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FAMILY PROCESS

ORIGINAL ARTICLE

A scale of parent-to-child emotions: Adaptation, factor structure, and measurement invariance

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Abstract

Emotions that parents feel when they think about their own child are extremely important in determining parenting approaches toward a child. Parental emotions should be defined under the rubric of human emotions that include both basic and self-conscious emotions. The Scale for Parent-to-Baby Emotions (SPBE) was developed underlying this concept, whereas an applicable scale for parent-to-child emotions for a wider age range for both mothers and fathers is needed. This study is aimed at examining the measurement invariance of this adapted scale among Japanese families. In a cross-sectional internet survey, men and women who had a child/children (including a fetus), whose eldest was aged up to 12 years old ($N=4600$), were recruited. The questionnaire, which included the Scale for Parent-to-Child-Emotions-62 (SPCE-62) created from the SPBE via a process of rigorous translation, focused only on the eldest child. The feasibility of the SPCE-62 was assessed by a panel of three researchers. Each domain of both basic and self-conscious emotions was examined both in terms of robust factor structure and stable measurement invariance by multi-group confirmatory factor analysis. Responses to individual items were examined via item response theory, including differential item functioning. This resulted in a 43-item SPCE consisting of 9 domains: Happiness (four items), Anger (six items), Fear (four items), Sadness (five items), Disgust (five items), Shame (five items), Guilt (seven items), Alpha Pride (three items), and Beta Pride (four items). An empirical construct of parental emotion toward a child was derived. The SPCE makes it possible to measure parent-to-child emotions across parents' gender and the three age ranges of the child.

KEYWORDS
basic emotions, differential item functioning analysis, item response theory, measurement invariance, parent-to-child emotions, self-conscious emotions

INTRODUCTION

A child or a fetus is a significant other for a parent. A representation of one's own child arouses emotions in a parent, and those emotions motivate a parent's behaviors. Positive emotions induce whereas negative emotions impair an appropriate parental approach toward a child. A parent who feels positive emotions toward a child is likely to be warm and supportive when interacting with his/her child. Positive emotional interactions in a family generally associate with a child's expressions of positive emotions and high-quality social functioning, contribute to the development of a child (Eisenberg et al., 1998). Therefore, emotions that parents feel when they think about their own child are extremely important in determining parental approaches toward a child. Parental emotions should be defined under the rubric of human emotions that include both basic and self-conscious emotions (Hada et al., 2021). Basic emotions are immediate reactions to an external or internal event, often containing a biological function (Ekman, 1971, 1994).

There are several subconstructs included in the domain of basic emotion: (a) Happiness is feelings that are enjoyable and are sought by the person; (b) anger is a response to interference with a pursued goal. It is also triggered in situations when someone is attempting to harm us (physically or psychologically) or someone we care about; (c) fear is a response to the threat of harm, physical or psychological. Fear activates impulses to freeze or run. It often triggers the onset of anger; (d) sadness is a response to the loss of an object or person to which one feels close (e.g., death of a loved one); (e) disgust is intense aversion to the sight, smell, or taste of something. It may also be evoked by people whose actions are revolting or by offensive ideas (Ekman & Cordaro, 2011).

Self-conscious emotions differ from basic emotions in that they require self-awareness and self-representation, which are linked to self-evaluations (Tracy & Robins, 2004). Shame, guilt, alpha pride, and beta pride are typical and distinctive self-conscious emotions. Shame is an acutely painful experience, feeling "self" evaluated painfully and negatively. Such self-scrutiny leads to a sense of shrinking, of being small, worthlessness and powerlessness, and being exposed (Tangney, 1990, 1996; Tangney, Miller, et al., 1996). On the contrary, guilt involves a focus on a specific behavior that is negatively evaluated, somewhat apart from the global self. Guilt does not affect one's core identity or self-concept. The sense of tension and regret often motivates confessing, apologizing, or somehow repairing the damage done (Tangney, 1990, 1996; Tangney, Miller, et al., 1996). In the meta-analytic investigation, dispositional guilt was positively correlated with pro-social orientation, such as negative hostility, empathy/forgiveness, and morality, whereas dispositional shame was negatively correlated (Tignor & Colvin, 2017). Pride has two types: alpha pride that is feelings of pride in the entire self and beta pride that feelings of pride stemming from the evaluation of a specific behavior (Tangney, 1990). Authentic pride (AP, synonymous with beta pride) and hubristic pride (HP, synonymous with alpha pride) are empirically distinct constructs that often align in opposite ways with personality and related variables, with AP exhibiting associations that suggest better psychological health than HP (Dickens & Robins, 2022).

Hada et al. (2022) developed the Scale for Parent-to-Baby Emotions (SPBE) based on the theory of basic and self-conscious emotions. In this scale, primary emotions when a mother notices her own baby's cry consist of 10 domains (i.e., happiness, anger, fear, sadness, disgust, surprise, shame, guilt, and alpha and beta prides) because the parental emotional reaction to the own baby cry is often represented as basic emotions and self-conscious emotions. We started reviewing literature including emotional reactions or responses toward their baby's cry which represents their infants' cues. Items of the SPBE were elicited from Japanese qualitative studies

on the mother's responses toward infants crying (Horikoshi et al., 2016; Nakayama, 2015; Okamoto & Matsuoka, 2003; Sugiura, 2008; Tabuchi, 1999; Tabuchi & Shimada, 2006), and the scales reported in the previous reports to measure emotions in general: PANNAS (Watson et al., 1988), the Multiple Mood Scale (Terasaki et al., 1992), and the Japanese version of Test of Self-Conscious Affect, version 3 (Hasui et al., 2009). These were then classified into emotion categories based on the concepts of basic and self-conscious emotion categories by researchers, including experts in midwifery or psychiatry. This multi-dimensional construct indicates that not a single emotion, but multiple emotions are evoked toward one's own baby simultaneously. The SPBE showed measurement invariance across parity and parents' gender. However, because the sample of their study was limited to postnatal women within one month after childbirth, the scale cannot be used for mothers with a preschool age or school-aged child or for pregnant women and partners. Baby's cry is the strongest stimuli for the parents in the attachment behavior in the infant period (Bowlby, 1969), whereas crying behavior is reduced as a child grows up. As same as baby's cry, images or thoughts of their own child could be stimuli for parents, and emotional reaction to the image or thought of their own child would be represented by basic emotions and self-conscious emotions. This construct should be applicable to parent-to-child emotions for a wider age range for both mothers and fathers.

In the Japanese culture, close relationships that seem to be an absence of a boundary between self and others are observed in family systems. Although closeness in family relationships does not seem to be adaptive in Western culture, it is adaptive and acceptable in Japan (Rothbaum et al., 2002). This study examined the measurement invariance of the SPCE developed in Japanese backgrounds; however, the SPCE is likely to measure culturally non-specific emotions due to bases on universal emotions.

