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Development of a scale for parent-to-baby emotions: Concepts, design, and factor structure

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Abstract

Aim: Although infant crying is a prerequisite for a baby's survival, it often leads to negative consequences for the caregivers. We hypothesized that this would be mediated by a primary emotion that we feel directly in response to an internal or external event. Hence, this study aimed to develop a new scale to measure basic and self-conscious emotions as primary emotions towards an infant's cry.

Methods: We conducted a cross-sectional web survey including the scale for parent-to-baby emotions (SPBE)—with 73 items elicited from a literature review—targeted at mothers at 1 month after childbirth (N = 879). A series of explanatory and confirmatory factor analyses were conducted using item parcels. Internal consistency of the scale was calculated by omega indices. We also examined measurement invariance of the scale.

Results: The theory-driven six basic emotions bifactor model (comparative fit index [CFI] = 0.968, root mean square of error approximation [RMSEA] = 0.070) and four self-conscious emotions factor model (CFI = 0.973, RMSEA = 0.079) were judged as the best models. They were stable in terms of configural, measurement, and structural invariances across parity.

Conclusion: The SPBE we created is a psychometrically robust measure to assess the primary emotions under the rubric of parent-to-baby emotions. It is a promising tool for measuring parent-to-baby emotions in clinical and research settings.

KEYWORDS

basic emotions, differences between nulliparas and multiparas, infant crying, infant gender, measurement and structural invariance, self-conscious emotions

INTRODUCTION

The caregiver's immediate emotional reaction to the infant crying may be an extremely important candidate as a mediator of baby cry on the maternal psychological maladjustment. Parental emotional reaction to the own baby cry is often represented as basic emotions and self-conscious emotions. It is feasible to assess parent-to-baby emotions in terms of basic emotions and self-conscious emotions.[1]

Seven characteristics of emotions have been described: (a) automatic appraisal, (b) commonalities in antecedent events, (c) presence in other primates, (d) quick onset, (e) brief duration, (f) unbidden occurrence, and (g) distinctive physiology.[2] These characteristics are appropriate to the caregiver's reaction to the infant crying. They include happiness (joy), anger, fear, sadness, disgust, and surprise. Whereas basic emotions are biological, self-conscious emotions are more reflective of internal self. Self-conscious emotions differ from basic emotions because they require self-awareness and self-representations.[3] Psychologists (e.g., Freud) have speculated about the linkage between psychopathology and shame and guilt, in which the latter two have the role of super-ego functions.[4] A growing theoretical and empirical literature has indicated importance of differentiation of shame and guilt in the phenomenology.[5–12] Pride contains two distinct dimensions (alpha pride and beta pride) characterized by distinctive ways of appraising the causes of accomplishments.[3,6,13,14] These self-conscious emotions motivate action towards the goals in embodied self-representations.[3,13] Own baby cry could stimulate the individuals to compare self-representations (e.g., "I want to be a smiling mother all the time") with external emotion-eliciting events (e.g., "My baby never stops crying"). The self-conscious emotions are evoked in parent's mind when their baby cries. Hence, we developed a new emotion scale towards infant crying constructed based on the basic emotion and self-conscious emotion theories to measure these emotional statuses. These different types of positive and negative emotions should be assessed in the same manner.

A statistically robust scale is necessary for assessing differences between groups derived from different backgrounds in the same manner. For example, we could not compare the mean values of the total score of the scale between first-time mothers and mothers with one child or more if the factor structure of the scale were not the same. Such a comparison would not make sense. For the purpose of comparison between groups of individuals with regard to their level on a trait, or to investigate whether trait-level scores should be differentiated correlates across groups, one must assume that the numerical values under consideration are on the same measurement scale.[15–18] Hence, measurement tools are required to examine the invariance including configural, measurement, and constructual invariance.

In the current study, our goal was to develop a robust scale that has measurement invariance for use with parents of infants, hoping that it would be useful in clinical and research situations. In the process of development of our new scale, we followed the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) study design checklist.[19] COSMIN was developed to evaluate the methodological quality of a study by measurement properties.[20,21]

METHODS

Study procedures and participants

The target of this cross-sectional study was mothers at 1 month after childbirth. The data used in the present study came from two web surveys via SurveyMonkey and Rakuten Insight. For the first data set, we used the web survey system SurveyMonkey, where we created the questionnaire. We distributed flyers calling for participation which included the QR code and the weblink for the SurveyMonkey website. This was done at outpatient services when mothers came for a 1-month check-up after childbirth. We distributed the flyers to approximately 4500 mothers and 679 mothers participated in our survey via SurveyMonkey. Our inclusion criteria were mothers who (a) lived with a 1-month old, (b) lived in Japan, and (c) stated that Japanese was their native language. Our exclusion criterion was cases of multiple births. For the second data set, with the cooperation of Rakuten Insight Inc., mothers at 1 month after childbirth were recruited from 47 prefectures in Japan. A total of 200 mothers participated in the Rakuten Insight survey. Rakuten Insight has a proprietary panel. We used the panel of parents with a child/children, named "the parent and child panel." All respondents provided personal information (e.g., date of birth, residence, gender, family, and occupation) when they created account as a respondent panel. Researchers were not able to know personal information except the member's age, residence area, and gender. All respondents were allocated an original ID number that researchers used for personal identification. Rakuten Insight set up the same questionnaire as that used in the first survey. Rakuten Insight sent a notification e-mail about the present survey with a URL to the parent and child panel members. Three screening questions identified the respondents who were eligible for the study. The two groups differed in none of the variables used in the present analyses except for a few points. Thus, as compared with the second group, the first group of women were significantly ($P < 0.001$ for multiple comparison) but slightly older while the mean age of the partner did not differ. The first group of women had a younger infant (39.2 [SD 1.2] days vs. 46.0 [9.3] days).

The questionnaire was preceded by an information page, with the aims of this research and affiliations of the study explained and information about ethical considerations. The questionnaire consisted of demographic variables and the measurement we created for this study (see below).

