Chapter 10
Lateral asymmetries in infants’ regulatory and communicative gestures
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Introduction

Lateralization of function is considered a central characteristic of brain organization [1-3] and is well established in adulthood. However, the nature of the lateralization during early development is controversial and findings are inconsistent. Our primary aim was to examine whether differences in the lateralization of expressive and regulatory gestures may reflect different hemispheric activity. To that end, the differential deployment of infant regulatory and social expressive gestures were examined during the non-stressful and stressful episodes of the Face-to-Face Still-Face paradigm (FFSF). Beyond the general importance of understanding the development of lateralization, examining the lateralization of emotional expressive as well as regulatory processes may have implications for infants’ and young children’s vulnerability to trauma and its effects such as dissociation.

Although neurophysiological and behavioral studies suggest an early functional brain asymmetry for emotional processing [4-8], the nature and even the presence of the specialization are debatable. According to some authors, the right hemisphere is specialized for the expression of emotion regardless of the hedonic valence or motivational significance of emotions [9,10]. In contrast, others argue that the hemispheres are more specialized, with the right hemisphere the seat of negative and avoidance-related emotions and the left hemisphere more specialized for positive emotions [11,12]. Despite the generality of the argument, few studies have looked at a range of emotional behaviors including gestures, postural changes and head movements as a way of examining lateralization, yet these behaviors are a critical feature of emotional expression and regulation and might be expected to be lateralized. Trevarthen [13] has argued that emotional gestures and self-regulatory gestures play an expressive function1 and are a class of movement distinct from movements (either gratuitous or action-specific) related to posture, locomotion, object grasping and exploration. Gianino and Tronick [14] described infants as having two different kinds of emotional behavior: self-directed regulatory behaviors (e.g., looking away, self-comforting and even self-stimulation) to modulate their levels of arousal and affect and other-directed regulatory behaviors that function to express the infants’ communicative or relational intent and solicitation of external regulation. Gianino and Tronick [14] hypothesized that self-directed regulatory behaviors would be expected in negative or possibly highly aroused positive states and stressful conditions, while other-directed behaviors would be expected during emotionally positive states with low levels of stress.

Note that the distinction between self- and other-directed behaviors is not hard and fast. Self-regulatory behaviors (e.g., thumb sucking) are utilized by the infant to regulate their emotional arousal, but they also simultaneously communicate the infant’s state of regulatory stability and possible need for regulatory scaffolding from the caregiver, whereas other-directed behaviors may express infants’ need for regulatory scaffolding from the caregiver (e.g., pick-me-up gestures). Although difficult to fully justify or document, a possible distinction between other- and self-directed behaviors may be that self-directed behaviors function

1Besides emotional gestures and self-regulating gestures, Trevarthen [13] proposed three other types of gestures: (a) gratuitous gestures, reflecting the infant’s ability to pick up information from the environment such as grasping and manipulating an object; (b) indicating gestures, directing attention or action and aimed to show another person an object or place of interest in the environment; and (c) symbolic gestures (emblems), constructing representations of actions, events, objects or situations.
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inadvertently to communicate a need for regulation, the intent or goal associated with them being self-regulation, whereas other-directed behaviors are intentional solicitations. Whatever may turn out to be the case, these different functions suggest a differential deployment of self- and other-directed behaviors related to infants’ affective state and contextual stress. Consequently, although such behaviors are complicated and not well understood, it is important to keep in mind that other-directed and self-directed regulatory behaviors are concurrent and reciprocal to each other such that each may affect the other [14–16].

Effective self-regulation, for example looking away, likely reduces the need for external regulatory scaffolding conveyed by other-directed gestures (e.g., banging hand on a surface). The regulatory system is highly dynamic over time.

Some research supports the suggestion of a differential deployment of self- and other-directed behaviors related to the stressfulness of the context to the infant. Gaze aversion as a component of the still-face effect can be seen as a form of self-directed regulation by the infant. Gianino and Tronick [14] found higher levels of self-soothing during the still-face. These behaviors are suggestive of self-directed attempts by infants to control high levels of arousal, negative emotions and behavioral dysregulation. These studies and others (for a review see Adamson and Frick [17]) have also found that infants actively engage in what can be seen as other-directed regulatory behaviors that function to express infants’ interactive intent (vocalizing, gesturing and communicating distress) and attempts to reengage the mother. But are self- and other-directed behaviors lateralized? Certainly if there is lateralization of emotional expressive functioning one might expect the regulation of emotion to be lateralized as well. This is an important issue because trauma is not only about the emotions experienced but also about how they are regulated, a function that may be even more critical than the emotional experience in and of itself. Most of the lateralization hypotheses about emotions do not deal with the issue of regulation. An exception is that of Schore [18], who has brought together a broad array of research, too extensive to review here, and forcefully argued that the right hemisphere not only controls the expression of all emotions but is also the seat of emotion regulation.