Psychological instruments should hold the same construct and meaning across different groups. A model, even though showing the best fit to one sample, cannot always show the best fit to another sample. Only when measurement invariance is assured, we can observe and compare scores directly between different groups of participants. We should examine measurement and structural invariance of the scale before using it in research and clinical settings. This procedure needs to proceed step by step, as follows: (a) configural invariance: the instrument has the same factors and patterns of items across groups; (b) metric invariance: factor loadings for the same items are invariant across groups; (c) scalar invariance: intercepts for the same items are invariant across groups; (d) residual invariance: residuals for the same items are invariant across groups; and (e) factor variance invariance: factor variances are invariant across groups (Vandenberg & Lance, 2000).

Although full measurement invariance (all of the measurement parameters of all items are the same across all groups) is needed in rigorous assessment, it is often difficult to achieve practically. A condition that measurement invariance holds for only a subset of items is known as *partial* measurement invariance. It is possible to validate group comparisons (e.g., means) using latent variable models when only some of the items are invariant (Byrne et al., 1989). Multi-group comparisons based on observed scores (latent means) produced no significant differences using partial invariance (Steinmetz et al., 2009). Hence, it is reasonable to consider using partial invariance as a multi-group testing procedure.

Cappelleri et al. (2014) explained that classical test theory is a traditional quantitative approach to testing the reliability and validity of a scale based on its items, assuming that observed score (X) = true score (T) + some error (E). As important as psychometric properties based on classical test theory (CTT) is, item response theory (IRT) casts light on psychological tests or scales. IRT is a modern approach to psychometric test design. Although classical test theory focusses on the *whole* test as a model-based approach, IRT focusses on each item one by one. IRT is a psychometric modelling framework for analyzing individual *items* of tests, scales, and other instruments that aim to measure underlying latent traits. Lord (1980) noted that each item in the pool is effective for measuring at each ability level. IRT makes it possible to illustrate how response

depends on level of ability or skill, as well as item difficulty by a mathematical statement. This relationship is given by the item characteristic curve (ICC). Differential item functioning (DIF) in IRT analysis plays an important role in measurement equivalences when different groups are to be compared in research or clinical situations. DIF concerns the possibility that items on a measure function differently for persons in two different groups (Nugent, 2017). The graded response model (GRM; Samejima, 1968, 1969) is comprised of a parametric IRT technique suitable for rating scales such as patient reported outcome measures (PROMs) (Revicki et al., 2015). ICCs that are estimated with the GRM are characterized by discrimination and threshold (location) parameters. The threshold parameters provide information on an item's difficulty or severity. The item information function (IIF) and the test information function (TIF) in IRT provide the local accuracy of trait estimation in scale (Samejima, 1994). The concepts, such as IIF and TIF, are missing in CTT. Models in IRT can estimate a parameter for each item, as well as for each person. Hence, we analyzed each item of SPCE by using IRT.

IRT parameters of each item in each domain of the parent-to-child emotions are needed for the degree of true emotional intensities to be calculated. Nevertheless, many previous studies reporting that prenatal emotional bonding status predicted postnatal emotional bonding status (Edhborg et al., 2011; Figueiredo & Costa, 2009; Müller, 1996; Nakamura et al., 2015; Ohashi et al., 2016; Tichelman et al., 2020) used different scales across the perinatal periods. This means that parent-to-child emotion based on the same concept should be meanable regardless of parental demographics (e.g., different parent's gender, different child's ages, different countries, etc.) so that predictions or trajectories could be much clearer.

It should be noted here that although cultural influences should not be treated as negligible, our study is based on the notion that human emotions and parent-to-child emotions in particular are universal across human cultures (Ekman, 1971). Hence, what is needed is a development of a culture non-specific scale. As the first step, our endeavor was to develop such a measure the factor structure of which was invariant across fathers and mothers and child age ranges. Invariance across cultures should be a focus of future studies. Reise et al. (1993) mentioned that "Once measurement invariance is established, additional theoretically important questions may be addressed, including questions regarding group differences in means or variances on the latent variables identified". In the parent-to-child emotions, we may find important differences between the two parents because mothers and fathers may really do experience these emotions differently. For example, when a mother feels fetal movement in her womb, she may feel happy. However, her partner (father) may not feel the same happiness as his partner (mother) feels because he cannot feel the same stimuli of fetal movement in his body. Such individual differences in emotional intensity may be clarified by the SPCE. Therefore, our primary purpose in this study is the development of a scale for maternal as well as paternal emotions toward their child with a wide range of ages from fetus to school-aged child based on the SPBE to validate its factor structure and measurement invariance (i.e., gender difference of parents and differences of child's age) and compare latent means of the factors. To achieve our goal, further analysis based on the IRT (i.e., DIF analysis and GRM) was conducted.

METHODS

Study procedures and participants

The study participants were men and women who had a child/children (including a fetus), whose eldest child's age was up to 12 years old. The parents were recruited independently. Our inclusion criterion was parents who were fluent in Japanese. The questionnaire focused on the eldest (or only) child (including a fetus). All participants were allocated into 20 segments by the parent's gender (father/mother) and child's age stages. Segments by child's age stages were: (a)

1st trimester in fetal stage, (b) 2nd trimester in fetal stage, (c) 3rd trimester in fetal stage, (d) 0 to 1 months old, (e) 2 to 6 months old, (f) 7 to 17 months old, (g) 18 months to 2 years old, (h) 3 to 5 years old, (i) 6 to 8 years old, and (j) 9 to 12 years old.

With the cooperation of Rakuten Insight Inc. (Setagaya, Tokyo), parents who were or whose partners were pregnant or live with their 0- to 12-year-old child/children were recruited from 47 prefectures in Japan. We aimed at recruiting 250 participants each for 20 segments: two parental genders (fathers and mothers) × the above-mentioned ten age ranges of children (including fetuses). Approximately 480,000 parents were enrolled as web-research respondents. Of these people, 276,890 had children and were solicited to participate in the survey. Participants were invited consecutively for each segment until the planned number of participants was reached. This number of participants was, however, not reached for four segments: (a) 1st trimester in fetal stage, (b) 2nd trimester in fetal stage, for both parental genders. This resulted in 4600 total participants. Of those, 4153 (90.3%) parents lived with a child. Their mean (SD) age was 36.1 (6.9) years old, and their partners' mean (SD) age was 35.5 (6.8) years old. Their occupational status was: regular employment 3076 (66.9%), irregular or part-time employment 585 (12.8%), self-employment 159 (3.5%), non-job status 572 (12.4%), 208 (4.5%) unknown. A web page for the survey was created by Rakuten Insight Inc. This contained all of the necessary information for participation, i.e., the aims of this research, affiliations of the principal researcher, and information about ethical considerations. The Rakuten Insight web page was available from the 30th of November to the 6th of December, 2021.

Ethical considerations

The authors declare that all procedures contributing to this study comply with the ethical standards of the national and institutional committees on human experimentation and with the Helsinki Declaration of 1975 as revised in 2008. All participants were informed about the aim and procedure of this survey and security of personal information, as well as anonymity assurance. They agreed to participate via the consent form on the web. This study was conducted under the approval of the Institutional Review Board (IRB) of the Kitamura Institute of Mental Health Tokyo (No. 2021101401).