A total of 879 mothers participated in our study. Table 1 presents the demographic data of the sample. Their mean (SD) age was 33.4 (4.6) years old. Among them, 426 (51.3%) were nulliparae and 404 (48.9%) were multiparae. The parity of 49 women was not known. The gender ratio of infants was even: 406 (48.9%) boys and 421 (50.7%) girls. The gender of 52 babies was not known. The SurveyMonkey web page was open from November 5, 2018 to September 30, 2019, and the Rakuten Insight web page was available from June 28 to July 1, 2019.

Measurements

The first part of this study was the construction of a new scale of mother's emotions towards the infant's cry based on the theories of basic and self-conscious emotions. First, scale items were elicited from qualitative studies on the mother's responses towards infants crying. We browsed the Japanese literature on this topic via Igaku Chuo Zasshi (Ichushi). Ichushi is bibliographic database that was established in 1903 and is being updated by the Japan Medical Abstracts Society (JAMAS), a nonprofit and nongovernmental organization. We identified six references[22–27] that described emotion words related to a mother's response towards infant crying. Next, items which were

TABLE 1 The demographic data of the sample

	Mean (SD)
Mother's age	33.4 (4.6) years old
Partner's age	35.4 (4.7) years old
Infant's age	40.1 (10.3) days
Infant's gestational age	39.0 (1.3) weeks
Infants' mean weight	3066 (408) g
	Frequency (%)
Parity	
Nulliparae	426 (48.5)
Multiparae	404 (46.0)
Not known	49 (5.5)
Gender of infants	
Boys	406 (46.1)
Girls	421 (47.9)
Not known	52 (6.0)
Mode of delivery	
Vaginally	614 (69.9)
Obstetrical anaesthesia	90 (10.2)
Caesarean section	157 (17.9)
Planned Caesarean section	94 (10.7)
Emergency Caesarean section	63 (7.2)
Not known	18 (2.0)

expected to reflect emotion words on the basis of theories of basic and self-conscious emotions were elicited from the following existing scales to measure emotions in general: PANNAS,[28] the Multiple Mood Scale,[29] the Japanese version of State-Trait Anger Expression Scale,[30] and the Japanese version[31] of Test of Self-Conscious Affect, Version 3.[32] These were then classified into emotion categories based on the concepts of basic (i.e., happiness, anger, fear, sadness, disgust, and surprise) and self-conscious (i.e., shame, guilt, and alpha and beta pride) emotions. These emotion words and items were adjusted into items which were described with brief sentences. We intended to have five or more items for each emotion category, taking into consideration that some of them might be deleted during analysis. Where the number of items was insufficient, we added ad hoc items which are consistent with concepts of the emotion category. This process was conducted through discussion with master course colleagues as well as the authors (M.I., Professor of Global Health Care and Midwifery Graduate School of Nursing, and T.K., FRCPsych). Finally, all 73 items were listed and presented randomly in the scale. Our new instrument, the Scale for Parent-to-Baby Emotions (SPBE), consists of 73 items with a five-point scale from 1 (did not feel at all) to 5 (felt extremely strongly). These items were presented with the direction "How strongly did you feel these emotions when your baby cried the most recently?"

Data analysis

We used a sample which had no missing cases for the SPBE ($N = 831$). To start, we examined the skewness and kurtosis of each item to confirm a normal distribution of the item. We then conducted item parcelling as a stratagem because of a fairly large number of questionnaire items. Item parcelling is a method of aggregating individual items into one or more item parcels, which has several merits. First, item parcelling can make clearer and more comprehensible representations of even multidimensional constructs[33] and greatly help to eliminate theoretically unimportant noises.[34] Second, parcelled indicators could be more normally distributed than using individual items,[35] therefore model fit would be improved by using parceled indicators rather than individual items. Each item must be unidimensional to be allocated to an item parcel.[33–36] Hence, before item parcelling, we calculated the Cronbach's α[37] coefficient and inter-item correlations for each emotion subscale separately. Although different parcel-forming algorithms exist, there is no standard algorithm to allocate items. Among methods of producing item parcels,[34] we applied the factorial algorithm. In this algorithm, first a factor analysis with a single-factor model must be performed on the scale and item parcels built in accordance with a guide which are computed factor loadings. The highest factor-loading item and the lowest factor-loading item are combined and allocated to each item parcel sequentially. Because three item parcels are recommended as the number of item parcels allocated for one subscale,[34,35] we created 18 and 12 parcels for the basic and self-conscious emotions subscales, respectively.

On the premise that human emotion has two dimensions (i.e., basic and self-conscious), we conducted exploratory factor analyses (EFAs) and confirmatory factor analyses (CFAs) on the two dimensions of human emotion separately. We divided the whole sample ($N = 831$) randomly into two groups: one ($n = 417$) for EFAs and another ($n = 414$) for CFAs. Within the group for EFAs, we examined the Kaiser–Meyer–Olkin (KMO) index and Bartlett's sphericity test to confirm the factorability of the data. The skewness, kurtosis, and communalities of all item parcels were also examined. We next performed a series of EFAs with PROMAX rotation by the maximum-likelihood method from a single-factor structure and subsequently models with an increasingly greater number of factors (i.e., two- and three-factor structures, and so on).

Next, we compared the goodness-of-fit of these models in a series of CFAs with maximum likelihood mean (MLM) adjusted using the second sample. This was the cross-validation of the models derived from EFAs. We also added theory-driven models (i.e., six basic emotion subscales and four self-conscious emotion subscales). If necessary, bifactor models were also built and examined. A bifactor model has a structure where the general factors and several specific (group) factors are nested[38–40] The fit of models with the data was examined in terms of χ^2 the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). According to conventional criteria, a good fit would be indicated by χ^2/degree of freedom (df) <2, CFI > 0.97, and RMSEA < 0.05, and an acceptable fit by $\chi^2/df < 3$, CFI > 0.95, and RMSEA < 0.08.[41,42] We also used the Akaike information criterion (AIC),[43] where a lower AIC was judged as being better. Starting from the single-factor model, the subsequent model was judged better only if its χ^2 value (for the *df* difference) was significantly lower than that for the former model.

