Journal of Psychiatric Research 135 (2021) 1–7

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

Factor structure of the Postpartum Bonding Questionnaire: Configural invariance and measurement invariance across postpartum time periods

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ARTICLE INFO

Keywords:
Postpartum bonding questionnaire
Factor structure
Configural and measurement invariance

ABSTRACT

Background: Despite the research and clinical significance of the Postpartum Bonding Questionnaire (PBQ), its psychometric properties have not been studied intensively. The goodness-of-fit of proposed factor models of the PBQ is poor. Configural and measurement invariance have never been reported.
Methods: As a secondary analysis of the previous paper (Ohashi et al., 2016), we analysed the PBQ data at 5 days and 1 month after childbirth among 247 mothers of a singleton. We created 9 parcels of PBQ items to perform confirmatory factor analysis (CFA). We also examined configural and measurement invariances of the PBQ factor structure between the two observation times.
Results: The CFI of the 3-factor model of the PBQ was .936 and .968 for 5 days and 1 month after childbirth, respectively. Configural, measurement (metric, scalar, and residual), and structural (factor variance and factor covariance) invariances were accepted. The mean of only 'anger and restrictedness' factor was scored higher at 1 month than 5 days after childbirth.
Conclusion: The 3-factor model of the PBQ was good in its fit with the data as well as robust in its measurement between the two observation time periods.

1. Introduction

"Every mother loves her own baby" is a myth: mothers with bonding disorders during the perinatal period suffer from the difficulty of having affectionate emotional bonds with their baby. Postnatal bonding disorder is one of the most serious mental health issues (Brockington 2017), which may be linked to other maternal psychological issues such as depression (Saito et al., 2019). It may also be followed by lack of desire to have another baby (Kitamura et al., 2019) as well as neonatal abuse (Baba et al., 2019). Research has shown that bonding disorders but not depression predicted neonatal emotional abuse at one month after childbirth (Choi et al., 2010; Kitamura et al., 2014; Ohashi et al., 2016b). Research has reported that mothers who have poor bonding towards their baby were characterised by poor mother-infant interactions (Hornstein et al., 2006).

Instruments have been developed for identifying postpartum bonding and bonding disorders (for review, Yamashita et al., 2019). One of them is the Postpartum Bonding Questionnaire (PBQ: Brockington et al., 2001). This questionnaire has been translated into many languages including French, German, Spanish, Swedish, Tamil, and Japanese (Yamashita et al., 2019) and is widely used in research and clinical settings. Nevertheless, its factor structure has been reported without clear consensus (Table 1). There may be a variety reasons for this lack of consensus. First, previous studies used different statistical methods. Some researchers used principal component analysis (PCA) (Brockington et al., 2001; Busonera et al., 2017; Reck et al., 2006; Vengadavaradan et al., 2019). However, PCA is different from factor analysis. PCA assumes a component that is presumed from several indicators (Fig. 1). For example, we can measure educational level, occupation, and annual income of individuals and from these we

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https://doi.org/10.1016/j.jpsychires.2020.11.017
Received 20 April 2020; Received in revised form 16 October 2020; Accepted 5 November 2020
Available online 9 November 2020
0022-3956/

Table 1
Comparison of studies on the factor structure of the PBQ.

Authors (year); Language	N	Research design	Timing of assessment	Type of factor analysis	No. of factors	Model fit	Configural invarinace	Measurement invariance
Brockington et al. (2001); **English**	104	CS	Not known	PCA	4	None	Not done	Not done
Reck et al. (2006); **German**	862	CS	2 weeks after CB	PCA	1(16 items)	None	Not done	Not done
Wittkowski et al. (2010); **English**	132	CS	3 months after CB	CFA/PCA	3*(23 items / 22 items)	CFI = .57, RMSEA = 0.19	Not done	Not done
Kaneko and Honjo (2014); **Japanese**	1786	CS	3 months after CB	EFA	1 (16 items)	None	Not done	Not done
Suetsugu et al. (2015); **Japanese**	244	TR	4 weeks after CB	EFA	4 (14 items)	None	Not done	Not done
Ohashi et al. (2016); **Japanese**	364	TR	1 month after CB	EFA/CFA	3	CFI = .82, RMSEA = 0.08	Not done	Not done
Garcia-Esteve et al. (2016); **Spanish**	840	CS	4–6 weeks after CB	EFA	4	None	Not done	Not done
Busonra et al. (2017); **Italian**	123	CS	3 months after CB	PCA	3	None	Not done	Not done
Vengadavaradan et al. (2019); **Tamil**	250	CS	4 weeks to 6 months after CB	PCA	5 (19 items)	None	Not done	Not done