Measurements

The original SPBE consisted of 73 items based on the theory of basic and self-conscious emotions (i.e., happiness, anger, fear, sadness, disgust, surprise, shame, guilt, and alpha and beta prides). In this original item, parents were asked to rate "How strongly did you feel these emotions when your baby cried the most recently" using a 5-point scale (1 = did not feel at all to 5 = felt extremely strongly). The adapted SPCE adapted this scale to ask parents "How strongly did you feel these emotions when you thought about your child? Please choose the number that best describes your feeling". These items were rated with a 7-point Likert scale (1 = did not feel at all to 7 = felt extremely strongly). Because we aimed to construct a measurement of the SPCE applicable to multi-cultural settings, we used forward and backtranslation procedures to create a scale that was appropriate in Japanese and English. Eight items did not have an appropriate expression in English. Three items were also items which were NOT appreciable for a fetus stage, preschool age, or school age (Supplementary Table 1). Therefore, 11 items were deleted in the procedure of modification from the SPBE to the SPCE, leading to a 62-item scale with 10 subscales (i.e., Happiness, Anger, Fear, Sadness, Disgust, Surprise, Shame, Guilt, and Alpha and Beta Prides).

Feasibility of each of the SPCE-62 items was blindly assessed by a panel of three researchers (one psychiatrist [TK], one clinical developmental psychologist [YO], and one midwife [YU]) about which domain it belonged to. "I got uneasy" (SPCE43) and "I was confused" (SPCE23) were originally created as Fear items but the panel concluded that these had the nuance of Surprise. Therefore, these two items were deleted. The panel considered that the item "I was upset" (SPCE25) should be moved from the Surprise to the Fear domain. The panel thought that two Shame items, "I felt bad" (SPCE34) and "I felt a lack of confidence" (SPCE19), had a nuance of Guilt and therefore were deleted from the scale. Because surprise is an emotion that is expressed immediately after an event and has a short duration as well as both positive (e.g., happy surprise) and negative (e.g., sudden sad news) valences, the panel decided that it was a very unstable emotion. Therefore, the Surprise domain was deleted. This process resulted in the remaining 54 items (SPCE-54).

Data analysis

Because our aim was to create a set of items that measure *each* domain of both basic and self-conscious emotions with (a) robust factor structure, (b) stable measurement invariance, and (c) robust IRT characteristics, we used the SPCE-54 and examined items belonging to basic and self-conscious emotions dimensions, separately. After calculating mean, SD, skewness, and kurtosis of each item, the goodness-of-fit of the items of each domain was measured by comparative fit index (CFI) in confirmatory factor analyses (CFAs). We thought CFI > 0.95 was a good fit with the data (Hu & Bentler, 1999). When CFI was less than 0.95, we suspected redundancy of items so the variance inflation factor (VIF) was used as a tool to identify such items. We deleted an item with the greatest VIF > 5.0 (James et al., 2013; Menard, 2001) one by one until CFI reached the level of 0.95. Whether CFI reached 0.95 or not even after deleting items with VIF > 5.0, we then examined measurement invariance of all of the remaining items for each domain, separately. We examined invariance between fathers ($n = 2336$) and mothers ($n = 2264$) starting from configural through metric and scalar to residual invariance. The measurement equivalence examined in accordance with the recommendation by Vandenberg and Lance (2000). In this recommendation, we confirmed invariance across each groups in terms of (a) configural invariance (each group were invariant in the construct), (b) metric invariance (factor loadings for similar indicators were invariant across groups), (c) scalar 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 judge invariance from one step to the next as "accepted (invariant)" when a model shows (a) a non-significant increase of χ^2 for df difference, (b) a decrease of comparative fit index (CFI) < 0.01, or (c) an increase of root mean square error of approximation (RMSEA) < 0.015 (Cheng, 2007; Desa, 2014 p. 20). $\chi^2$is sensitive to the sample size; therefore, CFI and RMSEA may be better indicators of measurement invariance. We used this criterion to avoid excessive "rejection" rates. When the fathers and mothers did not show stable measurement structure, we searched the z value for each pair of parameters (such as factor loading) and the parameter with the highest z (i.e., should be >1.96, $p < 0.05$) was deleted one by one until measurement invariance was obtained. The next step was the confirmation of measurement invariance across the three age ranges of the child: (a) fetal stage (FS, $n = 1100$), (b) infancy and preschool age (from 0 months

to 6 years) (I/PA, $n = 2500$), and (c) school age (6 to 12 years) (S, $n = 1000$). Multi-group CFAs (MGCFAs) were conducted across the three age groups (FS, I/PA, and S). The same procedures were adopted to treat measurement invariance as in the comparison between fathers and mothers. If the model was not invariant across the three age ranges, we compared models between a pair of adjacent age ranges (i.e., FS vs. I/PA, and I/PA vs. S). VIF detection and examination of measurement invariance by MGCFAs were performed using IBM SPSS version 28.0 and Amos version 28.0 software for Windows (IBM Japan).

Item response theory

After examination of measurement invariance by MGCFAs, we examined each *item* via IRT. All nine domains of the SPCE were separately analyzed using the GRM (Samejima, 1997). A GRM would provide adequate fit and an appropriate model within the SPCE. Since each domain of the SPCE, as will be discussed later, was adequate for evaluation as a unidimensional model by CFAs, we evaluated the local dependence (LD) which is a violation against IRT analysis. LD is flagging if any item pair's residual correlation was >0.2 (Reeve et al., 2007; Rimehaug et al., 2022). We examined LD for items for each domain of the SPCE with residuals from the CFA with Weighted Least Squares Means and Variance (WLSMV) estimator in R package "lavaan" (version 0.6-11) (Rosseel, 2012). Monotonicity was examined using R package "mokken" (version 3.0-6) (van der Ark, 2012), expecting scalability coefficients (coef_h) > 0.3 (Rimehaug et al., 2022; van der Ark, 2012). To ensure that the item parameters used to calculate T scores were applicable to all participants, DIF was assessed for parental gender differences (father and mother), and between child's age groups (i.e., FS vs. I/PA, FS vs. S, and I/PA vs. S) by a logistic ordinal regression model in R package "lordif" (version 0.3-3) (Choi et al., 2011). Uniform and non-uniform DIF were evaluated using McFadden's pseudo-R > 0.02 as critical value (Choi et al., 2011; Crane et al., 2006; Lameijer et al., 2020; Reeve et al., 2007). IRT plots from the GRM were also created with R package "ltm" (version 1.2-0) (Rizopoulos, 2006). The threshold item parameters and item discrimination parameters were calculated for each item. The IIF for each item was calculated from item-level parameter estimates. IIF is a curve that shows the amount of information about theta (difficulty) level that an item score provides at each point on the theta scale (Nugent, 2017). The TIF was obtained by summing of IIFs. TIF is a curve that shows the amount of information obtained from the total score on a scale about a person's latent trait level expressed on the theta metric at each theta level (Nugent, 2017). In all procedures for developing the SPCE, we referred to PROMIS Health Organization and PROMIS Cooperative Group (2013) considerably.