As discussed later, the present study showed that, among basic emotions, a bifactor model fitted the data best. We then examined whether group factors were so negligible that the model was sufficiently unidimensional. To this end, we used a group of ω coefficients. First, ω indicates the proportion of variance of the whole measurement explained by the general factor and all group factors. Second, ω_S indicates the proportion of the variance among items of each specific group factor explained by both the general and group factors. The percentage of the variance of the whole measurement explained by the general factor and all the group factors explained only by the general factor is termed omega hierarchical: ω_H. Similarly, the omega hierarchical subscale (ω_{HS}) indicates the percentage of the variance among items of each specific group factor explained by the group factor. Hence, the higher the ω_H, the more suggestive of unidimensionality.[18,44] Unidimensionality was also indicated by explained common variance (ECV) >0.8.[44,45]

After identifying the best fit model, we examined its measurement invariance across groups with different demographic features: nulliparae versus multiparae (parity) and mothers of boys versus girls (gender of the baby). We selected these two demographic features as point of measurement invariance for a few reasons. It is widely recognized that nulliparous and multiparous women differ in many psychological elements. Difference of the mothers' perception of the baby's gender may exist. For example, Japanese mothers prefer girls to boys,[46] thus gender preference may elicit different emotional reactions. The measurement invariance test was conducted in accordance with the recommendation by Vandenberg and Lance.[47] In this recommendation, we confirmed that the groups did not differ in terms of (a) configural invariance (each group had the same pattern of indicators and factors), (b) metric invariance, also known as weak factorial invariance (factor loadings for similar indicators were invariant across groups), (c) scalar invariance, also known as strong factorial invariance (intercepts of similar items were invariant across groups), (d) residual invariance, also known as strict factorial invariance (residuals of similar items were invariant across groups), (e) factor variance invariance (variances of similar factors were invariant across groups), (f) factor covariance invariance (covariances between factors were invariant across groups), and (g) factor mean invariance (means of factors were invariant across groups). We proceeded with tests for invariance step by step as we confirmed (a) a nonsignificant increase of χ^2 for *df* of difference, (b) a decrease of CFI less than 0.01, or (c) an increase of RMSEA < 0.01.[48,49]

RESULTS

Item parceling

The skewness and kurtosis of all the scale items are shown in Supporting information Tables 1 and 2. A few items (43SH, 19FE, 46SH, and 33DI) showed extremely high kurtosis. Among the whole sample, items of each subscale were characterized by excellent internal consistency with a Cronbach's α coefficient of more than 0.8 (Supporting Information Tables 1 and 2) as well as good interitem correlations (Supporting Information Tables 3–12). Items of each subscale were subjected to single-factor EFAs to show good communality and factor loading with 0.32 or higher[50] (Supporting Information Tables 13 and 14). These findings suggested that items for each subscale were unidimensional. Hence, these findings support our procedure of item parceling.

All of the 18 parcels for basic emotions and 12 parcels for self-conscious emotions showed excellent skewness and kurtosis (Table 2). Only two parcels (AN1 and FE1) showed skewness > 2.0 and kurtosis > 4.[51]

EFA

We performed EFAs for basic and self-conscious emotion parcels separately. We started from a single-factor model and gradually increased the number of factors. For the basic emotion parcels, the three-factor model showed that parcels of anger, sadness, and disgust loaded on the first factor whereas those of fear and surprise loaded on the second factor, and those of happiness loaded on the final factor (Table 3). In the four-factor model, however, no parcels loaded on the fourth factor with 0.3 or more.

For the self-conscious emotion parcels, the two-factor model matched the theoretical expectation with the shame and guilt parcels loaded on the first factor while the alpha and beta pride parcels loaded on the second factor (Table 4). Shame and guilt were not differentiated, nor were alpha and beta pride. In the three-factor model of self-conscious emotion parcels, only one parcel (BETA2) loaded highly on the third factor.

CFA

As cross-validation of the EFA-derived factor models, as well as theory-driven models of the basic and self-conscious emotion parcels, we used the second sample to perform CFAs in which different models were compared (Table 5). For the basic emotion parcels, the goodness-of-fit of the model was significantly better for the two-factor than the single-factor models. Improvement was also noted from the two-factor to the three-factor models, but the absolute value of goodness-of-fit was far below acceptable: CFI < 0.95 and RMSEA > 0.8. The theory-driven six-factor structure model, corresponding to the six basic emotions, showed a statistically significantly better fit than the three EFA-derived models. We further constructed a bifactor model that showed a better fit. Because happiness represents a positive emotion whereas the remaining five basic emotions (anger, fear, sadness, disgust, and surprise) represent negative emotions, we set a general factor influencing the five negative emotion item parcels (Figure 1). This showed an even better fit than any of the other models: CFI = 0.968, RMSEA = 0.070. The model fit using all samples (N = 831) was even better than when using second halved

TABLE 2 Parcels and items included each parcel, mean, SD, skewness, and kurtosis (sample for EFA, $n = 417$)

