Effect of postpartum experience and infant temperament on maternal beliefs about infant crying

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Abstract

Infant crying is an important signal for their survival and socio-cognitive development. It is unclear how maternal beliefs about infant crying change with their caregiving experience. Additionally, this study examined a bidirectional relationship between maternal beliefs and infants' temperament using longitudinal study design. Maternal beliefs about crying and infant temperament of first-time mothers were measured at 1-month intervals over a 4-month period (N = 339 at Wave 1 and N = 164 at Wave 4). We found that parent-oriented beliefs about crying increased with the mother's experience, and that infants high on surgency predicted changes in maternal beliefs. The current results suggest that the maternal beliefs change with an infant's development and parenting experience in the early postpartum period.

Background

Infant crying is the primary means of communicating feelings and needs to the parents (Soltis, 2004). Mothers are specifically drawn to their infants' signals (Thompson-Booth, Viding, Mayes, Rutherford, Hodsoll, & McCrory, 2014a, 2014b), which motivates caring behavior and leads to infant survival. Furthermore, the maternal sensitivity to crying is involved in the formation of infant-mother attachment security. Research has found sensitive parenting behavior toward distressed infants predicts infant's secure attachment, but parenting in a non-distressed situation does not predict attachment (Bell & Ainsworth, 1972; McElwain & Booth-Laforce, 2006). In early studies of infant attachment, the frequency of crying increased as the number of ignored crying episodes increased (Bell & Ainsworth, 1972). Taken together, attachment theorists emphasize providing prompt response to infant crying according to infants' needs and develop interventions to increase maternal sensitivity to infant crying (Hepworth et al., 2020).

However, whether a sensitive response to infant crying is desirable for infants and mothers, and how it affects infant development is still debated. Recent studies with larger samples have not confirmed the association between ignoring infant crying and subsequent increase in crying behavior, insecure attachment, or problem behavior (Bilgin & Wolke, 2020; Hubbard & Ijzendoorn, 1991). It has also been suggested that prompt responsiveness to crying is sometimes stressful for mothers and that they may be able to selectively ignore crying as their parenting experience increases. One of the reasons for these contradictory findings could be that maternal responses to crying may change within an individual as the infant develops; the mother, for example, gradually acquires strategies for coping with crying as their caregiving experience increases (Drummond, McBride, & Wiebe, 1993; Kurth et al., 2014). Furthermore, the cause of infant crying also changes from a signal for survival to a signal for social communication (Nakayama, 2010). Additionally, as infants develop, the brain structure and function of mothers also change (Kim et al., 2010; Parsons et al., 2017), which would facilitate the change in maternal response to infant crying. In order to develop effective interventions, the importance of longitudinal data on maternal changes in response to infant crying and its relationship to a child's development should be addressed.

Therefore, this study examined the relationship between intra-individual changes in maternal beliefs about crying and infant temperament development.

Mothers and non-mothers respond differently to infant crying as pregnancy and childbirth change the hormonal balance and brain structure and function (e.g. Barrett & Fleming, 2011). Functional brain imaging studies show, mothers while listening to infant crying have greater responses in the auditory cortex, amygdala, and supplementary motor cortex, which are involved in discriminating the emotional valence of an auditory stimuli and response behavior (Parsons et al., 2017; Seifritz et al., 2003; Witteman et al., 2019). Furthermore, animal studies have also shown that non-mothers engage in avoidance behaviors to infant stimuli, but mothers approach their infant after partum (Ehret, Koch, Haack, & Markl, 1987). The changes in the physiology of the mother facilitates sensitivity and seems to develop an approach that benefits the child's survival.

However, there is limited research on the changes in mothers' responses to crying after becoming mothers. Drummond found that coping strategies for infant crying gradually changed as the infant develops and differed between primiparous and multiparous mothers (Drummond et al., 1993). Kurth also found that postpartum mothers can manage their impulsive and obligatory feelings to stop their infant crying (Kurth et al., 2014). However, these studies were conducted through narrative and interview methods, and it remains to be seen if these findings are generalizable. Even in the parenting literature, it is posited that longitudinal studies are necessary to validate the theorized directionality of associations between parents and infant development (Taraban & Shaw, 2018).

Parenting behavior is formed by the caregiver's characteristics and is influenced by the child's temperament (Belsky, 1984). In infancy, temperament is an individual difference in the child's reactivity and self-regulation to a given environment (Rothbart, 2012). In parenting research, three broad dimensions of temperament have been especially well-studied: surgency, negative emotionality, and orientation (Taraban & Shaw, 2018). Many studies have focused on negative emotionality because it tends to show higher stress responses of infants to environmental stimuli, and mothers find it challenging to manage them (Crockenberg & Leerkes, 2003; Gauvain & Fagot, 1995). High surgency is also associated with more challenging to care of infant temperament; studies have found, infant surgency is substantially related to caregiving, play, and sensitivity changes in mothers (Planalp, Braungart-Rieker, Lickenbrock, & Zentall, 2013).

Recently, a revision of the model has been proposed in which parenting behavior and infant temperament development have a bidirectional relationship, especially up to the age of 2 years, when temperament is indeterminate (Taraban & Shaw, 2018). Some studies found that parenting predicts subsequent positive and negative emotionality in children (Belsky, Fish, & Isabella, 1991; Braungart-Rieker, Hill-Soderlund, & Karrass, 2010). Scaramella examined the causal relationship between infants' temperament and parenting behaviors at both 12 and 24 months postpartum period, the results indicated that mothers' harsh parenting at 12 months of age predicted increases in children's observed negative emotionality from 12 to 24 months. On the other hand, children's negative emotionality predicted a decline in mothers'

supportive parenting behavior from 12 to 24 months (Scaramella, Sohr-Preston, Mirabile, Robison, & Callahan, 2008).