RESULTS

Item and subscale analysis of the SPCE

After calculating mean, SD, skewness, and kurtosis of all of the scale items (Table S1), we performed a single factor CFA for each domain. All domains showed CFI greater than .95 except disgust, shame, and guilt of which CFIs were .913, .920, and .937, respectively (Table 1). When searching items among each of these three domains that were with VIF > 5.0, only one Disgust item (SPCE6) showed VIF > 5.0 (5.21) and was therefore deleted. Standardized factor loadings of all of the items in a single factor model of CFA were higher than .40 in each domain.

TABLE 1 Items No., label, contents, VIF, Cronbach's α, and CFI for each domain.

Item No.		Label	Contents (abbreviated sentences)	VIF	Cronbach's α	Comparative fit index (CFI)	Standardized factor loading as CFA 1-factor
Basic emotion							
Happiness	SPCE32	01HA	happiness	5.29	0.903	0.956	0.936
	SPCE29	02HA	relieved	1.30			0.478
	SPCE11	03HA	delight	2.55			0.777
	SPCE31	04HA	glad	4.61			0.909
	SPCE13	06HA	my child cute	2.94			0.807
	SPCE51	08HA	fond of my child	2.48			0.787
Anger	SPCE62	09AN	angry	4.74	0.957	0.970	0.899
	SPCE48	10AN	annoyed	5.45			0.920
	SPCE42	11AN	got into rage	4.38			0.893
	SPCE55	12AN	mad	5.93			0.930
	SPCE59	13AN	felt like shouting	5.46			0.920
	SPCE37	14AN	felt like throwing a thing	2.90			0.788
	SPCE45	15AN	hateful	2.52			0.739
Fear	SPCE26	16FE	scared	2.68	0.823	0.971	0.872
	SPCE14	19FE	horrified	1.73			0.683
	SPCE3	20FE	anxiety	1.29			0.459
	SPCE28	21FE	nervous	1.70			0.554
	SPCE25	42SU	upset	2.53			0.850
Sadness	SPCE17	24SA	sad	3.84	0.920	0.971	0.898
	SPCE16	25SA	pessimistic	3.37			0.867
	SPCE49	26SA	lonely	2.36			0.773
	SPCE58	28SA	disappointed	2.80			0.824
	SPCE30	29SA	depressed	2.65			0.821

TABLE 1 (Continued)

Item No.		Label	Contents (abbreviated sentences)	VIF	Cronbach's α	Comparative fit index (CFI)	Standardized factor loading as CFA 1-factor
Disgust[a]	SPCE5	30DI	couldn't put up with my child	4.47	0.939	0.913	0.848
	SPCE24	31DI	felt like throw it out	3.36			0.864
	SPCE40	32DI	fed up	3.87			0.876
	SPCE6	34DI	made me sick	5.21			0.882
	SPCE35	35DI	pestering	3.25			0.845
	SPCE18	36DI	unpleasant	2.46			0.778
Self-conscious emotion							
Shame[a]	SPCE1	43SH	ashamed	1.61	0.920	0.920	0.832
	SPCE38	44SH	pitiful	2.87			0.785
	SPCE7	45SH	felt like hiding away	2.40			0.767
	SPCE20	46SH	miserable	2.70			0.576
	SPCE27	48SH	felt like escaping	3.10			0.833
	SPCE57	50SH	Powerless	2.27			0.726
	SPCE60	51SH	Felt myself dreadful	3.17			0.812
	SPCE47	52SH	disqualified as a mother	2.44			0.751
Guilt[a]	SPCE50	53GU	guilty	3.82	0.944	0.937	0.882
	SPCE54	54GU	sorry	4.86			0.897
	SPCE21	55GU	inferior	2.62			0.759
	SPCE8	56GU	felt my child unfortunate	2.42			0.739
	SPCE9	58GU	I did wrong	2.86			0.807
	SPCE53	59GU	I did a terrible thing	4.51			0.890
	SPCE44	60GU	it's my fault	3.00			0.828
	SPCE39	61GU	I was accused	2.59			0.773

(Continues)

TABLE 1 (Continued)

Item No.		Label	Contents (abbreviated sentences)	VIF	Cronbach's α	Comparative fit index (CFI)	Standardized factor loading as CFA 1-factor
Alpha pride	SPCE52	62ALPHA	satisfied as a parent	2.04	0.824	0.991	0.796
	SPCE41	63ALPHA	proud of myself as a parent	1.92			0.763
	SPCE61	64ALPHA	proud being needed	1.53			0.636
	SPCE46	65ALPHA	I was a good parent	2.05			0.793
	SPCE2	66ALPHA	competent as a parent	1.31			0.520
Beta pride	SPCE56	68BETA	content with childcare	2.00	0.843	0.993	0.787
	SPCE4	70BETA	fulfilled in childcare	1.64			0.682
	SPCE33	71BETA	proud of my childcare	2.04			0.798
	SPCE36	72BETA	did a good childcare	1.92			0.766

Abbreviations: CFI, comparative fit index; VIF, variance inflation factor.

[a]Model fit was not acceptable (CFA < 0.950).

Measurement invariances between fathers and mothers by MGCFAs

For 9 separate domains, we performed measurement invariance of a single factor model between fathers and mothers. We confirmed the measurement invariance at the factor variance level for all of the items of the basic emotion domains, including 6 Happiness-, 7 Anger-, 5 Fear-, 5 Sadness-, and 5 Disgust-items. The measurement invariance of the 8-item Shame domain was rejected at the scalar invariance level. We searched the z value for each pair of parameters and deleted an item with the highest z value one by one until reaching stability of the model at the factor invariance level. Two Shame items were deleted: SPCE1 ($z = -8.79$) and SPCE20 ($z = -5.90$). The measurement invariance of the 8-item Guilt domain was rejected at the scalar invariance level. We deleted SPCE21 ($z = -4.97$) to reach the factor variance invariance level. Because the 5-item Alpha Pride domain model was rejected for its invariance at the scalar level, we deleted SPCE61 ($z = -2.95$) to reach factor variance invariance. The 4-item Beta Pride model was accepted for its easement invariance at the factor variance level without deleting any items. The final models for each domain reached factor variance invariance (Table 2).

We then calculated factor mean differences for all of the domains (Table 3). As compared with mothers, fathers rated Happiness, Anger, Shame, and Guilt significantly lower, whereas Alpha Pride was rated significantly higher. There were no differences between fathers and mothers in factor means of any other domains.

Measurement invariances across child age ranges by MGCFAs

The comparisons of almost all of the domains between FS, I/PA, and school age proved that each 1-factor model showed invariance from configural, metric, scalar, and factor variance (Table 4). An exception was Beta Pride. Full measurement invariance of Beta Pride did not hold when all of the measurement parameters of all items were the same across the three groups. We identified SPCE4 with a high z value. Therefore, we took the partial invariance approach for Beta Pride in which the scalar of SPCE4 was freely estimated.