CB, childbirth; CFA, confirmatory factor analysis; CFI, comparative fit index; CS, cross-sectional design; EFA, exploratory factor analysis; PCA, principal component analysis; RMSEA, root mean square error of approximation; TR, test-retest design. * Three-factor 23-item model did not show sufficient model fit by CFA, and PCA identified three-factor 22-item model.

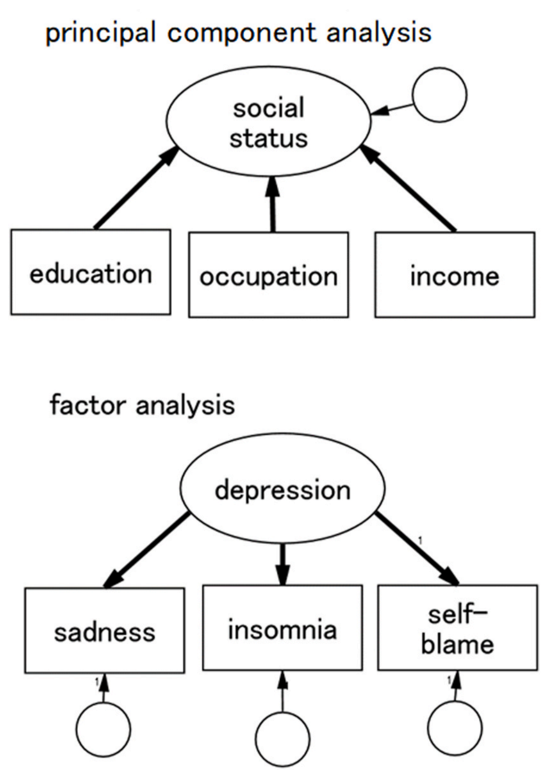

Fig. 1. Comparison of principal component analysis (PCA) and factor analysis.

presume social status. To put it differently, the educational level, occupation, and annual income of individuals are causes and social status is their result. On the other hand, factor analysis assumes the existence of a latent structure, i.e., factor, which is a cause of observable indicators. For example, researchers measure individuals' sadness, insomnia, and self-blame as reflections of latent depression. Here, depression is a cause and sadness, insomnia, and self-blame are the consequences or reflection of the latent variable, depression. As in many other psychological properties (DeVillis, 2016), bonding and bonding disorder are presumed latent properties that cause observable indicators. Hence, use of PCA as a means to identify factors of bonding disorder is not appropriate. Factor analysis should be given priority.

Second, some researchers performed exploratory factor analysis (EFA) but not confirmatory factor analysis (CFA) (Garcia-Esteve et al., 2016; Kaneko and Honjo, 2014; Suetsugu et al., 2015). The number of factors in EFA can be arbitrarily posited and, therefore, the model's fitness with the data should be estimated by CFA. The results of CFAs of the PBQ items were reported by Wittkowski et al. (2010) and Ohashi et al. (2016a). Wittkowski et al. however, tested the goodness-of-fit of the three-factor model based on four-factor model proposed by Brockington et al. (2001) in a sample of 104 mothers. They did not compare different models searching for the best fit model. Third, there were researchers who made short versions of the PBQ. Thus, Kaneko and Honjo (2014) and Suetsugu et al. (2015) proposed 16- and 14-item versions, respectively. Because many original PBQ items were deleted in these versions, comparison with the original 25-item version became impossible.