Unfortunately, little evidence is available on lateralization of regulation. In a widely cited study Trevathen [13,19] concluded that expressive and regulatory gestures (i.e., other-directed gestures) are asymmetrically organized to the left side of the brain. Trevathen coded only active fingering of their cloths or free moving of the body as indicators of self-directed regulatory behaviors. Although he states that he found asymmetries, he also notes – and our examination of his data confirms – that the observed asymmetries were highly labile, varied from visit to visit and were different in different ways for boys and girls. The observed variability and gender differences do not fit the lateralization hypothesis. Using the same sample and set of still photographs, Trevathen further argued that when the infants were mildly distressed (e.g., when they were confronted with an unresponsive mother), the pattern of gestures changed. The left hand was more active and the infants made more self-touching movements. This finding too suffers the same problems as those of the findings on other-directed behaviors (e.g., variability over sessions). Furthermore, Trevathen did not find an increase in asymmetries with age, an expected finding based on the general principle that differentiation of function generally characterizes development.

There is other evidence suggestive of an asymmetrical organization of expressive gestures. Fogel and Hannan [20] observed asymmetric hand movements (i.e., other-directed gestures) indicating right-side activation when mothers were asked to “chat” with their 3-month-old infants during a 2 minute spontaneous face-to-face interaction. Murray [21], using a television replay test (i.e., loss of contingency simulated through a videotape replay of the mothers’ responses) that disturbed the infants, found that 2-month-old infants increased touching of their clothes with both hands and showed increased and longer touching of their faces by their left hand, while expressive (other-directed) right-arm raising decreased. Neither the findings by Fogel and Hannan [20] nor those of Murray [21] support Trevathen’s conclusion [13,19], but they seem to support Schore’s argument [18]. Therefore, the question of lateralization of either form of expressive gesture remains open.

Using the FFSF paradigm in the study described in this chapter, we evaluated if there is a differential distribution of self- and other-directed expressive gestures related to the context of the different episodes, and if there are differences in the lateralization of expressive gestures in infants during normal and stressful interactions, which would indicate differential emotional hemispheric activity during the second
half of the first year of life. Our first hypothesis was that there would be a differential distribution of self- and other-directed gestures related to stress. Specifically, that there would be a greater use of other-directed gestures during normal interactions and a greater use of self-directed regulatory gestures during the still-face episode. In other words, we were expecting a normal interaction gestures effect, with more other-directed behaviors and a decrease in self-directed behaviors during the normal interaction compared with the still-face, and a reciprocal still-face gestures effect, with a reduction in other-directed gestures and an increase in self-directed gestures when the mother was unresponsive. Given Schore’s hypothesis [18,22] of the role of the right hemisphere in the regulation of emotions, our second hypothesis was that there would be a prevalence of self-directed regulatory gestures performed with the left side of the body (right hemisphere) during the stressful condition. However, although Schore would predict lateralization of other-directed gestures, given the inconclusiveness of the literature on early functional left brain asymmetry for expressive emotional behaviour, we did not expect a lateralization of other-directed gestures during any episode.