Subscale	Name	Item label (item no.)	Mean	SD	Skewness	Kurtosis
Parcels for basic emotions						
Happiness	HA1	04HA (E72), 02HA (E62), 05HA (E67)	7.38	2.99	0.43	−0.53
	HA2	06HA (E71), 08HA (E28), 07HA (E59)	9.56	2.74	0.11	−0.51
	HA3	03HA (E39), 01HA (E2)	5.26	1.99	0.40	−0.46
Anger	AN1	12AN (E36), 15AN (E49), 13AN (E58)	3.92	1.66	2.17	5.11
	AN2	10AN (E5), 14AN (E4)	2.94	1.29	1.21	0.35
	AN3	11AN (E40), 09AN (E15)	3.36	1.46	0.94	0.24
Fear	FE1	18FE (E31), 19FE (E55), 16FE (E6)	3.97	1.72	2.37	6.65
	FE2	22FE (E68), 21FE (E64), 20FE (E30)	5.38	2.54	0.97	0.23
	FE3	17FE (E60), 23FE (E43)	3.07	1.48	1.29	1.00
Sadness	SA1	25SA (E35), 28SA (E54)	2.77	1.27	1.86	3.65
	SA1	26SA (E34), 29SA (E10)	3.50	1.53	0.86	0.07
	SA3	24SA (E14), 27SA (E9)	3.13	1.51	1.28	0.90
Disgust	DI1	30DI (E53), 33DI (E25) 37DI (E73)	4.60	1.92	1.15	0.77
	DI2	34DI (E11), 36DI (E32), 31DI (E56)	5.04	2.29	1.04	0.34
	DI3	32DI (E12), 35DI (E50)	3.39	1.53	0.85	−0.16
Surprise	SU1	40SU (E51), 39SU (E13)	2.89	1.36	1.65	2.79
	SU2	38SU (E46), 42SU (E65)	3.24	1.57	1.03	0.02
	SU3	41SU (E44)	1.74	0.97	1.07	0.24
Parcels for self-conscious emotions						
Shame	SH1	52SH (E52), 43SH (E27), 49SH (E8), 44SH (E1)	6.12	2.41	1.24	1.28
	SH2	50SH (E24), 45SH (E21), 47SH (E33)	5.04	2.09	0.91	0.20
	SH3	51SH (E63), 46SH (E26), 48SH (E47)	4.29	1.78	1.53	2.18
Guilt	GU1	54GU (E23), 57GU (E69), 53GU (E7)	5.13	2.06	0.69	−0.20
	GU2	58GU (E48), 56GU (E61), 61GU (E19)	5.27	2.11	0.65	−0.40
	GU3	60GU (E16), 55GU (E22), 59GU (E38)	4.63	1.92	1.22	0.97
Alpha-pride	ALPHA1	63ALPHA (E70), 64ALPHA (E18)	4.63	1.99	0.51	−0.45
	ALPHA2	62ALPHA (E66), 66ALPHA (E20)	3.83	1.77	0.85	0.38
	ALPHA3	67ALPHA (E45), 65ALPHA (E29)	4.05	1.81	0.85	0.52
Beta-pride	BETA1	68BETA (E41), 69BETA (E17)	4.35	1.85	0.67	0.09
	BETA2	70BETA (E57), 73BETA (E3)	5.26	1.92	0.35	−0.37
	BETA3	71BETA (E37), 72BETA (E42)	4.43	1.90	0.54	−0.31

Note: The names of parcels and items were attributed to each emotion domain.

Abbreviations: ALPHA, alpha pride; AN, anger; BETA, beta pride; DI, disgust; EFA, exploratory factor analysis; FE, fear; GU, guilt; HA, happiness; SA, sadness; SH, shame; SU, surprise.

sample: CFI = 0.972, RMSEA = 0.066. We thought that the best fit was the modified bifactor model with the six specific factors and one general factor.

The single-factor model of self-conscious emotion parcels showed a poor fit with the data and the two-factor model was much better in terms of fit indices (Table 6). CFI and RMSEA were slightly improved by the theory-driven four-factor model, reaching an acceptable level (RMSEA = 0.079) (Table 6). A significant reduction of χ^2 was shown in the theory-driven four-factor model. In addition, the AIC of this model showed an even better fit than any other models. A bifactor model demonstrated an improper solution. Taking these findings into account, the

TABLE 3 EFA for basic emotions dimension ($n = 417$)

	Communality	One factor	Two-factor		Three-factor			Four-factor			
		I	I	II	I	II	III	I	II	III	IV
HA1	0.77	−0.15	0.13	**0.93**	0.08	0.08	**0.94**	0.06	0.05	**0.95**	0.06
HA2	0.79	−0.29	−0.01	**0.93**	−0.02	0.02	**0.93**	−0.03	−0.01	**0.94**	0.04
HA3	0.67	−0.24	0.01	**0.85**	0.03	−0.01	**0.86**	0.03	−0.01	**0.85**	−0.03
AN1	0.68	**0.75**	**0.74**	0.02	**0.89**	−0.08	0.15	**0.97**	−0.02	0.10	−0.25
AN2	0.64	**0.70**	**0.67**	−0.06	**0.85**	−0.12	0.06	**1.04**	0.04	−0.07	−0.59
AN3	0.70	**0.75**	**0.72**	−0.03	**0.91**	−0.12	0.10	**1.02**	−0.04	0.04	−0.33
FE1	0.63	**0.69**	**0.74**	0.09	0.18	**0.66**	0.01	0.22	**0.70**	−0.03	−0.13
FE2	0.75	**0.67**	**0.74**	0.13	−0.03	**0.91**	−0.01	−0.04	**0.85**	0.01	0.11
FE3	0.74	**0.73**	**0.77**	0.03	0.11	**0.78**	−0.07	0.10	**0.72**	−0.04	0.15
SA1	0.67	**0.78**	**0.77**	−0.05	**0.46**	**0.38**	−0.06	**0.44**	0.29	0.01	0.20
SA2	0.67	**0.81**	**0.78**	−0.10	**0.57**	0.28	−0.08	**0.59**	0.26	−0.06	0.01
SA3	0.63	**0.75**	**0.76**	−0.01	**0.41**	**0.42**	−0.03	**0.42**	**0.39**	−0.02	0.03
DI1	0.81	**0.88**	**0.82**	−0.13	**0.86**	0.05	−0.04	**0.87**	−0.02	0.02	0.10
DI2	0.81	**0.89**	**0.82**	−0.16	**0.87**	0.04	−0.07	**0.88**	−0.04	−0.01	0.11
DI3	0.75	**0.82**	**0.75**	−0.20	**0.87**	−0.05	−0.09	**0.87**	−0.12	−0.02	0.12
SU1	0.65	**0.57**	**0.65**	0.17	−0.06	**0.82**	0.04	−0.02	**0.88**	−0.02	−0.15
SU2	0.75	**0.62**	**0.70**	0.14	−0.13	**0.96**	−0.01	−0.12	**0.94**	−0.02	0.03
SU3	0.58	**0.48**	**0.59**	0.27	−0.14	**0.84**	0.14	−0.12	**0.85**	0.11	−0.04

Note: The names of parcels and items were attributed to each emotion domain. Factor loadings > 0.3 are in bold.

Abbreviations: AN, anger; DI, disgust; EFA, exploratory factor analysis; FE, fear; HA, happiness; SA, sadness; SU, surprise.