The two studies using CFA for PBQ items (Ohashi et al., 2016a; Wittkowski et al., 2010) both showed very unsatisfactory goodness-of-fit of the models: CFI was 0.82 and 0.57, respectively (although the final model was the best in comparison with other models). These statistics were not close enough to the often used criterion to be acceptable (CFI > 0.95). There may be several reasons for this unsatisfactorily low goodness-of-fit. First, a large number of the 25 items of the full PBQ may distort the item number/factor ratio. This may inevitably result in a large number of items belonging to each latent factor. This likely produces covariance of error variables (which violates the proposition of structural equation modelling). Kryazos (2018) mentioned three methods to deal with small sample size in CFA: (a) the use of indicators with good psychometric properties and with standardized coefficients > 0.70, (b) The use of equality constraints on the unstandardized coefficients of indicators that belong to the same factor, and (c) use item-parceling to analyses indicators. Considering these methods, the first one may lead to deletion of items from the original scale (therefore not the same questionnaire), and the second one needs constraint which is often unrealistic. Therefore, to avoid the possibility of deletion of the items and to put a more realistic assumption of the relationship of factor and items, it would be better to use a parceling method. By creating parcels and using them as indicators instead of scale items in CFA, the number of items belonging to each latent factor could be decreased and item/factor ratio become alleviated. It could be less likely to produce covariance of error variables. Second, a 6-point scale used for each PBQ item and extreme skewness of each PBQ item may violate normality of the data. Using parcels also alleviate skewness by aggregating the items. Taking into consideration these issues, we created parcels of PBQ items

(Matsunaga, 2008) in the present analyses. Parceling is aggregation of individual items into one or more composite variables. This may be followed by a better item/factor ratio, greater normality, and less covariance between error variables. CFA of these parcels rather than items may produce a more stable solution and therefore be more increasingly used in studies of psychometric properties. Three parcels per each factor was the recommended number (Matsunaga, 2008). While there are several means to create parcels, Matsunaga (2008) recommended selection of the items randomly to create parcels namely the random algorithm as the most appropriate.

Another drawback of the previous studies on the PBQ factor structure was lack of configural and measurement invariance of the model (Table 1). Identification of the best fit model for factor structure does not automatically indicate that the same test measures the same phenomena when used in different populations or used in the same population but at different times. Hence, configural and measurement invariance of the test should be examined before being used in the research and clinical settings (Byrne, 2009). Only when this is confirmed can researchers suggest that indicators of a test have the same meaning. Instruments to measure maternal bonding particularly need confirmation of measurement invariance across a puerperium period because maternal bonding varies greatly in a short period – around 6 months after childbirth (Brockington et al., 2001;.Klier 2006; Muzik et al., 2013; van Bussel et al., 2010; Yoshida et al., 2012). These procedures include the following methods (Vandenberg and Lance, 2000). Configural invariance is confirmed when each group (e.g., data at 5 days and 1 month after childbirth) has the same pattern of indicators and factors. Metric invariance (weak factorial invariance) is confirmed when factor loadings for similar indicators are invariant across groups (in addition to configural invariance). Scalar invariance (strong factorial invariance) is confirmed when intercepts of similar items are invariant across groups (in addition to metric invariance). Residual invariance (strict factorial invariance) is confirmed when residuals of similar items are invariant across groups (in addition to scalar invariance). In addition, structural invariance is needed as an evidence of factor structure robustness. It includes factor variance (variances for similar factors are invariant), factor covariance (covariances between similar factors are invariant), and factor mean (means of similar factors are invariant) invariances. It is recommended that hypothesis testing be conducted in this order (Vandenberg and Lance, 2000). If one step is rejected, the subsequent steps are not to be performed.

The present report is the secondary analysis of the previous study of the PBQ among a Japanese population of mothers 5 days and 1 month after childbirth (Ohashi et al., 2016a). The number of PBQ factors was reported from one to five in previous studies. Among them, Ohashi et al. (2016) found that the 3-factor model containing all of the PBQ items showed relatively acceptable model fit indices. However, no model showed satisfactorily good fit with the data. Therefore, in this reanalysis, we created parcels out of all of the PBQ items and re-examined the goodness-of-fit of Ohashi et al.'s model. We also cast light on the configural, measurement, and structural invariances of the 3-factor model of the PBQ proposed by Ohashi et al. Confirming factor structure of the PBQ by re-analysis of Ohashi's model is also the premise of subsequent analyses examining measurement invariance across the time period.