Obtaining a new set of domain items (after deleting items with a high z score), we calculated factor means of all of the domains between FS, I/PA, and school age (Table 5). When comparing with I/PA (i.e., rated as zero), scores of Anger, Disgust, Shame, and Guilt increased as the child became older. Happiness, Alpha Pride, and Beta Pride showed a peak at I/PA and decreased slightly at school age. Fear decreased as the child became older. Sadness was lower at I/PA but higher at school age (Table 6).

IRT assumptions

Since unidimensionality for each domain was confirmed by CFAs, LD was examined. No items had residual CFAs > 0.2 for each domain (Table S2). Therefore, all of the items were considered locally independent. The Mokken scalability coefficient for all of the items in each domain were between 0.433 (SPCE3) and 0.825 (SPCE55), well above the 0.3 cut-off among all of the SPCE items (Table S2). Therefore, monotonicity was confirmed for all items.

Measurement invariance by DIF

No items had DIF between fathers and mothers. Across the three different child's age groups, SPCE13 (06HA) ($R^2 = 0.0295$) and SPCE45 (15AN) ($R^2 = 0.0331$) were flagged for DIF between F and I/PA. SPCE45 (15AN) ($R^2 = 0.0413$) and SPCE27 (48SH) ($R^2 = 0.0319$) were also flagged

TABLE 2 Measurement invariance of final models for each domain between father group ($n = 2336$) and mother group ($n = 2264$).

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Happiness domain (SPCE32 (01HA), SPCE29 (02HA), SPCE11 (03HA), SPCE31 (04HA), SPCE13 (06HA), SPCE51 (08HA))									
Configural	882.226	18	49.015	Ref	0.955	Ref	0.102	Ref	Accept
Metric	896.205	23	38.965	13.939 (5)**	0.954	0.001	0.091	+0.011	Accept
Scalar	1240.561	29	42.778	344.356 (6)***	0.937	0.017	0.095	0.004	Accept
Residual	1505.151	35	43.004	264.591 (6)***	0.923	0.014	0.098	0.003	Accept
Factor variance	1626.188	36	45.172	121.037 (1)***	0.917	0.006	0.098	0.000	Accept
Anger domain (SPCE62 (09AN), SPCE48 (10AN), SPCE42 (11AN), SPCE55 (12AN), SPCE59 (13AN), SPCE37 (l4AN), SPCE45 (15AN))									
Configural	1099.649	28	39.273	Ref	0.970	Ref	0.091	Ref	Accept
Metric	1153.998	34	33.941	54.350 (6)***	0.968	0.002	0.085	+0.006	Accept
Scalar	1406.982	41	34.317	252.983 (7)***	0.961	0.007	0.085	0.000	Accept
Residual	1644.822	48	34.267	237.840 (7)***	0.955	0.006	0.085	0.000	Accept
Factor variance	1691.264	49	34.516	46.438 (1)***	0.953	0.002	0.085	0.000	Accept
Fear domain (SPCE26 (16FE), SPCE14 (19FE), SPCE3 (20FE), SPCE28 (21FE), SPCE25 (42SU))									
Configural	301.164	10	30.116	Ref	0.970	Ref	0.080	Ref	Accept
Metric	416.835	14	29.774	115.670 (4)***	0.958	0.012	0.079	+0.001	Accept
Scalar	634.935	19	33.418	218.100 (5)***	0.936	0.022	0.084	0.005	Accept
Residual	751.950	24	33.701	117.015 (5)***	0.925	0.011	0.081	+0.003	Accept
Factor variance	754.589	25	30.184	2.639 (1)^{NS}	0.925	0.000	0.080	+0.001	Accept
Sadness domain (SPCE17 (24SA), SPCE16 (25SA), SPCE49 (26SA), SPCE58 (28SA), SPCE30 (29SA))									
Configural	535.522	10	53.552	Ref	0.970	Ref	0.107	Ref	Accept
Metric	578.593	14	41.328	43.209 (5)***	0.968	0.002	0.094	+0.013	Accept
Scalar	677.356	19	35.650	98.764 (5)***	0.962	0.006	0.087	+0.007	Accept
Residual	1118.697	24	46.612	441.352 (5)***	0.937	0.025	0.100	0.013	Accept
Factor variance	1118.847	25	44.754	0.151 (1)^{NS}	0.937	0.000	0.098	+0.002	Accept

TABLE 2 (Continued)

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Disgust domain (SPCE5 (30DI), SPCE24 (31DI), SPCE40 (32DI), SPCE35 (35DI), SPCE18 (36DI))									
Configural	199.751	10	19.975	Ref	0.989	Ref	0.064	Ref	Accept
Metric	264.557	14	18.897	64.806 (4)***	0.986	0.003	0.062	+0.002	Accept
Scalar	508.968	19	26.788	244.411 (5)***	0.972	0.014	0.075	0.013	Accept
Residual	812.657	24	33.861	303.689 (5)***	0.955	0.017	0.085	0.010	Accept
Factor variance	824.544	25	32.928	11.888 (1)**	0.955	0.000	0.083	+0.002	Accept
Shame domain (SPCE38 (44SH), SPCE7 (45SH), SPCE27 (48SH), SPCE57 (50SH), SPCE60 (51SH), SPCE47 (52SH))									
Configural	789.612	18	43.867	Ref	0.955	Ref	0.097	Ref	Accept
Metric	820.516	23	35.675	30.904 (5)***	0.954	0.001	0.087	+0.010	Accept
Scalar	916.249	29	31.595	95.733 (6)***	0.949	0.005	0.082	+0.005	Accept
Residual	1328.820	35	37.966	412.570 (6)***	0.925	0.024	0.090	0.008	Accept
Factor variance	1357.057	36	37.696	28.238 (1)***	0.904	0.021	0.089	+0.001	Accept
Guilt domain (SPCE50 (53GU), SPCE54 (54GU), SPCE8 (56GU), SPCE9 (58GU), SPCE53 (59GU), SPCE44 (60GU), SPCE39 (61GU))									
Configural	1214.211	28	43.365	Ref	0.957	Ref	0.096	Ref	Accept
Metric	1255.428	34	36.924	41.217 (6)***	0.956	0.001	0.088	+0.008	Accept
Scalar	1336.646	41	32.601	81.218 (7)***	0.953	0.003	0.083	+0.005	Accept
Residual	1853.963	48	38.624	517.317 (7)***	0.935	0.018	0.090	0.007	Accept
Factor variance	1822.289	49	38.414	28.326 (1)***	0.934	0.001	0.090	0.000	Accept
Alpha pride domain (SPCE52 (62ALPHA), SPCE41 (63ALPHA), SPCE46 (65ALPHA), SPCE2 (66ALPHA))									
Configural	30.545	4	7.636	Ref	0.996	Ref	0.038	Ref	Accept
Metric	32.093	7	4.585	1.548 (3)^{NS}	0.996	0.000	0.028	+0.012	Accept
Scalar	69.891	11	6.354	37.797 (4)***	0.991	0.005	0.034	0.007	Accept
Residual	78.078	15	5.205	8.188 (4)^{NS}	0.990	0.001	0.030	0.004	Accept
Factor variance	79.174	16	4.948	1.095 (1)^{NS}	0.990	0.000	0.029	0.001	Accept

(Continues)

TABLE 2 (Continued)

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Beta pride domain (SPCE56 (68BETA), SPCE4 (70BETA), SPCE33 (71BETA), SPCE36 (72BETA))									
Configural	61.987	4	15.497	Ref	0.992	Ref	0.056	Ref	Accept
Metric	78.645	7	11.235	16.658 (3)**	0.990	0.002	0.047	+0.009	Accept
Scalar	94.001	11	8.546	15.536 (4)**	0.989	0.001	0.041	+0.006	Accept
Residual	108.731	15	7.249	14.730 (4)**	0.987	0.002	0.037	+0.004	Accept
Factor variance	119.975	16	7.948	11.243 (1)**	0.986	0.001	0.038	0.001	Accept

Abbreviation: NS, not significant.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 3 Factor mean differences (SE) in each domain of the SPCE.