TABLE 4 EFA for self-conscious emotions dimension ($n = 417$)

	Communality	One-factor	Two-factor		Three-factor		
		I	I	II	I	II	III
SH1	0.66	−0.15	−0.02	**0.82**	−0.00	**0.80**	−0.19
SH2	0.74	−0.16	−0.02	**0.89**	−0.02	**0.88**	−0.10
SH3	0.64	−0.18	−0.06	**0.78**	−0.023	**0.760**	−0.29
GU1	0.67	−0.10	0.03	**0.83**	0.01	**0.84**	0.08
GU2	0.64	−0.13	−0.00	**0.81**	−0.02	**0.82**	0.04
GU3	0.74	−0.08	0.06	**0.90**	0.04	**0.90**	0.06
ALPHA1	0.77	**0.90**	**0.90**	0.02	**0.90**	0.01	0.02
ALPHA2	0.76	**0.88**	**0.87**	−0.03	**0.91**	−0.05	−0.14
ALPHA3	0.73	**0.86**	**0.86**	0.02	**0.88**	0.01	−0.09
BETA1	0.70	**0.84**	**0.84**	−0.02	**0.81**	−0.01	0.18
BETA2	0.70	**0.83**	**0.83**	−0.04	**0.79**	−0.01	**0.32**
BETA3	0.80	**0.91**	**0.92**	0.04	**0.90**	0.05	0.10

Note: The names of parcels and items were attributed to each emotion domain. Factor loadings > 0.3 are in bold.

Abbreviations: ALPHA, alpha pride; BETA, beta pride; EFA, exploratory factor analysis; GU, guilt;. SH, shame.

TABLE 5 Model comparison for basic emotions dimension (factorial algorithm parceling)

Model (n = 414)	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	AIC
Models derived from EFA							
One-factor	2931.148/135 = 21.712	Ref	0.599	Ref	0.217	Ref	3039.148
Two-factor	2025.517/134 = 15.116	905.631 (1)***	0.729	0.13	0.179	0.038	2135.517
Three-factor	1038.687/132 = 7.869	986.83 (2)***	0.870	0.141	0.125	0.054	1152.687
Theory-driven basic emotions model							
Theory-driven six-factor	443.899/120 = 3.699	594.788 (12)***	0.954	0.084	0.078	0.047	581.899
Theory-driven six-factor bifactor	336.710/102 = 3.301	107.189 (18)***	0.966	0.012	0.072	0.006	510.710
Theory-driven six-factor modified bifactor	**329.708/105 = 3.140**	114.191 (5)***	0.968	0.014	0.070	0.008	**497.708**
Model (N = 831)							
Theory-driven six-factor modified bifactor	483.135/105 = 4.601	153.427 (0)	**0.972**	0.004	**0.066**	0.004	651.135

Note: The theory-driven basic emotions six-factor modified bifactor model was compared with the theory-driven basic emotions six-factor model. The best indices are in bold.

Abbreviations: AIC, Akaike information criteria; CFI, comparative fit index; EFA, exploratory factor analysis; RMSEA, root mean square error of approximation;

*P < 0.05; **P < 0.01; ***P < 0.001.

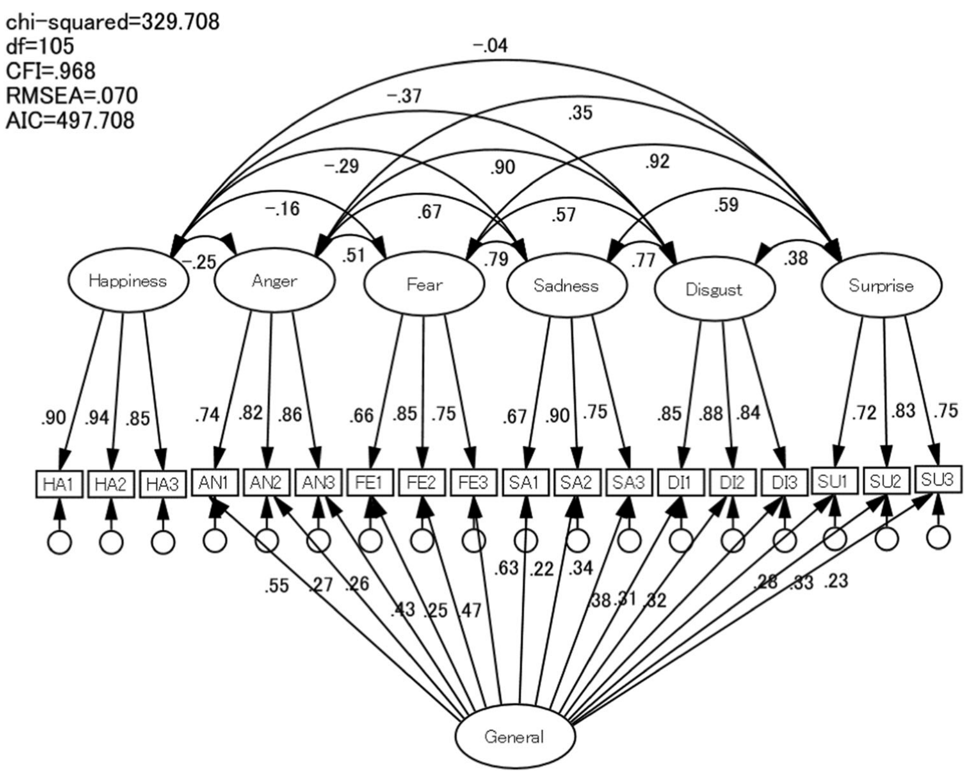

FIGURE 1 Confirmative factor analysis of theory-driven basic emotions modified bifactor model (n = 414). AIC, Akaike information criteria; CFI, comparative fit index; RMSEA, root mean square error of approximation. Paths are standardized. Significant paths are in bold. The names of error variables are deleted

four-factor theory-driven model was the best fit to the data. The model fit using all samples (N = 831) was even better than when using second halved sample: CFI = 0.980, RMSEA = 0.069. We therefore selected the four-factor theory-driven model for the self-conscious emotions dimension (Figure 2).