2. Methods

2.1. Study procedures and participants

We solicited 55 obstetric clinics in Kumamoto Prefecture (located in the centre of Kyushu Island southwest of Tokyo) to participate with this questionnaire survey. Of these 55 clinics, 18 (33%) responded to our request including one university hospital, 12 public and private hospitals, and 5 private clinics. Hence, although this is a convenience sample, it was still considered to be a mixture of different types of antenatal institutions in this area. We then asked for the participation of pregnant women of at least 28 weeks' gestation who attended one of these antenatal clinics during the entire month of November 2011 (N = 1450). We distributed a set of questionnaires to these women during late pregnancy and again at 5 days (while in the hospital) and 1 month (while attending the one-month health check-up) after childbirth. In this study, after the explanation of the aims and methods of the study, including ethical consideration, women voluntarily returned the questionnaire via postal service indicating the intention to participate to the researcher (TK). In addition, some of the obstetric and demographic information regarding participants were also obtained from obstetric facility staff.

Because we were interested in the measurement and structure invariance between 5 days and 1 month after childbirth, the women who returned all three questionnaires, during late pregnancy (at least 28 weeks of gestation) and 5 days and 1 month after childbirth, became target participants in the study. Furthermore, because the maternal attitudes and emotions towards each baby of a twin is not necessarily the same, only mothers with a singleton were included in this study ($n = 247$). The mean (SD) of their age was 30.2 (4.7) years. The mean (SD) of their partner's age was 32.3 (6.1) years. Forty-eight percent of women ($n = 119$) were primiparas. This did not differ from that of mothers in general during that year in Japan (Ministry of Health, Labour and Welfare, 2013).

2.2. Measurements

The PBQ (Brockington et al., 2001) consists of 25 items that assesses mother's attitudes and emotions towards their infant. These items are rated on a 6-point scale (0–5). Higher scores indicate that the mother has a more negative attitude towards the infant. Eight items are positively worded, and these are reverse scored. Ohashi et al. (2016a) reported a 3-factor model of the PBQ: Anger and Restrictedness (AR), Lack of Affection (LA), and Rejection and Fear (RF). AR is associated with the mother's annoyance with or anger towards their baby and feeling that they were 'trapped'. LA represents lack of maternal affection and intimacy towards their baby. RF relates to maternal rejection and internal fear towards their baby. Thus, higher scores of the total or each subscale indicate that the mother has negative affection towards the baby.

2.3. Data analysis

Ohashi et al. (2016) compared different models of the PBQ factor structures including (a) a 3-factor model derived from an EFA in Ohashi's study, (b) a 4-factor model proposed by Brockington et al. (2001), (c) a 1-factor model proposed by Kaneko and Honjo (2014), and (d) a 4-factor model proposed by Suetsugu et al. (2015). This study reported that, among these four models, the best fit was obtained by the 3-factor model derived from Ohashi's EFA.

In the present secondary analysis, we first examined means, SDs, skewness, and kurtosis of all of the PBQ items. Then, we created 3 parcels for each of the 3 factors of the PBQ proposed by Ohashi et al. (2016a). Each parcel was generated by summing the scores of indicators randomly selected from the same factor of Ohashi's model, where items in a parcel would be regarded as unidimensional. Because, as noted later, many parcels were positively skewed, they were log transformed. The goodness-of-fit of factor structure models were examined in terms of different indices: χ^2, CFI, and root mean square error of approximation (RMSEA). A good fit was defined as $\chi 2/df < 2$, CFI >0.97, and RMSEA < 0.05. An acceptable fit was defined as $\chi 2/df < 3$, CFI >0.95, and RMSEA < 0.08 (Bentler, 1990; Schermelleh-Engel et al., 2003). However, when sample size is relatively small (smaller than $n = 500$) or model is complex, these criteria might be stringent, and use of more flexible criteria is suggested: CFI ≥0.90, RMSEA ≤0.10 (Weston and Gore, 2006). We also considered these flexible criteria in examining model fit. In addition, we used the Akaike information criterion (AIC: Akaike, 1974), in which a lower AIC was judged as being better. At 5 days and 1 month after

Table 2
Mean, SD, skewness, and kurtosis of each PBQ item and parcels at 5 days and 1 month after childbirth.