Although it has been suggested that there is a bidirectional relationship between parenting and infant temperament, only a few studies have directly examined this relationship (Taraban & Shaw, 2018), and no studies have examined the relationship between temperament and maternal response to infant crying. As mentioned above, crying is an important means of communication between children and parents, which is necessary for their survival and attachment formation, and infant crying is also a behavioral indicator which reflects the temperamental aspect of stress responsiveness. Therefore, it is likely that the mother's response to crying is more closely related to her infant's temperament than to parenting behavior in other situations, and it is important to examine the relationship between them in order to provide new insights into both parenting behavior and children's temperament development.

The purpose of this study was to examine the process of intra-individual changes in maternal beliefs toward crying and their interactive relationship with infant temperament. We used the Infant Crying Questionnaire (ICQ; Haltigan et al., 2012), a questionnaire that measures adult's beliefs and response intention to infant crying, which divides beliefs into infant-oriented and parent-oriented beliefs. Infant-oriented beliefs are beliefs that care about the crying infant and focuses on the infant, while parent-oriented beliefs focus on the caregivers. The infant's temperament was obtained using the short form of the Japanese version of the Infant Behavior Questionnaire-Revised (IBQ-R; Nakagawa, Kimura, & Sukigara, 2009). These questionnaires were repeatedly administered to first-time mothers at a total of four time points.

- Hypothesis 1: Maternal beliefs about infant crying would change within individuals. In particular, infant-oriented beliefs would decrease and parent-oriented beliefs would increase as the child develops.
- Hypothesis 2: Infant's temperament would be related bi-directionally to changes in maternal beliefs about crying. In particular, high negative emotionality and surgency would be associated with changes in infant crying beliefs, and infant crying beliefs would be associated with changes in negative emotionality later in the child's development (Planalp et al., 2013; Scaramella et al., 2008).

1. Methods

1.1 Ethics statement

The study protocol was approved by the Ethics Committees of XXX. All participants provided informed consent for participation in this study.

1.2 Participants

The questionnaire survey was conducted four times (1–4 waves). The interval between each wave was approximately one month (September to December 2019). All data were collected from a web-based nationwide survey through Macromill, a marketing research company with monitors throughout Japan. The initial sample consisted of 339 Japanese-speaking mothers. There were 289 participants in Wave 2, 240 in Wave 3, and 164 in Wave 4. All participants were first-time mothers and their children were less than four months of age at Wave 1. To determine the sample size, we consulted the simulation, in which the effect of sample size on the result of LGM was calculated (Hamilton, Gagne, & Hancock, 2003). The simulation results showed the effect of sample size on various parameters of LGM, such as convergence rate and RMSEA on each number of measurement point (4, 5, and 6 time points). The results showed that for the four time points LGM, the RMSEA was below .05, and the convergence rate was above 95% if the sample size was above 100 under all conditions. Allowing for dropout, we sampled over 300 participants at Wave 1 which resulted in a sufficient sample by Wave 4. The sociodemographic composition of the samples is presented in Table 1. The sociodemographic characteristics of the current samples did not differ across waves. This study was approved by the ethics review board of Kyoto University. Informed consent was obtained from all mothers.

Table 1. The sociodemographic composition of the samples

Characteristic	Wave1, N = 339[1]	Wave2, N = 289[1]	Wave3, N = 240[1]	Wave4, N = 164[1]	p-value[2]
Mother's age	28.7 (4.1)	28.9 (4.1)	29.0 (4.1)	29.1 (4.1)	0.79
Child's age	1.83 (1.40), 0.00-4.00	2.92 (1.41), 1.00-5.00	3.99 (1.42), 2.00-6.00	5.04 (1.40), 3.00-7.00	<0.001
Child's sex					0.42
female	147 (43)	125 (43)	107 (45)	83 (51)	
male	192 (57)	164 (57)	133 (55)	81 (49)	
Premature	37 (11)	30 (10)	20 (8.3)	12 (7.3)	0.51
Underweight	39 (12)	33 (11)	25 (10)	19 (12)	0.98
Job					0.99
Employed	172 (51)	149 (52)	120 (50)	84 (51)	
Unemployed or on leave of absence	167 (49)	140 (48)	120 (50)	80 (49)	
Home income					>0.99
less than 2 million yen	7 (3.2)	7 (3.7)	7 (4.5)	5 (4.5)	
2 -4 million yen	54 (25)	47 (25)	38 (25)	26 (24)	
4 -6 million yen	67 (31)	51 (27)	45 (29)	36 (33)	
6 -8 million yen	39 (18)	39 (21)	27 (18)	17 (15)	
8 -10 million yen	35 (16)	31 (16)	26 (17)	18 (16)	
10-15 million yen	13 (5.9)	11 (5.8)	10 (6.5)	7 (6.4)	
more than 15 million yen	4 (1.8)	4 (2.1)	1 (0.6)	1 (0.9)	
Unknown	120	99	86	54	

[1]Mean (SD); Mean (SD), Minimum-Maximum; n (%)