Research study

We studied 30 healthy full-term infants (14 females, 16 males). Infants were tested between 6 to 12 months of age (mean age, 8.3 ± 1.6). The infants were clinically normal and had uncomplicated prenatal, perinatal and neonatal courses. Left-handed mothers were excluded from the study because we found one study [23] that presented evidence for a maternal effect on infant hand-use preferences, as well as the more well-established finding of the genetics of hand preferences [24]. Mothers and infants were videotaped during the FFPSF procedure based on the original paradigm developed by Tronick (see Tronick et al. [25] for details). Infants’ gestures were coded using the Infant Self-directed Regulatory and Other-directed Gestures Coding System (ISOG; R. Montirocco, S. Marseglia and C. Pupino, unpublished data 2005). The ISOG was specifically designed for scoring the gestures that infants can make during the face-to-face interaction (R. Montirocco, R. Borgatti and T. Tronick unpublished data). The ISOG cover two areas: other-directed gestures and self-regulatory gestures. The other-directed gestures cover hand movements that express emotions and are usually associated with making interpersonal contact. These movements are accompanied by facial expressions, eye movements and vocalizations that further convey the subject’s expressive intent to communicate (e.g., extending one or more fingers, arm moving upwards, banging hand on table, reaching out for mother, touching mother with hand). The self-directed regulatory gestures include hand movements aimed at facilitating, protecting or stimulating the body and at regulating the infant’s inner state (e.g., touching a close surface, touching clothes, touching head or face, touching arm or hand, touching mouth or sucking one or more fingers). Only unilateral gestures were considered as these single-handed gestures are mutually exclusive. The ISOG coding used software developed by the Bioengineering Laboratory of Scientific Institute “E. Medea” (Picture Analyzer and Behavior Coder – PACO). This software allows coders to indicate the time unit to 1 second for each observed behavior. To evaluate reliability, one-third of the videotaped data was separately coded with each of two coding systems by independent coders blind to the study purposes and hypotheses. Different coders were used for the Infant and Caregiver Engagement Phases System [26] and the ISOG systems. Reliability was evaluated in two ways. The mean proportion of agreement ranged from 0.82 to 0.91% and Cohen’s kappa values ranged from 0.71, caregiver engagement to 0.75.

The ISOG codes were grouped into four configurations: right-sided other-directed gestures; left-sided other-directed gestures; right-sided self-directed regulatory gestures; left-sided self-directed regulatory gestures. The proportion of time for the four ISOG configurations of gestures was calculated. To examine if there was a global lateral bias affecting the gestures, two combined variables were obtained by separately totaling the proportions of two kinds of expressive gestures produced by each infant with the left side of the body (left-sided gestures combined left-sided other-directed and self-directed gestures) and the right side (right-sided gestures combined right-sided other-directed and self-directed gestures). These measures reflect the proportions of gestures for each side of the body during each episode of the FFPSF, regardless of type. To examine if there was an expressive gestures effect related to episode, two combined variables were obtained by summing the proportions of self-directed regulatory gestures (combining right-sided and left-sided self-directed gestures) and other-directed gestures (combining right-sided and left-sided other-directed gestures). These measures reflect the overall amount of self-directed regulatory gestures and other-directed
Fig. 10.1. Mean proportion time of infant's gestures performed with the right or left hemi-body across the Face-to-Face Still-Face paradigm.

gestures produced by each infant during each episode of the FFSF, regardless of body side. The following questions were pursued using the generated data.

Was there an overall left-side or right-side gestures bias and a gender effect? The findings suggested that infants showed no significant overall lateral bias of gestures, that is, no tendency to have more movements on one side compared to the other; there were no findings for gender.

Were there increases in other-directed behaviors and decreases in self-directed gestures during the normal interaction and reductions in other-directed gestures and increases in self-directed gestures during the still-face? The findings supported the hypothesis of a self-other-directed gestures effect by episode (Fig. 10.1). Self-directed gestures significantly increased from play episode to still-face and decreased from still-face to the reunion episode, returning to the levels of the play episode. Other-directed gestures significantly decreased from play to still-face and significantly increased from still-face to reunion, but did not return to the level in the play episode. These findings highlight a still-face gestures effect and a reunion gestures effect, supporting the interpretation that the reunion episode is a challenging task for the infant (Fig. 10.1).

Was there a prevalence of self-directed regulatory gestures performed with the left-side of the body (right hemisphere activation) during the stressful condition? Self-directed regulatory gestures performed with the left side were significantly more common during the still-face than during the play and reunion episodes, supporting the hypothesis that there would be an asymmetry of left-sided self-directed regulatory gestures.

Was there a lateralization of other-directed gestures? Analysis revealed a significant overall main effect of episode for left-sided other-directed gestures as well (Fig. 10.1). Other-directed regulatory gestures performed with the left side were significantly more common during the play and reunion than during the still-face. There were no significant main effects for other-directed gestures and self-directed gestures performed with the right side.

Discussion

This study evaluated the differential utilization and lateralization by infants of socioemotional expressive gestures and self-directed coping (self-directed regulatory gestures versus other-directed gestures). The findings support the hypothesis that there is a differential distribution of self-directed and other-directed gestures related to the stress experienced by the infant. Other-directed gestures were more common during the play and reunion and self-directed behaviors were more common during the still-face phases of the FFSF. Self-directed as well as other-directed gestures were lateralized to the left side. These findings suggest that during the FFSF infants showed greater right hemisphere activation and that the activation is associated with different kinds of gestures related to episode.