	Father's factor mean (SE) compared with mother
Happiness	-0.758 (0.048)***
Anger	-0.184 (0.049)***
Fear	−0.036 (0.041)^{NS}
Sadness	+0.086* (0.032)
Disgust	−0.039 (0.038)^{NS}
Shame	−0.137 (0.033)***
Guilt	−0.108 (0.035)**
Alpha pride	+0.186 (0.040)***
Beta pride	−0.025 (0.044)^{NS}

Abbreviation: NS, not significant.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

for DIF between F and S. We removed those items with DIF to secure measurement invariance across the different age groups (Table S3).

GRM

In all domains, the item threshold ranged from −2.085 to 4.200 (Table S4). In the Happiness domain, the item discrimination parameters ranged from 1.204 (SPCE29 "relieved") to 4.6 for (SPCE32 "happiness"). In the Anger domain, the item discrimination parameters ranged from 2.392 (SPCE37 "felt like throwing something") to 3.569 (SPCE55 "mad"). In the Fear domain, the item discrimination parameters ranged from 0.881 (SPCE3 "anxiety") to 3.550 (SPCE26 "scared"). In the Sadness domain, the item discrimination parameters ranged from 2.699 (SPCE49 "lonely") to 3.475 (SPCE17 "sad"). In the Disgust domain, the item discrimination parameters ranged from 2.545 (SPCE5 "couldn't put up with my child") to 3.431 (SPCE24 "felt like throwing it out"). In the Shame domain, the item discrimination parameters ranged from 2.167 (SPCE7 "felt like hiding away") to 3.647 (SPCE60 "felt myself dreadful"). In the Guilt domain, the item discrimination parameters ranged from 2.469 (SPCE8 "felt my child unfortunate") to 3.729 (SPCE54 "sorry"). In the Alpha Pride domain, the item discrimination parameter ranged from 1.280 (SPCE2 "competent as a parent") to 2.911 (SPCE46 "I was a good parent"). In the Beta Pride domain, the item discrimination parameters ranged from 1.943 (SPCE4 "fulfilled in childcare") to 2.819 (SPCE33 "proud of my childcare").

IIFs and TIFs were graphed from the parameters (Figures S1 and S2). It is of note that SPCE29 "relieved", SPCE3 "anxiety", and SPCE2 "competent as a parent" showed low, nearly flat lines in IIFs as compared to the other items that belonged to the same domain (see Happiness, Fear, and Alpha Pride in Figure S1). These items that drew lower lines in IIF were in accordance with low indices for a discrimination parameter. Therefore, we deleted SPCE29 "relieved", SPCE3 "anxiety", and SPCE2 "competent as a parent" from the SPCE. Therefore, the final number of SPCE items that remained was 43.

DISCUSSION

In this study, an empirical construct for parent-to-child emotions emerged. The final version of the SPCE consists of nine domains: Happiness (four items), Anger (six items), Fear (four

TABLE 4 Measurement invariance of final models for each domain between fetal stage (FS; $n = 1100$), infancy/preschool age (I/PA; $n = 2500$), and school age (S; $n = 1000$).

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Happiness domain (SPCE32 (01HA), SPCE29 (02HA), SPCE11 (03HA), SPCE31 (04HA), SPCE13 (06HA), SPCE51 (08HA))									
Configural	825.407	27	30.571	Ref	0.960	Ref	0.080	Ref	Accept
Metric	856.690	37	22.372	13.939 (5)^{NS}	0.958	0.002	0.069	+0.011	Accept
Scalar	1288.382	49	25.760	344.356 (6)***	0.937	0.021	0.074	0.005	Accept
Residual	1498.720	61	24.119	246.591 (6)***	0.927	0.010	0.072	+0.002	Accept
Factor variance	1524.561	63	24.199	121.037 (1)***	0.926	0.011	0.071	+0.001	Accept
Anger domain (SPCE62 (09AN), SPCE48 (10AN), SPCE42 (11AN), SPCE55 (12AN), SPCE59 (13AN), SPCE37 (l4AN), SPCE45 (15AN))									
Configural	975.746	42	23.232	Ref	0.973	Ref	0.070	Ref	Accept
Metric	1392.575	54	62.313	416.829 (12)***	0.961	0.012	0.073	0.003	Accept
Scalar	2263.665	68	33.586	871.089 (14)***	0.937	0.024	0.084	0.009	Accept
Residual	3011.214	82	36.922	747.549 (14)***	0.915	0.022	0.088	0.004	Accept
Factor variance	3101.486	84	36.922	90.272 (2)***	0.913	0.002	0.088	0.000	Accept
Fear domain (SPCE26 (16FE), SPCE14 (19FE), SPCE3 (20FE), SPCE28 (21FE), SPCE25 (42SU))									
Configural	297.200	15	19.813	Ref	0.971	Ref	0.064	Ref	Accept
Metric	361.246	23	15.706	64.046 (8)***	0.965	0.007	0.057	+0.007	Accept
Scalar	479.442	33	14.529	118.196 (10)***	0.954	0.023	0.054	+0.003	Accept
Residual	661.976	43	15.395	182.534 (10)***	0.936	0.017	0.056	0.002	Accept
Factor variance	662.094	45	14.713	0.118 (2)^{NS}	0.936	0.000	0.055	+0.001	Accept
Sadness domain (SPCE17 (24SA), SPCE16 (25SA), SPCE49 (26SA), SPCE58 (28SA), SPCE30 (29SA))									
Configural	881.795	30	29.393	Ref	0.950	Ref	0.079	Ref	Accept
Metric	902.990	34	26.559	21.196 (4)***	0.949	0.001	0.075	+0.004	Accept
Scalar	966.601	39	24.785	63.610 (5)***	0.946	0.003	0.072	+0.003	Accept
Residual	1029.633	44	23.401	63.032 (5)***	0.942	0.004	0.070	+0.002	Accept
Factor variance	1043.761	45	23.195	14.128 (1)***	0.942	0.000	0.069	+0.001	Accept

TABLE 4 (Continued)