[2]One-way ANOVA; Pearson's Chi-squared test

1.3 Materials

1.3.1 Infant Crying Questionnaire (ICQ)

The ICQ was used to measure mothers' beliefs or response intentions to infant crying. This questionnaire contained 31 items based on two secondary factors and four first-factor structures. Although the original version of the ICQ assumed five first order factors, including directive control in parent-oriented beliefs, subsequent studies including the original author's work have used only four subscales by excluding directive control (Leerkes, Su, Calkins, Henrich, & Smolen, 2017; Pruitt, McKay, Lelakowska, & Ekas, 2020). In the present study, we also excluded directive control. Infant-oriented beliefs include attachment and communication, while parent-oriented beliefs include minimization and spoiling for crying infants. Infant-oriented items included concerns about the infant's welfare, a desire to help the infant, sympathy, or empathy for the infant (e.g., 'I felt sad for the baby'). On the other hand, parent-oriented items included self-focused concerns, negative and avoidance reactions toward the infant, or responses that are of interest or importance to the mother but not the infant (e.g., 'All that crying made me feel nervous'). Each item was rated on a 5-point scale ranging from 1 (never) to 5 (always). The original version of the ICQ was translated into Japanese by the first author after obtaining permission from the original authors, and then back-translated by an English proofreading company. Prior to this study, the reliability and validity of the Japanese version of the ICQ were examined through confirmatory factor analyses and correlation analyses with related questionnaires. These results are reported in the Supplementary information.

1.3.2 The short form of Japanese version of Infant Behavior Questionnaire-Revised (IBQ-R)

The Japanese version of the IBQ-R included 85 items evaluated on a 7-point scale, which reflects the relative frequency of infant reactions to certain situations within the last week. These were then tabulated under 14 subscales (activity level, distress to limitations, fear, duration of orienting, smiling and laughter, high-intensity pleasure, low-intensity pleasure, soothability, falling reactivity, cuddliness, perceptual sensitivity, sadness, approach, and vocal reactivity). An item-weighted sum of approach was employed to create the temperament clusters: activity level, distress to limitations, perceptual sensitivity, high-intensity pleasure, vocal reactivity, and fear subscales formed the "Surgency" cluster; low-intensity pleasure, smiling and laughter, activity, duration of orienting, and cuddliness formed the "Negative emotionality" cluster (all scales were inverted); and sadness (inverted), falling reactivity, and soothability formed the "Orienting" cluster.

1.4 Statistical analysis

To test the hypotheses, we proceeded in a two-step manner. We first sought to examine cross-sectional effects across the four waves to examine inter-individual effects of infant age on maternal beliefs on

infant crying (Parsons et al., 2017). A regression analysis was conducted for each wave entering ICQ scores as dependent variables and the infant's monthly age as the independent variable. Next, the LGM was employed to examine the longitudinal trajectories of infant-oriented and parent-oriented beliefs about infant crying over the 4-month postpartum period. LGM is a multivariate statistical method within the framework of structural equation modeling that allows for the modeling of repeated measures data to estimate intra-individual growth patterns over time. Finally, the association between changes in maternal beliefs about infant crying and infant temperament was analyzed using parallel LGM, which integrated three LGM for each outcome variable and analyzed the cross-sectional, prospective, and parallel associations among variables. The R 3.6.1 (R Core Team, 2019) and lavaan packages (Rosseel, 2012) were used for the analyses. We regarded $p < .05$ as statistically significant for each analysis, using two-tailed testing.

2. Results

Participants who chose the same option for all questions were excluded from the analyses; two participants were excluded from Wave 1, zero from Wave 2, one from Wave 3, and one from Wave 4. The scores of infant-oriented and parent-oriented beliefs toward infant crying by children's age are shown in Figure 1.

2.1 Cross-sectional results

Regression analysis was conducted separately for each wave (Table 1). In Wave 1, infant-oriented beliefs increased and parent-oriented beliefs decreased with a child's increase in monthly age. In the other waves, there was no considerable association between infant crying beliefs and monthly infant age.

Table 2. Results of regression analysis predicting ICQ from child age in each Wave

		Infant-oriented beliefs			Parent-oriented beliefs		
Group	Characteristic	Beta	95% CI[1]	p-value	Beta	95% CI[1]	p-value
Wave1	Child age	0.04	0.01, 0.07	0.010	-0.08	-0.13, -0.02	0.006
Wave2	Child age	0.03	-0.01, 0.06	0.10	-0.02	-0.08, 0.04	0.47
Wave3	Child age	0.01	-0.04, 0.05	0.80	0.04	-0.03, 0.11	0.26
Wave4	Child age	-0.03	-0.08, 0.03	0.33	0.07	-0.02, 0.16	0.12

[1]CI = Confidence Interval

2.2 Latent growth analysis

We used latent growth analysis to test the hypothesis that maternal beliefs about infant crying changes within individuals as their caregiving experience increases.

First, the four-time points scores about beliefs about infant crying were fitted to univariate latent growth curve models (LGM). Regarding the change in infant-oriented beliefs, the LGM provided adequate fit to the observed data [$\chi 2$ (5) = 4.421, p = 0.490; comparative fit index (*CFI*) = 1.000; root mean square error of

approximation (*RMSEA*) = 0.000]. The estimated mean level for the sample at Wave 1 was significantly different from zero (M = 4.554, 95%CI = [4.497, 4.612], p = 0.000), and there were significant individual differences ($\sigma 2$ = 0.088, 95%CI = [0.055, 0.121], p = 1.68e-07). The sample as a whole did not show significant developmental change (M = -0.004, 95%*CI* = [-0.0267, 0.018], p = 0.714), nor individual differences in growth rates were observed in infant-oriented beliefs ($\sigma 2$ = 0.006, 95%*CI* = [-0.000436, 0.012], p = 0.069).