The findings confirm our first hypothesis. The findings on the preferential distribution of self-directed
gestures related to stress are consistent with studies reporting an increase of self-touching behaviors for infants during several stressful situations, such as being left alone by the mother, the entrance of a stranger, a television replay test or maternal still-face [21,27–30]. They are also consistent with the findings of increased infant self-clasping and oral self-comfort behaviors in infants of depressed mothers. Thus infants make a greater use of gestures to self-regulate the negative states experienced during the still-face. One might well expect that infants and children who experience trauma will show much more extreme, perhaps chronic, differential distributions of self- versus other-directed behaviors, with self-directed gestures in greater prominence. The occurrence of such extremes may be possible signs of trauma (see below).

The findings suggest that gestures are an essential component of the mix of modalities that are assembled for self-regulatory purposes and that they should be given more consideration in future studies. The results also confirm that infant self-regulation increases in various distress situations. Furthermore, the findings in the reunion episode support that there also is a differential deployment of self- and other-directed regulatory behaviors and make clear just how complex the interplay is between forms of regulation and affect. Although the levels of negative affect in the reunion episode remain at the levels seen with still-face, the level of positive affect returns to play episode levels. Self-directed gestures reduce from still-face levels and return to the play episode levels, while other-directed gestures are still below the level seen in the play but higher than during the still-face. The finding on the high level of negative affect supports the argument advanced by Weinberg and Tronick [31] that the reunion episode actually is stressful because of the carryover of negative affect from the recent experience of the still-face and because the dyad also has to renegotiate and repair the stress of mismatches inherent to normal interactions [15].

This explanation however, does not seem complete because it would also be reasonable to expect a very high level of self-directed gesturing to regulate the stress of the reunion, something not seen. Perhaps the findings suggest that self-directed regulation even in the face of high levels of negative affect can be modulated or offset by high levels of positive affect, as seen in the reunion episode. A further speculation is that because of the immediate past negative experience of the still-face episode, infants are still hesitant to use other-directed gestures with the mother for fear that she will not respond. In a sense it may be that following the still-face, infants are unable to make sense out of the mothers’ intent during the reunion – she simultaneously is saying “hello” and “goodbye” [25] – and as a consequence the infants do not yet trust that she will respond to their other-directed gestures. Consequently, their intention to communicate remains diminished and other-directed behaviors remain relatively low. Such confusion may well characterize children who have experienced trauma and may lead to their hesitancy to interact even with individuals who were not part of their traumatic experience.

Overall differential distribution of self- and other-directed behaviors in relation to the different social contexts suggests that the regulatory capacities of the infant are highly tuned and quite sophisticated. The infants experience the different contexts differently, appear to quickly make sense of them, and to organize a different regulatory strategy in each. This degree of regulatory sophistication is greater than one might expect from many existing brain models of regulatory control, which suggest that cortical development of executive centers is requisite for effective self-regulation [32]; however, a different view is put forward by Wager et al. [33]. Rather, the findings suggest that regulatory control is found in the limbic or other lower structures that control emotions and their expression and the regulation of emotions, and that the mechanisms controlling them change with development. Thus, it might be more reasonable to suggest that regulation and activation are always coupled regardless of the mechanisms involved. Brazelton [34], for example, has shown that even newborns are capable of self-regulating their levels of arousal using gestures (e.g., thumb sucking) or the deployment of attention (e.g., looking at objects, attending to sounds) long before cortical or possibly even limbic mechanisms are developed. One might picture a functional organization of the brain in which action capacities generated at one level of the brain at one developmental stage are part of a larger organization that is capable of regulating those same capacities. In a sense, there are functional arcs in which capacities – for example, for action and inhibition – develop together to be replaced in development by more advanced action and inhibitory capacities [35]. Therefore, during the episodes of the FFSF paradigm, infants can engage in other- and self-directed behaviors that involve both these action-oriented behaviors and simultaneously regulate them, and the
control is found in limbic and other brain areas without any great involvement of cortical mechanisms.

