side infant holding: Results from "family album" photographs. Ethol Sociobiol 12:337–343.

Manning JT, Chamberlain AT. 1990. The left-side cradling preference in great apes. Anim Behav 39:1224–1227.

Manning JT, Chamberlain AT. 1991. Left-side cradling and brain lateralization. Ethol Sociobiol 12:237–244.

Middlekauff HR, Shah JB, Yu JL, Hui K. 2004. Acupuncture effects on autonomic responses to cold pressor and handgrip exercise in healthy humans. Clin Auton Res 14:113–118.

Muller-Nix C, Forcada-Guex M, Pierrehumbert B, Jaunin L, Borghini A, Ansermet F. 2004. Prematurity, maternal stress and mother–child interactions. Early Hum Dev 79:145–158.

Oldfield RC. 1971. The assessment and analysis of handedness: The Edinburgh Inventory. Neuropsychologia 9:97–113.

Otto MW, Yeo RA. 1993. Hemispheric activation, affective judgements, and pain perception. Psychother Psychosom 60:186–194.

Reissland N. 2000. The cradling bias in relation to pitch of maternal child-directed language. Br J Dev Psychol 18:179–186.

Rheingold HL, Keene GC. 1965. Transport of the human young. In: Foss BM, editor. Determinants of infant behavior, Vol. 3. London: Bethner. p 87–110.

Saling M, Bonert R. 1983. Lateral cradling preferences in female preschoolers. J Gen Psychol 142:149–150.

Saling M, Tyson G. 1981. Lateral cradling preferences in nulliparous females. J Gen Psychol 139:309–310.

Salk L. 1973. The role of the heartbeat in the relations between mother and infant. Sci Am 228:24–29.

Sarlani E, Farooq N, Greenspan JD. 2003. Gender and laterality differences in thermosensation throughout the perceptible range. Pain 106:9–18.

Schiff BB, Gagliese L. 1994. The consequences of experimentally induced and chronic unilateral pain: Reflections of hemispheric lateralization of emotion. Cortex 30:255–267.

Sieratzki JS, Woll B. 1996. Why do mothers cradle babies on their left? Lancet 347:1746–1748.

Sieratzki JS, Woll B. 2002. Neuropsychological and neuropsychiatric perspectives on maternal cradling preferences. Epidemiol Psichiatr Soc 11:170–176.

Sieratzki JS, Woll B. 2004. The impact of maternal deafness on cradling laterality with deaf and hearing infants. J Deaf Stud Deaf Educ 9:387–394.

Souza-Godeli MRC. 1996. Lateral cradling preferences in children. Percept Mot Skills 83:1421–1422.

Todd BK. 2001. The origins and functions of the left-cradling preference in human females, Unpublished doctoral thesis, University of Sussex.

Todd BK, Butterworth G. 1998. Her heart is in the right place: An investigation of the "heartbeat hypothesis" as an explanation of the left side cradling preference in a mother with dextrocardia. Early Dev Parent 7:229–233.

Tomaszycki M, Cline C, Griffin B, Maestripieri D, Hopkins WD. 1998. Maternal cradling and infant nipple preferences in rhesus monkeys (Macaca mulatta). Dev Psychobiol 32:305–312.

Turnbull OH, Bryson HE. 2001. The leftward cradling bias and hemispheric asymmetry for speech prosody. Laterality 6:21–28.

Turnbull OH, Lucas MD. 1991. Lateral cradling preferences in males: The relationship to infant experience. J Gen Psychol 152:375–376.

Turnbull OH, Lucas MD. 1996. Is the leftward cradling bias related to lateral asymmetries in attention? J Gen Psychol 157:161–167.

Van der Meer A, Husby A. 2006. Handedness as a major determinant of functional cradling bias. Laterality 11:263–276.

Vauclair J, Donnot J. 2004. Infant holding biases and their relations to hemispheric specializations for perceiving facial emotions. Neuropsychologia 43:564–571.

Weatherill RP, Almerigi JB, Levendosky AA, Bogat GA, von Eye A, Harris LJ. 2004. Is maternal depression related to side of infant holding? Int J Behav Dev 28:421–427.

Webster-Stratton C. 1990. Stress: A potential disruptor of parent perceptions and family interactions. J Clin Child Psychol 19:302–312.

Wolf S, Hardy JD. 1941. Studies on pain: Observations on pain due to local cooling and on factors involved in the cold pressor effect. J Clin Invest 20:521–533.