Subsequently, regarding parent-oriented beliefs, the univariate LGM provided an adequate fit to the observed data [$\chi 2$ (5) = 5.333, p = 0.377; *CFI* = 0.999; *RMSEA* = 0.0203]. The estimated mean level for the sample at Wave 1 was significantly different from zero (M = 2.327, 95%*CI* = [2.228, 2.425], p = 0), and there were significant individual differences ($\sigma 2$ = 0.293, 95%*CI* = [0.197, 0.389], p = 1.99e-09). Overall, the participants showed significant increases in parent-oriented beliefs (M = 0.039, 95%*CI* = [0.007, 0.07], p = 0.017). In addition, there was a significant individual differences in the growth rate ($\sigma 2$ = 0.018, 95%*CI* = [0.003, 0.032], p = 0.015).

Next, we conducted multivariate parallel growth models to test for associations between changes in infant- and parent-oriented beliefs and changes in infant temperament, including surgency, negative emotionality, and orientation for four months in the postpartum period. Table 2 presents the correlations between latent growth factors in models for (a) surgency, (b) negative emotionality, and (c) orientation. In a prospective association, higher temperament surgency was negatively associated with changes in infant-oriented beliefs and positively associated with changes in parent-oriented beliefs. This suggests that parents of children who showed high surgency as a temperament were more likely to experience a gradual decline in infant-oriented beliefs and an increase in parent-oriented beliefs about their infant crying. There was no effect of other temperaments on beliefs about crying. Additionally, there was no effect of crying beliefs on temperamental development.

Table 3. Parameter estimates from the parallel latent growth models

		(a) Surgency			(b) Negative emotionality			(c) Orientation		
		Estimate (b)	95% CI[1]		Estimate (b)	95% CI[1]		Estimate (b)	95% CI[1]	
Cross-sectional association	Intercept (IO[2]) ~ Intercept (Temperament)	0.02260	-0.02744	0.07265	-0.060651	-0.11334	-0.00796	-1.97e-02	-5.60e-02	0.01661
	Intercept (PO[3]) ~ Intercept (Temperament)	0.05935	-0.02764	0.14634	0.036045	-0.05407	0.12616	7.33e-02	9.95e-03	0.13657
Prospective association	Intercept (IO[2]) ~ Slope (Temperament)	0.00822	-0.00599	0.02242	-0.004913	-0.02227	0.01244	-1.52e-03	-1.67e-02	0.01363
	Intercept (PO[3]) ~ Slope (Temperament)	-0.01369	-0.03830	0.01091	0.003641	-0.02645	0.03374	-1.05e-02	-3.67e-02	0.01560
	Intercept (Temperament) ~ Slope (IO[2])	-0.04912	-0.07024	-0.02799	0.008398	-0.01197	0.02877	-2.85e-03	-1.70e-02	0.01131
	Intercept (Temperament) ~ Slope (PO[3])	0.03575	0.00740	0.06410	0.015748	-0.01326	0.04476	-1.08e-03	-2.11e-02	0.01893
Parallel association	Slope (IO[2]) ~ Slope (Temperament)	0.00922	0.00346	0.01498	-0.003913	-0.01074	0.00292	8.43e-04	-5.09e-03	0.00677
	Slope (PO[3]) ~ Slope (Temperament)	-0.00227	-0.01016	0.00561	0.000649	-0.00902	0.01032	1.06e-02	2.02e-03	0.01909
Chi-square		70.95816	0.03370		58.911064	0.20857		1.13e+02	1.31e-06	
CFI		0.98233			0.991237			9.26e-01		
RMSEA		0.04977			0.031533			8.70e-02		

[1]CI = Confidence Interval, [2]IO = Infant-oriented beliefs, [3]PO = Parent-oriented beliefs

3 Discussion

The present study adopted a longitudinal research design to examine whether maternal beliefs about infant crying change within individuals. To the best of our knowledge, the present study is the first to show longitudinal associations between maternal beliefs on infant crying and infant temperament development. The results showed that maternal parent-oriented beliefs about infant crying increased intra-individually. In addition, substantial individual differences were found in the growth processes of parent-oriented beliefs. Furthermore, in terms of the parallel relationship with infant temperament development, mothers of children with higher surgency, which reflects greater responsiveness and activity

level to external stimuli, were more likely to have decreased infant-oriented beliefs and increased parent-oriented beliefs. There was no association between other temperaments and maternal beliefs. These results suggest an overall pattern of increasing parent-oriented beliefs and that infant temperament characteristics accelerate or decelerate this growth changes in maternal beliefs.

The cross-sectional analysis revealed a positive association between infant age and infant-oriented beliefs and a negative association between infant-oriented beliefs and parent-oriented beliefs only in Wave 1 (0-4 months). This result appears to be consistent with the results of a previous study, which found that immediately after birth, infants cry indiscriminately as a physiological reflex, but gradually crying becomes a means of social communication and a caregiver-oriented signal (Bell & Ainsworth, 1972). In the early stages, first-time mothers respond in a trial-and-error fashion regardless of the type of crying, but they gradually start identifying what each type of crying implies and take individualized action for each situation by 16 weeks (Drummond et al., 1993). Parsons showed that the functional brain activity in the amygdala and orbitofrontal cortex to infant crying is correlated with infant's monthly age in a cross-sectional research (Parsons et al., 2017). These areas are involved in empathy, reward processing, and the core network of reflective caregiving. It is possible that mothers increase their infant-oriented beliefs as they get better at understanding the reasons and the infant's emotions behind each type of crying during the 0-4 month period. However, no cross-sectional association between infant age and maternal beliefs about crying was found at later time points. Immediately after birth, the infant is vulnerable and crying is a signal function (Soltis, 2004). At which time it is considered adaptive for infant survival to empathize and respond immediately to crying. According to attachment theory, postpartum mothers are rewarded by the infant's cries and are immediately motivated to approach and make physical contact with them (Bowlby, 1969). Winnicott described this phenomenon as an "almost illness" and argued for the necessity of gradual separation of mother and child (Winnicott, 1956). Recent studies have reported that mothers may be able to partially judge the urgency of crying (Kurth et al., 2014) and that mothers may ignore crying out more frequently with their experience (Bilgin & Wolke, 2020).