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Disgust domain (SPCE5 (30DI), SPCE24 (31DI), SPCE40 (32DI), SPCE35 (35DI), SPCE18 (36DI))									
Configural	200.016	15	13.334	Ref	0.989	Ref	0.052	Ref	Accept
Metric	301.611	23	13.114	101.595 (8)***	0.984	0.005	0.051	+0.001	Accept
Scalar	499.371	33	15.132	197.760 (10)***	0.973	0.011	0.055	0.004	Accept
Residual	625.578	43	14.548	126.207 (10)***	0.966	0.007	0.054	+0.001	Accept
Factor variance	647.235	45	14.383	21.657 (2)***	0.965	0.001	0.054	0.000	Accept
Shame domain (SPCE38 (44SH), SPCE7 (45SH), SPCE27 (48SH), SPCE57 (50SH), SPCE60 (51SH), SPCE47 (52SH))									
Configural	725.736	27	26.879	Ref	0.959	Ref	0.075	Ref	Accept
Metric	778.407	37	21.038	52.672 (10)***	0.957	0.003	0.066	+0.009	Accept
Scalar	1159.272	49	23.659	380.865 (12)***	0.935	0.022	0.070	0.004	Accept
Residual	1487.828	61	24.391	328.556 (12)***	0.917	0.018	0.071	0.001	Accept
Factor variance	1509.308	63	23.957	21.481 (2)***	0.916	0.001	0.071	0.000	Accept
Guilt domain (SPCE50 (53GU), SPCE54 (54GU), SPCE8 (56GU), SPCE9 (58GU), SPCE53 (59GU), SPCE44 (60GU), SPCE39 (61GU))									
Configural	1199.358	42	28.556	Ref	0.958	Ref	0.077	Ref	Accept
Metric	1345.287	54	24.913	145.928 (12)***	0.953	0.005	0.072	+0.005	Accept
Scalar	1673.459	68	24.610	328.172 (14)***	0.942	0.011	0.072	0.000	Accept
Residual	2468.618	82	30.105	795.160 (14)***	0.914	0.028	0.080	0.008	Accept
Factor variance	2496.926	84	29.725	28.308 (2)***	0.913	0.001	0.079	+0.001	Accept
Alpha pride domain (SPCE52 (62ALPHA), SPCE41 (63ALPHA), SPCE46 (65ALPHA), SPCE2 (66ALPHA))									
Configural	32.219	6	5.370	Ref	0.996	Ref	0.031	Ref	Accept
Metric	45.385	12	3.782	13.166 (8)*	0.995	0.001	0.025	+0.006	Accept
Scalar	115.413	20	5.771	70.028 (8)***	0.985	0.010	0.032	0.007	Accept
Residual	135.765	28	4.849	20.352 (8)**	0.983	0.002	0.029	+0.003	Accept
Factor variance	136.018	30	4.534	0.252 (2)^{NS}	0.983	0.000	0.028	+0.001	Accept

(Continues)

TABLE 4 (Continued)

	χ^2	df	χ^2/df	$\Delta\chi^2$ (df)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
Beta pride domain (SPCE56 (68BETA), SPCE4 (70BETA), SPCE33 (71BETA), SPCE36 (72BETA)) Partial invariance (Scalar of SPCE4 was freely estimated)									
Configural	62.497	6	10.416	Ref	0.992	Ref	0.045	Ref	Accept
Metric	69.183	12	5.765	6.686 (6)^{NS}	0.992	0.000	0.032	0.013	Accept
Scalar	163.593	18	11.104	94.310 (6)***	0.980	0.012	0.042	0.010	Accept
Residual	183.744	26	7.067	20.251 (8)**	0.978	0.002	0.036	+0.006	Accept
Factor variance	187.218	28	6.686	3.474 (2)^{NS}	0.978	0.000	0.035	+0.001	Accept

Abbreviations: NS, not significant.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 5 Factor mean differences (SE) in each domain of the SPCE between fetal stage (FS; $n = 1100$), infant/preschool age (I/PA; $n = 2500$), and school age (S; $n = 1000$).

	Factor mean difference (SE)			
Domain	**Fetal stage (FS)**	**Infant/Preschool age (I/PA)**	**School age (S)**	**Comparison**
Happiness	0	0.663 (0.059)***	0.380 (0.072)***	FS < S < I/PA
Anger	0	0.548 (0.058)***	1.256 (0.070)***	FS < I/PA < S
Fear	0	−0.215 (0.051)***	−0.224 (0.061)***	S < I/PA < FS
Sadness	0	−0.034 (0.049)^{NS}	0.318 (0.059)***	FS, I/PA < S
Disgust	0	0.148 (0.046)**	0.381 (0.056)***	FS < I/PA < S
Shame	0	0.221 (0.040)***	0.483 (0.048)***	FS < I/PA < S
Guilt	0	0.228 (0.043)***	0.587 (0.052)***	FS < I/PA < S
Alpha pride	0	0.302 (0.050)***	0.203 (0.060)***	FS < S < I/PA
Beta pride	0	0.511 (0.055)***	0.279 (0.066)***	FS < S < I/PA

Note: Factor mean differences for fetal stage (FS; $n = 1000$) = 0.

Abbreviation: NS, not significant.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 6 Factor mean differences (SE) in each domain of the SPCE between fetal stage (FS; $n = 1100$), infant/preschool age (I/PA; $n = 2500$), and school age (S; $n = 1000$).

	Factor mean difference (SE)			
Domain	**Fetal stage (FS)**	**Infant preschool age (I/PA)**	**School age (S)**	**Comparison**
Happiness	−0.663 (0.059)***	0	−0.283 (0.061)***	FS < S < I/PA
Anger	−0.548 (0.058)***	0	0.078 (0.060)***	FS < I/PA < S
Fear	0.215 (0.051)***	0	−0.009 (0.052)^{NS}	I/PA, S < FS
Sadness	0.034 (0.049)^{NS}	0	0.352 (0.050)***	FS, I/PA < S
Disgust	−0.148 (0.046)**	0	0.232 (0.048)***	FS < I/PA < S
Shame	−0.221 (0.040)***	0	0.262 (0.041)***	FS < I/PA < S
Guilt	−0.258 (0.043)***	0	0.328 (0.044)***	FS < I/PA < S
Alpha pride	−0.302 (0.050)***	0	−0.099 (0.051)^{NS}	FS < I/PA, S
Beta pride	−0.511 (0.055)***	0	−0.232 (0.057)***	FS < S < I/PA

Note: Factor mean differences for infant/preschool age (I/PA; $n = 1000$) = 0.

Abbreviation: NS, not significant.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

items), Sadness (five items), Disgust (five items), Shame (five items), Guilt (seven items), Alpha Pride (three items), and Beta Pride (four items). The initial 62 items of the SPCE were reduced to 43 items. These emotions are fundamental basic/self-conscious emotions that motivate parental behaviors. The uniqueness of our study was the instrument's measurement invariances, including factorial invariance of each domain of the SPCE, which were held across the parents' gender and child's age setting. The factorial structure of a theoretical construct is equivalent across populations (Byrne, 2013). This evidence makes it possible to compare scores of parents between different genders and child's age.