Another of the findings on gestures during the reunion episode is noteworthy. Prior work has shown that facial and vocal communication during the reunion episode return to the levels seen in the first play episode. Here we found that other-directed gestures did not. These findings indicate that the different expressive systems – facial expressions, vocalization and gestures – are not as tightly linked as was previously thought [30]. The less-tight coupling among the different modalities suggests the speculation that infants can make blended configurations or assemblages of expressive gestures in which one modality enhances or diminishes the meaning or intensity of another modality. For example, blended intermodal configurations might convey different messages at the same time – smiles communicating an intention for social engagement while simultaneous self-touching communicates the intention to disengage. Blended communicative configurations might also convey differences in the intensity of the message (e.g., smiling while self-touching conveys that the infant intends to play, but that the play should be low-key, whereas a smile coupled with a big other-directed gesture conveys the intention to play intensely). Certainly, consideration of gestures in relation to other expressive modalities suggests that infants' communicative repertoires are not only complexly organized but also nuanced and subtle. The existence of this blending would contradict the view held by those examining facial expressions that blended emotions are a later development [36]. The findings suggest that we should look more carefully at the interplay of expressive systems and the subtleties of facial expression that have typically been seen as disorganized. Such an examination might reveal an orderliness in the relations of the subtle facial changes and gestural expressions.

As expected, we found that left-sided regulatory gestures were more frequent during the still-face than during the play episode. These findings are indicative of a greater activation of the right hemisphere. We also found that during normal interactions infants performed other-directed gestures with the left side. These findings suggest that right hemisphere activation is associated with behaviors related to normal and stressful interactive conditions. The finding is consistent with the work of Bazhenova and colleagues [37] and with electrophysiological investigations performed during separation from the mother and withdrawal as a result of negative emotional conditions. During these conditions, a selective activation of the right frontotemporal anterior regions has been documented [38,39]. These findings support a growing body of evidence showing that the neural circuitry of the stress system is located in the right brain [22,40–43]. Consequently, it seems plausible that infants cope with the emotional distress caused by unresponsive mothers through self-regulation behaviors associated with a greater activation of the right hemisphere. In sum, this finding supports the view that during a stressful condition there is a state-dependent activation of the right hemisphere [22,39]. Our finding of increased left-sided other-directed behaviors during normal interaction associated with making interpersonal contact (e.g., touching mother with hand) is inconsistent with previous experimental findings and with theoretical views suggesting that it is the left side of the brain that controls the approach behaviors [44]. Therefore, it is possible to suggest that the right hemisphere is involved in both positive interpersonal contact and its regulation. More generally, these findings suggest that the right hemisphere is more involved in the social and biological functions involved in infant–caregiver emotional bonding [22,45]. Alternatively, our findings on the lateralization of self- and other-directed behaviors to the right hemisphere could be explained in the light of the well-established observation that the right side of the brain matures more quickly than the left side [46–48]. Such a left–right gradient could be evaluated by looking at asymmetries of other-directed behaviors in younger infants and following them longitudinally. We think Schore would predict strong lateralization of other-directed behaviors in younger infants that continues with development or, perhaps, with the development of increasing complex and explicit social behavior, the control shifting to the left side of the brain with a concomitant reduction in asymmetry. This suggestion would integrate Schore’s and Davidson’s views with a developmental perspective.

Conclusions

Our study shows self- and other-directed behaviors to be differentially deployed in relation to the stressfulness of the context, a finding which suggests that infants are sensitive to what is going on in an interaction and adjust their behavior in highly specific ways. Support for a lateralization of self- and other-directed behaviors to the right hemisphere was found, lending support to views of the specialization of the right
hemisphere for both regulatory and communicative emotional processing. The findings suggest the need to study the use of different gestures with simultaneous measurement of brain function over a wider age span. Such studies would also be useful with samples of high-risk infants whose behavior and brain organization may be compromised (e.g., preterm infants, infants with lateralized white matter disorder). This hypothesis about preterm infants is currently under investigation at our laboratory.

One final point. Infant gestures are a lifelong form of human communication that is used to convey meaning even earlier than the onset of language. However, it remains controversial as to whether gestures should be considered part of the linguistic system or a separate system for conveying meaning. It is well established that the left hemisphere is specialized for language. Even infant babbling is lateralized to the left hemisphere [49]. In contrast, the neural sites for the expression of social-emotional communication are generally viewed as lateralized to the right hemisphere. Had we found other-directed gestures lateralized to the right side of the body, it would suggest that, like babbling, they are linguistic in nature. However, we found that these were preferentially distributed to the left side of the body, suggesting that the neural basis of gestures develops independently from the development of the linguistic system and that the gestural system for conveying meaning is an independent meaning-making system.

In conclusion, the present research demonstrates the need to consider gestures when evaluating regulatory and interactive behavior and the usefulness of these behaviors for exploring the development of lateralization and the subtlety of expressive behavior in infants. Micro-analytic study of gestures and other expressive modalities over time in different contexts with samples of low- and high-risk infants and dyads is needed to further explore these issues.

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References


The Impact of Early Life Trauma on Health and Disease

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