The present study showed a gradual increase in parent-oriented beliefs in the longitudinal analysis, which may reflect a gradual shift in focus from infant crying to the self and withdraw from always being preoccupied with the infant (Winnicott, 1956). The discrepancy between the results of the cross-sectional data analysis and the longitudinal data analysis can be attributed to the dynamic developmental changes that are not captured by the cross-sectional study design (Kraemer, Yesavage, Taylor, & Kupfer, 2000; Murayama, 2012). Although many studies have argued in favor of the importance of sensitive parenting to crying infants and have developed interventions to enhance it (e.g., Bell & Ainsworth, 1972; Hepworth et al., 2020), the sensitive response of mothers may not always be beneficial, and depends on the mother-child relationship and the age of the infant. In the future, it will be useful for both general and clinical research to examine what the desired response to crying is for both mothers and children through a more long-term and comprehensive study design.

The results of the univariate LGM showed substantial individual differences in growth patterns in parent-oriented beliefs. The results of the multivariate LGM revealed that infant surgency explained some of this.

Mothers of infants with higher surgency in Wave 1 were more likely to decline subsequent infant-oriented beliefs, while parent-oriented beliefs increased. The current results are consistent with a previous study that found that mothers engage in caregiving behaviors less when infant temperament is high in surgency (Planalp et al., 2013). Surgency is a superordinate factor of the infant temperament approach, which is characterized by sensation seeking, high activity level, impulsivity, and positive emotionality. Mothers of infants with high activity tracked their infant's location more closely (Kochanska & Aksan, 2004), which may reflect that those mothers need to observe their child more and tend to engage in proactive control. Infants high on surgency are more challenging to control, and children with high surgency are at higher risk for developmental problems such as externalizing problems, for example, aggression, conduct disorders, and ADHD (Putnam, 2012). Besides, the acoustic characteristics of crying and infants' temperament have been examined in previous studies, and the cries of infants with high surgency are higher in the fundamental frequency than those infants who are low on surgency (Huffman et al., 1994). An increase in fundamental frequency was associated with more harsh maternal responses (Out, Pieper, Bakermans-Kranenburg, Zeskind, & Ijzendoorn, 2010). Daily maternal experience of mothers who have infants that cry with high fundamental frequencies might decrease the caregiving and empathic response to crying, and may increase avoidant feelings. As mentioned above, while infants high on surgency are at a higher risk for externalizing problems, children of caregivers with high parent-oriented beliefs are also more likely to manifest externalizing problems after six months (Haltigan et al., 2012). The current results suggest that a high level of surgency may lead to more parent-oriented beliefs and change parenting behaviors, which may lead to conduct problems in children in the long-term. Although the present study did not find an effect of maternal beliefs about crying on children's temperamental change, but there may be socio-psychological affects in the longer term, and thus, bidirectional association should be explored in the future.

3.1 Limitation and future research

The present study adopted a robust longitudinal methodology and statistical modeling to examine the bidirectional intra-and inter-individual changes in mothers and infants. However, the following limitations exist and should be addressed in future research. First, the present study focused on subjective maternal beliefs about infant crying, and objective measures for mothers and infants were not obtained. As previously mentioned, this scale measures the sensitivities observed in mother-infant interactions, infant's development in social behavior, individual differences in maternal insecure attachment, and depression that leads to individual differences in parenting (Haltigan et al., 2012; Leerkes, Parade, & Burney, 2010; Leerkes, Parade, & Gudmundson, 2011; Pruitt et al., 2020). Additionally, the mother's perception of crying —rather than observable factors of crying such as frequency of crying—may be more closely related to caregiver stress (Leerkes et al., 2015). Although the present study was not designed to examine parenting behavior itself or frequency of infant crying, future research should include observable objective factors of crying to comprehensively examine the relationship between the observed parenting behavior, frequency of crying, mother's perception of infant crying, and developmental changes by using voice-activated digital recording devices or video-recording (Cabana et al., 2021). Second, in the present study,

the mothers' temperamental differences were not included in the measure. Since 20-60% of the temperament is inherited (Saudino, 2005), maternal individual variation in temperament may influence both changes in infant temperament and maternal beliefs about infant crying. Recently, a framework called a genetically informed design has been proposed (Taraban & Shaw, 2018), in which a common genetic background between mother and child determines both the infant's temperament and parenting behavior; for example, a dopamine receptor gene polymorphism (DRD4) is involved in the development of the infant's temperament (Holmboe, Nemoda, Fearon, Sasvari-Szekely, & Johnson, 2011), but it also affects both the infant-oriented beliefs and parent-oriented beliefs of ICQ (Leerkes et al., 2017). In other words, it should be noted that the similarity of genetic background and temperament between parents and their children may determine the bi-directionality of postpartum mother and infant development. Therefore, future studies should include both maternal and child genetic polymorphisms and temperament, to get a comprehensive understanding of the directionality of the association.

Declarations

Data availability

The data, codes and Rmarkdown files are available on the FigShare (https://figshare.com/s/d8df679d9651edce7bda). This view-only link will be replaced by the DOI once this manuscript has been accepted.

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Additional information

The authors declare no competing interests.