Parcel	Item	N	Contents	Mean	SD	Skewness	Kurtosis	Skewness after log trans	Kurtosis after log trans
ANGER & RESTRICTEDNESS: 5 days after childbirth									
1		240	Parcel 1 = items 2, 7, 22, & 25	5.04	3.01	0.32	0.40	−1.14	0.78
	07	247	My baby winds me up	0.45	0.70	1.52	2.24		
	02	247	I wish the old days when I had no baby would come back	0.32	0.67	2.84	10.23		
	22	244	I feel confident when changing my baby	2.21	1.45	−0.12	−1.10		
	25	241	My baby is easily comforted	2.03	1.46	0.32	−0.66		
2		242	Parcel 2 = items 8, 12, 13, 19, & 24	2.52	2.85	1.52	3.93	0.16	-.1.31
	19	247	My baby makes me anxious	0.43	0.79	2.22	6.16		
	13	247	I feel trapped as a mother	0.72	1.09	1.90	3.68		
	12	243	My baby cries too much	0.81	0.98	1.15	1.10		
	8	247	My baby irritates me	0.55	0.76	1.25	1.17		
	24	246	I feel like hurting my baby	0.02	0.13	7.70	57.71		
3		246	Parcel 3 = items 3, 14, 18, & 23	1.39	1.70	1.52	2.50	0.42	−1.05
	14	247	I feel angry with my baby	0.19	0.50	2.77	7.89		
	23	246	I feel the only solution is for someone else to look after my baby	0.75	0.91	1.08	0.73		
	03	247	I feel distant from my baby	0.42	0.92	3.01	10.66		
	18	247	I have done harmful things to my baby	0.02	0.16	10.62	121.20		
ANGER & RESTRICTEDNESS: 1 month after childbirth									
1		243	Parcel 1 = items 2, 7, 22, & 25	5.13	3.18	0.23	−0.15	−1.07	0.31
	07	246	My baby winds me up	0.76	0.84	0.97	1.30		
	02	245	I wish the old days when I had no baby would come back	0.43	0.69	1.39	0.82		
	22	246	I feel confident when changing my baby	2.03	1.47	0.10	−1.02		
	25	244	My baby is easily comforted	1.94	1.36	0.28	−0.58		
2		242	Parcel 2 = items 8, 12, 13, 19, & 24	3.17	2.86	1.21	3.06	−0.32	−1.06
	19	246	My baby makes me anxious	0.36	0.68	2.01	4.16		
	13	244	I feel trapped as a mother	0.95	1.14	1.38	2.07		
	12	245	My baby cries too much	1.00	1.13	1.19	0.99		
	08	245	My baby irritates me	0.82	0.87	1.17	2.74		
	24	246	I feel like hurting my baby	0.02	0.14	6.84	45.16		
3		243	Parcel 3 = items 3, 14, 18, & 23	1.61	1.89	1.45	2.46	0.32	−1.15
	14	246	I feel angry with my baby	0.33	0.62	2.22	6.30		
	23	244	I feel the only solution is for someone else to look after my baby	0.80	0.96	1.18	1.32		
	03	245	I feel distant from my baby	0.46	0.99	2.88	8.99		
	18	246	I have done harmful things to my baby	0.02	0.15	6.20	36.79		
LACK OF AFFECTION: 5 days after childbirth									
1		247	Parcel 1 = items 9 & 11	0.49	1.11	2.57	6.10	1.85	2.20
	11	247	I enjoy playing with my baby	0.38	0.90	2.96	9.66		
	09	247	I feel happy when my baby smiles or laughs	0.11	0.48	6.20	49.53		
2		247	Parcel 2 = items 1 & 4	0.61	1.17	2.66	8.03	1.45	1.14
	04	247	I love to cuddle my baby	0.26	0.74	4.14	20.91		
	01	247	I feel close to my baby	0.35	0.67	2.07	4.11		
3		247	Parcel 3 = items 10 & 16	0.68	1.42	2.59	6.81	1.62	1.45
	16	247	My baby is the most beautiful baby in the world	0.36	0.89	2.86	8.03		
	10	247	I love my baby to bits	0.32	0.76	3.24	13.36		
LACK OF AFFECTION: 1 month after childbirth									
1		246	Parcel 1 = items 9 & 11	0.49	1.13	4.09	24.06	1.84	2.95
	11	246	I enjoy playing with my baby	0.37	0.74	2.53	8.18		
	09	246	I feel happy when my baby smiles or laughs	0.11	0.55	6.78	53.64		
2		246	Parcel 2 = items 1 & 4	0.50	1.09	2.59	6.26	1.81	2.14
	04	246	I love to cuddle my baby	0.24	0.73	4.28	21.92		
	01	246	I feel close to my baby	0.26	0.60	2.65	7.17		
3		245	Parcel 3 = items 10 & 16	0.71	1.39	2.25	4.70	1.45	0.78
	16	246	My baby is the most beautiful baby in the world	0.38	0.88	2.88	9.19		
	10	245	I love my baby to bits	0.33	0.75	3.18	12.99		
REJECTION & FEAR: 5 days after childbirth									
1		247	Parcel 1 = items 5 & 6	0.23	0.67	3.77	17.14	2.66	6.36
	05	247	I regret having this baby	0.03	0.18	5.32	26.47		
	06	247	The baby does not seem to be mine	0.19	0.60	3.99	20.36		
2		247	Parcel 2 = items 15 & 17	0.07	0.41	8.60	91.91	5.49	34.50
	17	247	I wish my baby would somehow go away	0.06	0.38	10.14	122.43		
	15	247	I resent my baby	0.02	0.13	7.71	57.96		
3		246	Parcel 3 = items 20 & 21	0.18	0.68	5.13	31.65	3.48	12.39
	21	247	My baby annoys me	0.07	0.31	5.71	39.91		
	20	246	I am afraid of my baby	0.11	0.46	5.08	30.05		
REJECTION & FEAR: 1 month after childbirth									
1		246	Parcel 1 = items 5 & 6	0.22	0.67	4.10	19.82	2.84	7.68
	05	246	I regret having this baby	0.04	0.23	5.46	32.45		
	06	246	The baby does not seem to be mine	0.17	0.57	4.47	25.91		
2		246	Parcel 2 = items 15 & 17	0.07	0.33	4.81	23.35	4.40	18.58
	17	246	I wish my baby would somehow go away	0.04	0.23	5.46	32.45		
	15	246	I resent my baby	0.03	0.17	5.71	30.82		