In comparison of factor means between fathers and mothers, fathers' emotions were rated lower than mothers on most emotions: Happiness, Anger, Shame, and Guilt. Gender differences

in latent mean observed through several dimensions of the SPCE were in concordance with Deng's (2016) reports. This author recorded heart rate (HR) as an indicator of emotional experience while the participants watched 16 video clips that included eight types of emotion (sadness, anger, horror, disgust, neutrality, amusement, surprise, and pleasure). Participants were rated on valence, arousal, and motivation, using the paper version Self-Assessment Manikin (Hodes et al., 1985). Although men and women had the same emotional experience, stronger emotional expressivity, particularly higher arousal, was observed among more women than men in anger, amusement, pleasure, horror, disgust, and sadness. Gender roles are different between men and women. Women believe in emotional sensitivity; men believe in emotional self-control (Shields, 2005, 2013; Shields & Warner, 2008). Emotional function as a parent in parenting behavior is likely to differ between men and women. Fathers' Alpha Pride was higher than mothers' in this study. Men are more prone to Alpha Pride (pride in self) than women, whereas women are more prone to Shame and Guilt (Tangney, 1990). Therefore, fathers are likely to report more Alpha Pride than mothers. On the other hand, mothers are likely to feel more Shame and Guilt than fathers, when they imagine their child. Caution should be exercised before drawing conclusions because our sample was Japanese parents where fathers (men) are reluctant to express emotions directly. Alternatively, men may be less likely to recognize mental illnesses when they are depressed (Andou & Kitamura, 2013).

In comparison of factor means between the three age groups, parents of a child of fetal stage were scored the lowest in all of the domains except for Fear. Humans feel disgusted when they encounter a moral violation of divinity (Haidt & Graham, 2007; Rozin et al., 1999). It would be hard for a parent to feel disgusted if he/she found divinity in his/her own child. Presumably because of necessity of care and protection, the parent feels a kind of divinity in their own younger child. Therefore, the factor mean for Disgust may become higher as the child becomes older. In our study, Anger also became higher as the child became older. Anger and Rejection, one of the dimensions of the Mother Infant Bonding Scale (MIBS), was associated with the older age of the child (Kitamura et al., 2015). This suggests that parent's Anger emotions are similar to the concepts of Anger and Rejection in MIBS. Parents are more likely to experience the Anger emotion as the child gets older. Shame and Guilt also become higher as the child becomes older. It is of note that self-conscious emotions such as Shame and Guilt which a parent has toward a child increases as one's own child grows older.

Fear is an emotion that arises with the threat of harm, either physical, emotional, or psychological, real or imagined (Ekman & Friesen, 2003), focusing on the threat of future harm (Lazarus, 1991). A parent recognizes his/her responsibility for and obligation to a child even if the child is a fetus. A parent and a mother in particular is a sole protector of the fetus. A parent may be fearful to bear the entire responsibility for their own child's life and future. As the fetus is born and grows from infancy into toddlerhood. A parent gradually attains the parental role in the process of their own child's growth. The Fear emotion may fade gradually, whereas a parent may attain "pride" as a parent instead of fear. Those emotions should be assessed separately, and it may be better not to add the scores of all domains together. Weidman et al. (2017) claimed that measuring one specified distinct emotion rather than closely related emotion will better be able to affirm empirical claims. Different parent-to-child emotions are likely to have different motivations and lead to different behaviors.

The empirical construct of parent-to-child emotions that the SPCE identifies is unique and casts new light on the concept of parental bonding toward a child. Since the term "maternal–infant bonding" was first introduced by Rubin (1967a, 1967b), this concept has been discussed for a couple of decades (Kinsey & Hupcey, 2013; Walsh, 2010). Many tools for measuring mother-to-infant bonding have been developed. However, psychometric properties and qualities of these instruments were reported, in a systematic review (Wittkowski et al., 2020), as inadequate with only three scales rated "low" and 14 measures as "very low" for relevance,

comprehensiveness, and comprehensibility. Despite clinical and research importance of parental bonding, we have no tools yet to measure it with scientific rigor. We think that there is confusion about boundaries of the bonding concept. Some authors define it as an expression of only parental love toward a child (e.g., Maternal Antenatal Attachment Scale [MAAS, Condon, 1993]), some define it a set of parental emotions toward a child (e.g., Mother to Infant Bonding Questionnaire [MIBQ, Kumar & Hipwell, 1996]), and some others expand it from parental emotion to parenting motivation and behaviors (including parental harm toward a child) (e.g., The Postpartum Bonding Questionnaire [PBQ, Brockington et al., 2006; Brockington et al., 2001]; Prenatal Attachment Inventory [PAI, Müller, 1993]). We claim that parental emotion, motivation, and practices should be both conceptualized and measured separately. In addition, bonding studies thus far have focused mainly on mothers. Unduly little attention has been paid to fathers' bonding. Our study demonstrated the SPCE was psychometrically the same for mothers and fathers. Only with such a measure can researchers compare maternal and paternal emotions toward a child. The development of the SPCE may contribute to opening a new avenue of parental bonding research.

Our study is not without limitations. First, the data we used for validation and measurement invariance results were actually from Japanese parents in Japanese culture. Hence, validation to use this scale should be examined across different cultural settings. Second, the target of this study was limited to parents' emotions toward his/her eldest child (or fetus). We need to confirm whether the same construct with our study can be replicated to parental emotions toward the second or subsequent child. Third, our study was a cross-sectional design, and test-retest reliability was not examined. We need to examine the stability of each domain of our new scale among the same participants followed up across a certain interval. Fourth, construct validity, including convergent validity and discriminant validity awaits thorough investigation. We have a plan to do this soon. Of theoretical interest is consideration of the items deleted during the "brush up" procedure. We may have overlooked important differences between the two parents because mothers and fathers may really do experience these emotions differently. Nevertheless, we think, as many emotion researchers (after the classical work done by Darwin, 1872), that emotions are essential the same across people with different attributes and that emotions are also "colored" by the characteristics of attributes (such as parents' gender and others). Research on the attributional coloring should be ushered by studies about attribute-non-specific elements of emotions. Our research was based on this assumption. Needless to say, we are interested in future studies focusing the effects of parental gender, children's age, cultural and linguistic differences to name just a few, on the attribute specific aspects of parental emotions. Finally, although the number of items was reduced to 43, it may still be too many items for use in clinical or research settings and follow-up situations in particular. We need to develop an abridged version. Our report may be followed by a report of development of a short version of the SPCE. Taking into account these drawbacks, the SPCE is a promising tool for measuring parent-to-child emotions.

CONCLUSION

The SPCE was developed via a process of rigorous conceptualization and translation, careful consideration by research members, and detailed statistical analysis in this study. An empirical construct of parental emotions toward a child was derived. These derived constructs were confirmed by measurement invariance across parents' gender and the three age ranges of the child. In addition, factor mean differences of each domain were compared. The SPCE makes it possible to measure parent-to-child emotions across parents' gender and the three age ranges of the child.

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DATA AVAILABILITY STATEMENT

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

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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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