References

Barrett, J., & Fleming, A. S. (2011). Annual research review: All mothers are not created equal: Neural and psychobiological perspectives on mothering and the importance of individual differences. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *52*(4), 368–397. https://doi.org/10.1111/j.1469-7610.2010.02306.x (Original work published)

Bell, S. M., & Ainsworth, M. D. (1972). Infant crying and maternal responsiveness. *Child Development*, *43*(4), 1171–1190. (Original work published)

Belsky, J. (1984). The determinants of parenting: A process model. *Child Development*, *55*(1), 83–96. https://doi.org/10.1111/j.1467-8624.1984.tb00275.x (Original work published)

Belsky, J., Fish, M., & Isabella, R. A. (1991). Continuity and discontinuity in infant negative and positive emotionality: Family antecedents and attachment consequences. *Developmental Psychology*, *27*(3), 421–431. https://doi.org/10.1037/0012-1649.27.3.421 (Original work published)

Bilgin, A., & Wolke, D. (2020). Parental use of 'cry it out' in infants: No adverse effects on attachment and behavioural development at 18 months. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *61*(11), 1184–1193. https://doi.org/10.1111/jcpp.13223 (Original work published)

Bowlby, J. (1969). *ATTACHMENT AND LOSS*. Basic Books. (Original work published)

Braungart-Rieker, J. M., Hill-Soderlund, A. L., & Karrass, J. (2010). Fear and anger reactivity trajectories from 4 to 16 months: The roles of temperament, regulation, and maternal sensitivity. *Developmental Psychology*, *46*(4), 791–804. https://doi.org/10.1037/a0019673 (Original work published)

Cabana, M. D., Wright, P., Scozzafava, I., Olarte, A., DiSabella, M., Liu, X., & Gelfand, A. A. (2021). Newborn daily crying time duration. *Journal of Pediatric Nursing*, *56*, 35–37. https://doi.org/10.1016/j.pedn.2020.10.003 (Original work published)

Crockenberg, S., & Leerkes, E. (2003). Infant negative emotionality, caregiving, and family relationships. In A. C. Crouter (Ed.), *Children's influence on family dynamics: The neglected side of family relationships , (pp* (Vol. 269, pp. 57–78). Lawrence Erlbaum Associates Publishers, x: Mahwah, NJ, US. (Original work published)

Drummond, J. E., McBride, M. L., & Wiebe, C. F. (1993). The development of mothers' understanding of infant crying. *Clinical Nursing Research*, *2*(4), 396–410; discussion 411–413. https://doi.org/10.1177/105477389300200403 (Original work published)

Ehret, G., Koch, M., Haack, B., & Markl, H. (1987). Sex and parental experience determine the onset of an instinctive behavior in mice. *Die Naturwissenschaften*, *74*(1), 47. https://doi.org/10.1007/BF00367047 (Original work published)

Gauvain, M., & Fagot, B. (1995). Child temperament as a mediator of mother-toddler problem solving. *Social Development*, *4*(3), 257–276. https://doi.org/10.1111/j.1467-9507.1995.tb00065.x (Original work published)

Haltigan, J. D., Leerkes, E. M., Burney, R. V., O'Brien, M., Supple, A. J., & Calkins, S. D. (2012). The infant crying questionnaire: Initial factor structure and validation. *Infant Behavior & Development*, *35*(4), 876–883. https://doi.org/10.1016/j.infbeh.2012.06.001 (Original work published)

Hamilton, J., Gagne, P. E., & Hancock, G. R. (2003). The effect of sample size on latent growth models. *Annual meeting of the american educational research association*, 23. Chicago, IL, USA. (Original work published)

Hepworth, A. D., Berlin, L. J., Salas, K., Pardue-Kim, M., Martoccio, T. L., & Jones Harden, B. (2020). Increasing maternal sensitivity to infant distress through attachment-based intervention: A randomized controlled trial. *Attachment & Human Development*, 1–16. https://doi.org/10.1080/14616734.2020.1834592 (Original work published)

Holmboe, K., Nemoda, Z., Fearon, R. M. P., Sasvari-Szekely, M., & Johnson, M. H. (2011). Dopamine D4 receptor and serotonin transporter gene effects on the longitudinal development of infant temperament. *Genes, Brain, and Behavior*, *10*(5), 513–522. https://doi.org/10.1111/j.1601-183X.2010.00669.x (Original work published)

Hubbard, F. O. A., & Ijzendoorn, M. H. van. (1991). Maternal unresponsiveness and infant crying across the first 9 months: A naturalistic longitudinal study. *Infant Behavior & Development*, *14*(3), 299–312. https://doi.org/10.1016/0163-6383(91)90024-m (Original work published)

Huffman, L. C., Bryan, Y. E., Pedersen, F. A., Lester, B. M., Newman, J. D., & Carmen, R. del. (1994). Infant cry acoustics and maternal ratings of temperament. https://doi.org/10.1016/0163-6383(94)90021-3 (Original work published)

Kim, P., Leckman, J. F., Mayes, L. C., Feldman, R., Wang, X., & Swain, J. E. (2010). The plasticity of human maternal brain: Longitudinal changes in brain anatomy during the early postpartum period. *Behavioral Neuroscience*, *124*(5), 695–700. https://doi.org/10.1037/a0020884 (Original work published)

Kochanska, G., & Aksan, N. (2004). Development of mutual responsiveness between parents and their young children. *Child Development*, *75*(6), 1657–1676. https://doi.org/10.1111/j.1467-8624.2004.00808.x (Original work published)

Kraemer, H. C., Yesavage, J. A., Taylor, J. L., & Kupfer, D. (2000). How can we learn about developmental processes from cross-sectional studies, or can we? *The American Journal of Psychiatry*, *157*(2), 163–171. https://doi.org/10.1176/appi.ajp.157.2.163 (Original work published)