(*continued on next page*)

Table 2 (*continued*)

Parcel	Item	N	Contents	Mean	SD	Skewness	Kurtosis	Skewness after log trans	Kurtosis after log trans
3		244	Parcel 3 = items 20 & 21	0.18	0.67	5.19	33.89	3.37	11.38
	21	244	My baby annoys me	0.10	0.37	4.50	23.39		
	20	246	I am afraid of my baby	0.09	0.39	5.38	31.60		

Table 3
Comparison of PBQ factor structure models.

Model	χ^2	df	χ^2/df	$\Delta\chi^2$ (*df*)	CFI	ΔCFI	RMSEA	ΔRMSEA	AIC
5 days after CB									
1-factor	163.364	27	6.051	Ref	.811	Ref	0.143	Ref	217.364
3-factor	69.984	24	2.916	3.135	.936	0.125	0.088	0.055	129.984
1 month after CB									
1-factor	254.635	27	9.431	Ref	.735	Ref	0.185	Ref	308.635
3-factor	51.407	24	2.142	7.289	.968	0.233	0.068	0.117	111.407

***$p < .001$; AIC, Akaike information criteria; CB, childbirth; CFI, comparative fit index; RMSEA, root mean square error of approximation.

childbirth separately, we compared three models, starting from (a) a 1-factor model, then (b) a 3-factor model proposed by Ohashi et al. (2016a), and finally to (c) a 3-factor bifactor model (with a general factor). The model was considered better than the previous one only when the difference of χ^2 between the two models was statistically significant. This is because a simpler model meets the requirement of the parsimony principle.