As the basic emotions were best explained by the bifactor model, we then examined whether the model was sufficiently multidimensional or whether the subscale (group) factors were so negligible that the model was virtually unidimensional (Table 7). Most of the whole-scale variance was explained by this model. Hence the scale showed excellent internal

TABLE 6 Model comparison for self-conscious emotions dimension (factorial algorithm parceling)

Model (n = 414)	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	AIC
Models derived from EFA							
One-factor	2457.186/54 = 45.503	Ref	0.509	Ref	0.318	Ref	2529.186
Two-factor	215.035/53 = 4.057	2212.151 (1)***	0.967	0.458	0.083	0.512	289.035
Theory-driven self-conscious models							
Theory-driven four-factor	178.166/48 = 3.712	36.869 (5)***	0.973	0.006	0.079	0.004	**262.166**
Model (N = 831)							
Theory-driven four-factor	**238.223/48 = 4.963**	59.563 (0)	**0.980**	0.007	**0.069**	0.010	322.223

Note: CFI, comparative fit index. The best indices are in bold.

Abbreviations: AIC, Akaike information criteria; EFA, exploratory factor analysis; RMSEA, root mean square error of approximation.

*P < 0.05; **P < 0.01; ***P < 0.001.

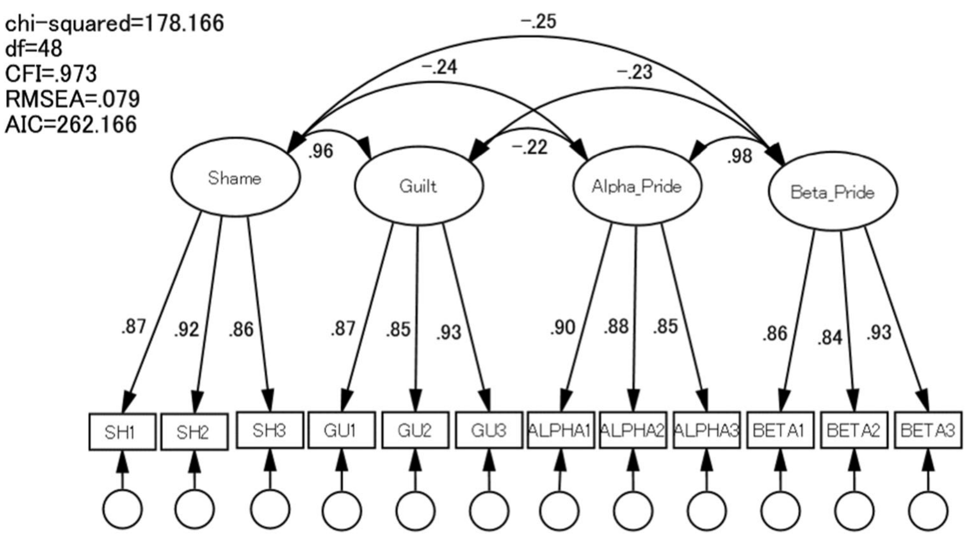

FIGURE 2 Confirmative factor analysis of the self-conscious emotions four-factor model (n = 414). AIC, Akaike information criteria; CFI, comparative fit index; RMSEA, root mean square error of approximation. Paths are standardized. The names of error variables are deleted

consistency. The general factor, however, explained less than half of the whole-scale variance, rejecting the possibility of unidimensionality. On the other hand, group factors, particularly happiness, explained more than 70% of the variance of each subscale. This suggests that although the general factor added some contribution to the whole-scale variance of the group for negative emotions, each subscale substantially influenced the variance of each group. ECV was 0.146, also suggesting multidimensionality.

TABLE 7 Omega coefficients for the theory-driven six-factor modified bifactor model

Factors	ω/ω_S	ω_H/ω_{HS}
General	0.942	0.464
Happiness	0.924	0.924
Anger	0.920	0.770
Fear	0.888	0.708
Sadness	0.917	0.726
Disgust	0.944	0.819
Surprise	0.859	0.760

Note: ω, omega; ω_S, omega subscale; ω_H, omega hierarchical; ω_{HS}, omega hierarchical subscale.

Measurement invariance, construct invariance, and factor mean

The comparisons between nulliparae and multiparae, as well as mothers of boys and girls, showed that the theory-driven six-factor modified bifactor model and the theory-driven four-factor self-conscious model were invariant from configural, metric, scalar, factor variance, and factor covariance perspectives (Tables 8 and 9). It was therefore proven that the factor structure of the present instrument had the same factor structure regardless of the parity of mothers and gender of infants.

Factor means differed in terms of parity and gender of child. Compared to multiparae, nulliparae were rated higher in anger, fear,

TABLE 8 Measurement invariances for the theory-driven six-factor modified bifactor model

	χ^2	*df*	χ^2/df	$\Delta\chi^2(df)$	CFI	ΔCFI	RMSEA	ΔRMSEA	AIC	Judgement
Nulliparae (*n* = 426) vs. multiparae (*n* = 404)										
Configural	603.014	210	2.871	Ref	0.970	Ref	0.047	Ref	939.014	ACCEPT
Metric	705.361	236	2.989	102.347 (26)***	0.964	0.006	0.048	0.001	989.361	ACCEPT
Scalar	864.586	254	3.404	159.225 (18)***	0.953	0.011	0.053	0.005	1112.586	ACCEPT
Residual	1171.628	272	4.307	307.042 (18)***	0.931	0.012	0.062	0.009	1393.495	ACCEPT
Factor variance	1294.001	279	4.638	122.373 (7)***	0.922	0.011	0.065	0.003	1492.001	ACCEPT
Factor covariance	1415.850	293	4.832	121.849 (14)***	0.914	0.008	0.067	0.002	1585.850	ACCEPT
Boys (*n* = 406) vs. girls (*n* = 421)										
Configural	632.318	210	3.001	Ref	0.969	Ref	0.049	Ref	968.318	ACCEPT
Metric	685.389	236	2.904	53.071 (26)**	0.967	0.002	0.048	0.001	989.389	ACCEPT
Scalar	709.056	254	2.792	23.667 (18)	0.967	0.000	0.047	0.001	957.056	ACCEPT
Residual	748.064	272	2.750	39.008 (18)*	0.965	0.002	0.046	0.001	960.064	ACCEPT
Factor variance	761.918	278	2.741	13.853 (6)*	0.964	0.001	0.046	0.000	961.918	ACCEPT
Factor covariance	793.662	293	2.709	31.744 (15)**	0.963	0.001	0.046	0.000	963.662	ACCEPT