Kurth, E., Kennedy, H. P., Zemp Stutz, E., Kesselring, A., Fornaro, I., & Spichiger, E. (2014). Responding to a crying infant - you do not learn it overnight: A phenomenological study. *Midwifery*, *30*(6), 742–749. https://doi.org/10.1016/j.midw.2013.06.017 (Original work published)

Leerkes, E. M., Parade, S. H., & Burney, R. V. (2010). Origins of mothers' and fathers' beliefs about infant crying. *Journal of Applied Developmental Psychology*, *31*(6), 467–474. https://doi.org/10.1016/j.appdev.2010.09.003 (Original work published)

Leerkes, E. M., Parade, S. H., & Gudmundson, J. A. (2011). Mothers' emotional reactions to crying pose risk for subsequent attachment insecurity. *Journal of Family Psychology: JFP: Journal of the Division of Family Psychology of the American Psychological Association*, *25*(5), 635–643. https://doi.org/10.1037/a0023654 (Original work published)

Leerkes, E. M., Su, J., Calkins, S., Henrich, V. C., & Smolen, A. (2017). Variation in mothers' arginine vasopressin receptor 1a and dopamine receptor D4 genes predicts maternal sensitivity via social cognition. *Genes, Brain, and Behavior*, *16*(2), 233–240. https://doi.org/10.1111/gbb.12326 (Original work published)

Leerkes, E. M., Supple, A. J., O'Brien, M., Calkins, S. D., Haltigan, J. D., Wong, M. S., & Fortuna, K. (2015). Antecedents of maternal sensitivity during distressing tasks: Integrating attachment, social information processing, and psychobiological perspectives. *Child Development*, *86*(1), 94–111. https://doi.org/10.1111/cdev.12288 (Original work published)

McElwain, N. L., & Booth-Laforce, C. (2006). Maternal sensitivity to infant distress and nondistress as predictors of infant-mother attachment security. *Journal of Family Psychology: JFP: Journal of the Division of Family Psychology of the American Psychological Association*, *20*(2), 247–255. https://doi.org/10.1037/0893-3200.20.2.247 (Original work published)

Murayama, K. (2012). Validity : Historical and psychometric perspectives. *The Annual Report of Educational Psychology in Japan*, *51*, 118–130. https://doi.org/10.5926/arepj.51.118 (Original work published)

Nakagawa, A., Kimura, Y., & Sukigara, M. (2009). Development of short form of the japanese infant behavior Questionnaire-Revised. *Studies in Humanities and Cultures*, *12*, 15–25. (Original work published)

Nakayama, H. (2010). Development of infant crying behavior: A longitudinal case study. *Infant Behavior & Development*, *33*(4), 463–471. https://doi.org/10.1016/j.infbeh.2010.05.002 (Original work published)

Out, D., Pieper, S., Bakermans-Kranenburg, M. J., Zeskind, P. S., & Ijzendoorn, M. H. van. (2010). Intended sensitive and harsh caregiving responses to infant crying: The role of cry pitch and perceived urgency in an adult twin sample. *Child Abuse & Neglect*, *34*(11), 863–873. https://doi.org/10.1016/j.chiabu.2010.05.003 (Original work published)

Parsons, C. E., Young, K. S., Petersen, M. V., Jegindoe Elmholdt, E.-M., Vuust, P., Stein, A., & Kringelbach, M. L. (2017). Duration of motherhood has incremental effects on mothers' neural processing of infant vocal cues: A neuroimaging study of women. *Scientific Reports*, *7*(1), 1727. https://doi.org/10.1038/s41598-017-01776-3 (Original work published)

Planalp, E. M., Braungart-Rieker, J. M., Lickenbrock, D. M., & Zentall, S. R. (2013). Trajectories of parenting during infancy: The role of infant temperament and marital adjustment for mothers and fathers. *Infancy: The Official Journal of the International Society on Infant Studies*, *18*, E16–E45. https://doi.org/10.1111/infa.12021 (Original work published)

Pruitt, M. M., McKay, E. R., Lelakowska, G., & Ekas, N. V. (2020). The infant simulator paradigm with Non-Parents: Attitudes, physiology, and observed caregiving. *Journal of Child and Family Studies*, *29*(9), 2515–2529. https://doi.org/10.1007/s10826-019-01643-x (Original work published)

Putnam, S. P. (2012). Positive emotionality. In M. Zentner (Ed.), *Handbook of temperament , (pp* (Vol. 750, pp. 105–123). New York, NY, US: The Guilford Press, xvii. (Original work published)

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. (Original work published)

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. (Original work published)

Rothbart, M. K. (2012). Advances in temperament. *Handbook of Temperament*, 3–20. (Original work published)

Saudino, K. J. (2005). Behavioral genetics and child temperament. *Journal of Developmental and Behavioral Pediatrics: JDBP*, *26*(3), 214–223. https://doi.org/10.1097/00004703-200506000-00010 (Original work published)

Scaramella, L. V., Sohr-Preston, S. L., Mirabile, S. P., Robison, S. D., & Callahan, K. L. (2008). Parenting and children's distress reactivity during toddlerhood: An examination of direction of effects. *Social Development*, *17*(3), 578–595. https://doi.org/10.1111/j.1467-9507.2007.00439.x (Original work published)

Seifritz, E., Esposito, F., Neuhoff, J. G., Lüthi, A., Mustovic, H., Dammann, G., … Di Salle, F. (2003). Differential sex-independent amygdala response to infant crying and laughing in parents versus nonparents. *Biological Psychiatry*, *54*(12), 1367–1375. https://doi.org/10.1016/s0006-3223(03)00697-8 (Original work published)