After confirming the goodness-of-fit of the factor structure model, we further examined configural and measurement invariance across the two observation periods. If one step is rejected, the subsequent steps are not to be performed. Invariance from one step to the next was 'accepted' if we noticed either (a) a non-significant increase of χ^2 for *df* of difference, (b) a decrease of CFI less than 0.01, or (c) an increase of RMSEA less than 0.01 (Chen, 2007; Cheung and Rensvold, 2002). CFI and RMSEA may be better indicators of judging measurement invariance than χ^2 because χ^2 is sensitive to the sample size and, therefore, may produce excessive 'rejection' rates.

Because of the missing data of the PBQ could be regarded as missing completely at random (Little's MCAR test: $p = .9656$), we handled the missing data by pairwise deletion except for CFA, in which we handled the missing data by full information maximum likelihood method.

All statistical analyses were conducted using IBM SPSS 25 and 27, and Amos 25.

3. Ethical consideration

This study was approved by the Institutional Review Board (IRB) of the Kitamura Institute of Mental Health Tokyo.

4. Results

Of the 25 PBQ items, 18 and 17 showed skewness greater than 2.0 at both 5 days and 1 month after childbirth, respectively. Their kurtosis was also extremely positive. Of the total of 9 parcels we created: 6 showed skewness of 2 or more at both 5 days and 1 month after childbirth. Therefore, we log transformed parcels and yet 3 parcels still showed skewness of 2 or greater at both 5 days and 1 month after childbirth. However, their skewness became much milder (Table 2).

At 5 days and 1 month after childbirth separately, we compared different factor structure models using CFAs (Table 3). At both observation times, the 3-factor model showed acceptable fit with the data (CFI = 0.936 and 0.968 at 5 days and 1 month after childbirth, respectively). A 3-factor bifactor model (with a general factor) showed improper solution.

Using the 3-factor model of the PBQ factor structure, we examined configural and measurement invariance between 5 days and 1 month after childbirth. After accepting configural invariance, all the measurement invariances were accepted (Table 4). Factor variances and factor covariances (Fig. 2) did not differ between the two observation times. As to the factor mean, only the mean of AR was significantly higher at 1 month after childbirth than that at 5 days after childbirth (M = 0.101, *SE* = 0.046, $p < .05$).

5. Discussion

This study showed that the 3-factor structure of the full PBQ items showed acceptable fit with the data when PBQ items were parceled. Previous studies of CFA of PBQ items failed to achieve this level of fitness probably because of drawbacks using the item rather than parcels when conducting factor analysis. Such a procedure may include items with extreme skewness and large number of items for each factor. The former was, to some extent, overcome by log transformation and the latter by making parcels (Little et al., 2002, 2013; Hall et al., 1999). The PBQ items may be divided into three categories including AR, LA, and RF. This is important from both research and clinical perspectives. Correlates of bonding disorders may be better understood by linking them with specific factors separately. Clinical intervention may be constructed by paying attention to these specific factors.

It has never been tested whether the PBQ would show the same factor structure when used in different time periods. Our study showed that the

Table 4
Measurement and structural invariance of the PBQ.

	χ^2	df	χ^2/df	$\Delta\chi^2$ (*df*)	CFI	ΔCFI	RMSEA	ΔRMSEA	Judgement
configural	121.392	48	2.529	Ref	.954	Ref	0.056	Ref	ACCEPT
metric	130.440	54	2.416	9.048 (6) NS	.952	.002	0.054	-0.002	ACCEPT
scalar	152.762	63	2.425	22.322 (9) **	.943	.009	0.054	0.000	ACCEPT
residual	178.901	72	2.485	26.140 (9) **	.932	.011	0.055	0.001	ACCEPT
factor variance	180.336	75	2.404	1.435 (3) NS	.933	+.001	0.053	-0.002	ACCEPT
factor covariance	183.643	78	2.354	3.307 (3) NS	.933	.000	0.052	-0.001	ACCEPT

*$p < .05$; **$p < .01$; ***$p < .001$; CFI, comparative fit index; RMSEA, root mean square error of approximation.