Abbreviations: AIC, Akaike information criteria; CFI, comparative fit index; RMSEA, root mean square error of approximation.
$^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

TABLE 9 Measurement invariances for the theory-driven 4four-factor model

	χ^2	*df*	χ^2/df	$\Delta\chi^2(df)$	CFI	ΔCFI	RMSEA	ΔRMSEA	AIC	Judgement
Nulliparae (*n* = 426) vs. multiparae (*n* = 404)										
Configural	302.029	96	3.146	Ref	0.977	Ref	0.051	Ref	470.029	ACCEPT
Metric	310.944	104	2.990	8.915 (8)	0.977	0.000	0.049	+0.002	462.944	ACCEPT
Scalar	415.877	116	3.585	104.933 (12)***	0.967	0.010	0.056	0.007	543.877	ACCEPT
Residual	467.498	128	3.652	51.621 (12)***	0.962	0.005	0.057	0.001	571.498	ACCEPT
Factor variance	517.392	132	3.920	49.894 (4)***	0.957	0.005	0.059	0.002	613.392	ACCEPT
Factor covariance	525.360	138	3.807	7.968 (6)	0.957	0.000	0.058	+0.001	609.360	ACCEPT
Boys (*n* = 406) vs. girls (*n* = 421)										
Configural	311.483	96	4.196	Ref	0.977	Ref	0.052	Ref	479.483	ACCEPT
Metric	326.687	104	3.991	15.205 (8)*	0.976	0.001	0.051	+0.001	478.687	ACCEPT
Scalar	345.972	116	3.777	19.284 (12)*	0.975	0.001	0.049	+0.002	473.972	ACCEPT
Residual	384.77	128	3.813	38.798 (12)***	0.973	0.002	0.049	0.000	488.770	ACCEPT
Factor variance	387.405	132	3.762	2.635 (4)	0.973	0.000	0.048	+0.001	483.405	ACCEPT
Factor covariance	405.961	138	3.741	18.557 (6)**	0.972	0.001	0.049	0.001	489.961	ACCEPT

Abbreviations: AIC, Akaike information criteria; CFI, comparative fit index; RMSEA, root mean square error of approximation.
$^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

sadness, disgust, and surprise, and lower in happiness (Table 10). Compared to mothers of girls, mothers of boys were rated higher in disgust and general factors than those of girls. As for self-conscious emotions, nulliparae were rated higher in shame and guilt but lower in alpha and beta pride. There were no differences in terms of means of self-conscious emotion factors between mothers with boys and those with girls (Table 11).

DISCUSSION

In the current study, we measured mother's emotions towards infant crying using the SPBE. We found evidence for its content validity, structural validity, and internal consistency. The theory-driven models were evaluated in terms of the fitness to the data by CFA series for both basic and self-conscious emotions. Hence, the SPBE was reflecting the

TABLE 10 Factor mean for the theory-driven six-factor modified bifactor model

	Factor mean (SE)						
	Happiness	Anger	Fear	Sadness	Disgust	Surprise	General
Nulliparae compared with multiparae	−0.355**	0.287**	0.954***	0.696***	0.469***	0.566***	−0.018NS
	(0.12)	(0.11)	(0.09)	(0.010)	(0.11)	(0.06)	(0.10)
Boys compared with girls	−0.106NS	0.121NS	0.173NS	0.165NS	0.339*	−0.066NS	−0.203*
	(0.19)	(0.09)	(0.18)	(0.11)	(0.17)	(0.11)	(0.10)

Abbreviations: NS, not significant; SE, standard error.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

TABLE 11 Factor mean for the theory-driven four-factor model

	Factor mean (SE)			
	Shame	Guilt	Alpha_Pride	Beta_Pride
Nulliparas compared with multiparas	0.974*** (0.117)	0.989** (0.135)	−0.265* (0.114)	−0.327* (0.129)
Boys compared with girls	0.080NS (0.121)	−0.048NS (0.139)	−0.179NS (0.115)	−0.131NS (0.131)

Abbreviations: NS, not significant; SE, standard error.
*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

theory of basic and self-conscious emotions. Weidman et al. insisted that researchers need to label their scale based on the terms or concepts comprising it to close the gap between theory and measurement.[52] The theoretical model for "parent-to-baby emotions" needs to be explained by human emotions. The construction and names of subscales of the SPBE came from theories of basic emotions and self-conscious emotions.

In the basic emotion dimension, the best fit model was a bifactor model in which five negative emotion factors but not the happiness factor also loaded on the general factor. As expected, the five negative emotion factors were correlated with each other whereas the happiness factor was negatively correlated with the others. This suggested that although there appeared to be six basic emotion factors, these may also be grouped into positive and negative ones. To note Ekman, negative emotions could be differentiated by a change of heart rate and temperature.[53] We need to identify correlates of the autonomous nervous system or other biological markers.

In the self-conscious dimension, the four-factor theory-driven model was identified. Negative self-conscious emotions such as shame and guilt are not unusual among mothers facing an infant crying. The infant crying may be a stimulus to elicit awareness of "self" among mothers. Such negative emotions are evoked because infant crying is a self-relevant negative life event for mothers. Baby-cry-induced emotions are observed worldwide. Narrative expressions are found such as "Parents felt ashamed feeling that they were not good enough parents" or "They believed that others thought that they were bad parents."[54] Tangney, Wagner, Hill-Barlow et al. indicated that shame and guilt were related to anger.[55] Identification of shame may be immensely helpful when intervening with a mother if she has negative emotions such as anger, hostility, and irritation, or behaves aggressively towards her baby. Alternatively, shame and guilt are followed by depression.[5,9,56,57] In an investigation on life events after childbirth, the severity of infant crying was linked with depression.[58]

Whereas shame and guilt represent the negative aspect of self-conscious emotions of mothers towards infant crying, the two types of pride represent the positive aspect. Pride evoked by the infant's cry may be preceded by an evaluation concerning the "global self as a mother" (alpha pride) and "specific self as a mother" (beta pride). A mother is proud of herself or her own behaviors if she successfully soothes her own baby. When a mother is aware of her baby's authentic needs for safety, protectiveness, and comfort, she is conscious of "self" as a mother whom her baby is seeking. Therefore, she feels pride as well as happiness about infant crying. It may be such positive self-conscious emotions that underlie self-esteem (alpha pride) and self-efficacy (beta pride) about parenting, and thus appropriate and efficient parenting practices. These aspects have received less attention so far. Future studies should focus more on the positive self-conscious emotions of mothers towards infant crying.