Soltis, J. (2004). The signal functions of early infant crying. *The Behavioral and Brain Sciences*, *27*(4), 443–58; discussion 459–490. https://doi.org/10.1017/S0140525X0400010X (Original work published)

Taraban, L., & Shaw, D. S. (2018). Parenting in context: Revisiting belsky's classic process of parenting model in early childhood. *Developmental Review: DR*, *48*, 55–81. https://doi.org/10.1016/j.dr.2018.03.006 (Original work published)

Thompson-Booth, C., Viding, E., Mayes, L. C., Rutherford, H. J. V., Hodsoll, S., & McCrory, E. (2014a). I can't take my eyes off of you: Attentional allocation to infant, child, adolescent and adult faces in mothers and non-mothers. *PloS One*, *9*(10), e109362. https://doi.org/10.1371/journal.pone.0109362 (Original work published)

Thompson-Booth, C., Viding, E., Mayes, L. C., Rutherford, H. J. V., Hodsoll, S., & McCrory, E. J. (2014b). Here's looking at you, kid: Attention to infant emotional faces in mothers and non-mothers. *Developmental Science*, *17*(1), 35–46. https://doi.org/10.1111/desc.12090 (Original work published)

Winnicott, D. W. (1956). Primary maternal preoccupation. In P. Mariotti (Ed.), *The maternal lineage: Identification, desire, and transgenerational issues* (pp. 59–66). (Original work published)

Witteman, J., Van IJzendoorn, M. H., Rilling, J. K., Bos, P. A., Schiller, N. O., & Bakermans-Kranenburg, M. J. (2019). Towards a neural model of infant cry perception. *Neuroscience and Biobehavioral Reviews*, *99*, 23–32. https://doi.org/10.1016/j.neubiorev.2019.01.026 (Original work published)

Figures

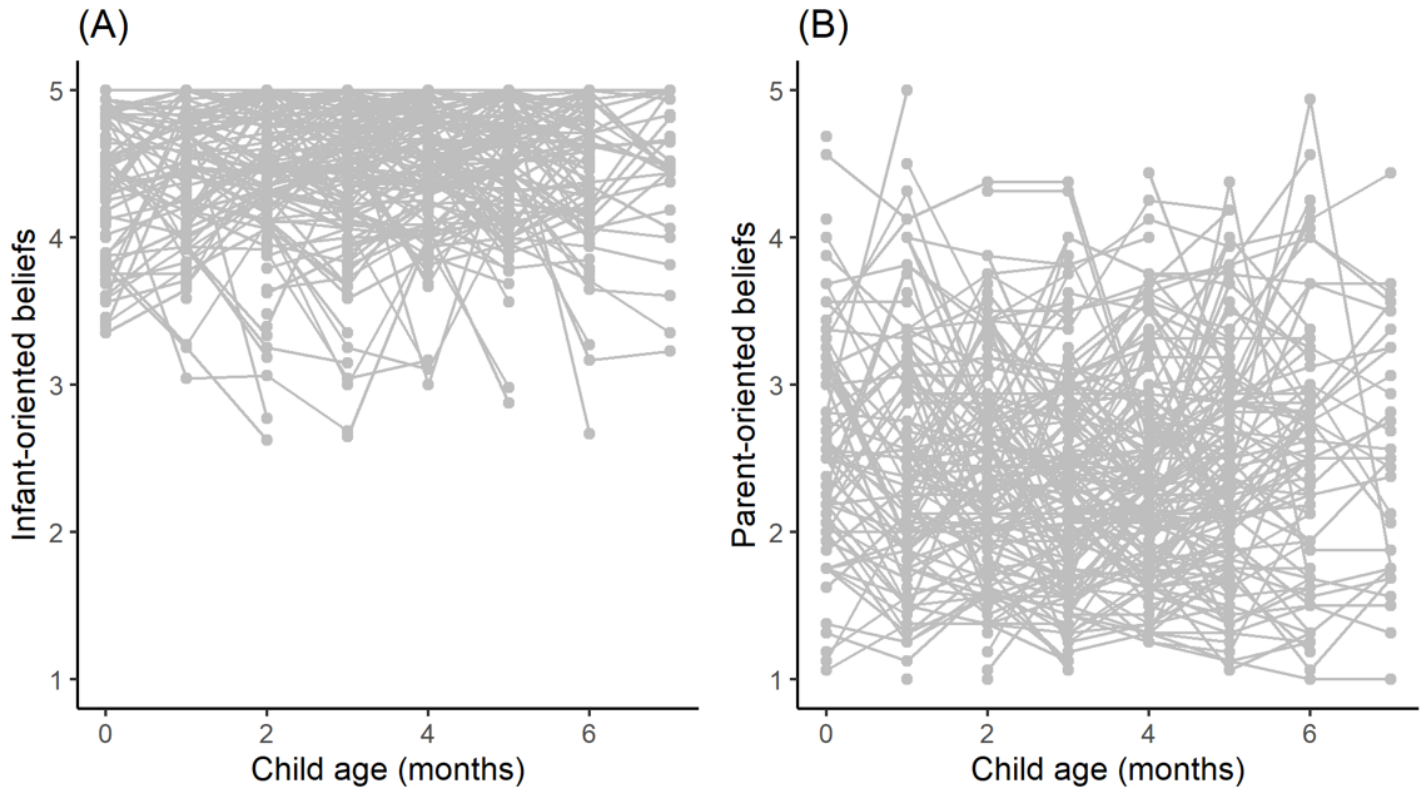

Figure 1

Score of (A) Infant-oriented beliefs and (B) Parent-oriented beliefs at each the child's age. The same participants were connected by line segments.

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