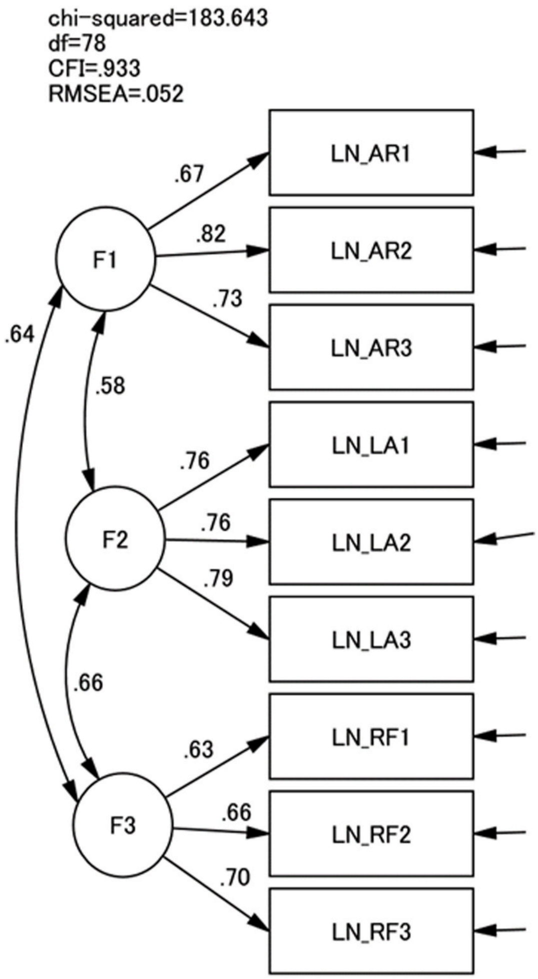

Fig. 2. Factor covariance invariance of the PBQ at day 5 and 1 month after childbirth
F1, F2, and F3 are Anger and Restrictedness, Lack of Affection, and Rejection and Fear, respectively. AR1, AR2, and AR3 are parcels of Anger and Restrictedness. LA1, LA2, and LA3 are parcels of Lack of Affection. RF1, RF2, and RF3 are parcels of Rejection and Fear. All the paths are standardiz
ed. Error variables are calculated but not shown.

PBQ showed the same factor structure whether used in the early days or 1 month after childbirth. This was the case not only at the configural but even the factor covariance level. This is promising in that we may use the PBQ repeatedly and compare the data collected at different time periods. To the extent of the findings, the suggested 3-factor model could be applied the period of early days to 1 month after delivery. It should be examined in further studies to extend periods which the 3-factor model is applicable.

Limitations of this study should be noted. First, the attrition rate of the present sample may raise concern. Replication studies are needed before reaching a conclusion. The fact that many PBQ items showed extreme skewness may indicate that the PBQ may be a better fit as a means to screen cases of bonding disorders among an at-risk population such as mothers reported to a Child Protection Agency or mothers who are admitted to mother-baby units. We obtained a better fit of the model by making parcels. However, this technique is relatively new and still a target of statistical debate (e.g., Meade and Kroustalis, 2006). The participants of the present study were only mothers. Fathers should be included in studies and the factor model of the PBQ among mothers and fathers should be compared.

Taking into consideration these drawbacks, this study demonstrated that the Japanese version of the PBQ has a robust factor structure with three subscales. This can be used repeatedly at different time points during the postnatal period.

Author contribution

Asami Matsunaga: Conceptualization, Methodology, Software, Writing-Original draft preparation. Yukiko Ohashi: Conceptualization, Writing-Original draft preparation, Kyoko Sakanashi: Writing-Review & Editing, Project administration, Toshinori Kitamura: Conceptualization, Methodology, Software, Writing-Original draft preparation, Supervision.

Declarations of interest

None.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

Acknowledgements

We thank all participating mothers and the staff of the antenatal clinics they attended and Dr. Chiyo Fujii for valuable comments on the manuscripts.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2020.11.017.

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