Mothers' emotion towards infant crying differs between different groups. For example, shame, guilt, and fear are significantly more prominent among first-time mothers. First-time mothers are in the process of obtaining a role as a mother.[59] These findings indicate that first-time mothers feel challenged towards caring for their infants. First-time mothers should be provided with mental healthcare more than before. Continuous feelings of shame, guilt, and fear may lead to mental health problems and we think that our results may be used when designing a preventive means for postnatal mental illnesses. Compared to mothers of girls, mothers of boys scored significantly higher in terms of disgust and general (negative emotions) factors. This might be linked to the gender difference of the mothers' perception of the baby's gender. Thus, unlike Indian mothers, Japanese mothers prefer girls to boys.[45] Such baby gender preference is likely to induce feeling of disgust among caregivers.

Negative basic emotions may be a consequence of the mother's feeling of frustration,[60–62] depression,[63] or perception that her spiritual ideal as a mother (e.g., the Virgin with Child) has been polluted.[64] These may be elicited from not only the current but also past experiences.[65–67] Hence, the profiles of the mother's emotions towards infant crying manifest various patterns depending on her current as well as past conditions and situations. Perinatal health professionals can understand these emotion profiles towards infant crying using the SPBE.

The internal consistency of the SPBE was excellent. The basic emotions were best explained by the bifactor model having multidimensional constructs. The omega index of each factor was more than 0.7 and ECV was as low as 0.146. These results suggest that we should capture the parent-to-baby emotions as multidimensional constructs. The theory-driven six modified bifactor model for basic emotions has a general factor. In this model, the general factor had some contribution to the whole-scale variance of the group for negative emotions, but each subscale (specific factors) substantially influenced the variance of each group. Each group factor was not negligible, but the general factor also contributed to negative emotion factors.

It was proven that the factor structure of the SPBE had the same factor structure regardless of the parity of mothers and gender of infants by the examination of measurement invariance. The SPBE has a robust construct and structure. Although it goes beyond the scope of the present report, what should be performed is a multi-group CFA for assessing cross-cultural validity between different groups in terms of age, gender, and disease characteristics (COSMIN study design checklist).[19]

Our study has limitations. First, it has too many items to be useful for clinical scenarios or research, therefore we need to develop a shorter version. Another theoretical problem is that each item was rated with a five-point scale. One may claim that the items should be regarded as ordinal. Nevertheless, such coarsely categorized variables can be treated normally. This is because goodness-of-fit is little impacted by the number of categories if the items are not very skewed and factor loadings are not underestimated if the categories were not as few as two or three and if the items were not much skewed.[68]

Second, for defining how a mother's emotions relates to perinatal mental health or mother–child interaction, convergent-validity and discriminant-validity need to be examined. To ensure that the newly constructed category of emotion can measure the intended emotion, we need to carry out a study examining the association between the new scale scores and the scores of other variables that are theoretically related to maternal emotion towards baby cry. They may include, for example, maternal parenting behaviors, child abuse, breastfeeding ratio, and infant's temperament, to name just a few. Third, the current study used a cross-sectional design and test-retest reliability was not examined. Because maternal emotions towards a baby may be influenced by many elements, such as the baby's physical and temperamental conditions, they may temporarily vary. For longitudinal use, examination of measurement invariance in terms of multiple time points over a long period of time is needed. It is reasonable to think that the measured emotion is not stable even in the same person because emotion may vary even in response to baby cry depending on various factors, including the mother's mood state, the existence of another person, and the event triggering the cry. We speculate that some types of emotions are stable across time and others vary greatly. The former is more trait-like while the latter is more state-like. Longitudinal studies with multiple observation times may give us an insight into trait-state differences.

It is necessary to have a longitudinal study covering a wide range of the child's age from childbirth through infancy/toddlerhood to school childhood because the child's age is a very important factor in determining maternal emotion. Special attention should be paid to the difference in maternal emotion in terms of the child's age in the first few weeks and months after childbirth.

What remains to be investigated is the association between the maternal emotions and adverse situations, such as traumatic birth, illness in the mother or baby, prematurity, and others that could affect the emotional state of the mother and therefore the interpretation of the baby's condition. Such studies may be available after creating a short version of this scale.

Furthermore, it is necessary to replicate the study among fathers as well as step- and fostering parents. Another important population is parents who are listed as abusive parents. Taking into account these drawbacks, the SPBE is a promising tool for measuring parent-to-baby emotions.

CONCLUSION

The SPBE illustrated the rubric of parental emotions towards infant crying based on the basic and self-conscious emotion theories. These emotions should be evoked as primary emotions when an infant cries, therefore they play an important role as mediators in response to internal or external events. We should pay more attention to these emotions. The SPBE may make it possible to assess these primary emotions under the rubric of parent-to-baby emotions to provide the tailor-made care with consideration for individual differences.

AUTHOR CONTRIBUTIONS

Ayako Hada and Masumi Imura performed the research design. Ayako Hada collected the data. Ayako Hada and Toshinori Kitamura performed statistical analyses. Ayako Hada wrote the manuscript. All the authors read and approved the final draft.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

The data set analyzed and used in this study may be available upon reasonable request to the first author.

EHICS APPROVAL STATEMENT

This study was conducted under the approval of the Ethical Committee of Japanese Red Cross College of Nursing, to which the responsible researcher (A.Y.) belongs (No. 2018-068).

PATIENT CONSENT STATEMENT

All participants were provided with an explanation about the aim as well as the procedure of this survey and the security of personal information. They were regarded as agreeing to participate by responding to the questionnaire via web survey.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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