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How to Measure Maternal-Foetal Bonding: Validation of the Croatian Version of the Prenatal Attachment Inventory

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Abstract

Maternal-foetal bonding represents a bond that a mother has with her foetus. This study aimed to examine the psychometric properties of the Prenatal Attachment Inventory (PAI) in Croatian pregnant women. Adult pregnant women (N = 850) between 13 and 28 weeks of pregnancy filled out the PAI, Edinburgh Postnatal Depression Scale (EPDS), anxiety subscale of the Depression, Anxiety, and Stress Scale (DASS-21), and Pregnancy Concerns Scale (PCS). Confirmatory factor analyses (CFA) have shown that the hypothesised factor structures from previous studies demonstrated poor model fit. Subsequently, exploratory factor analysis (EFA) was conducted on half of the sample (n = 425) and revealed a two-factor structure. However, this was not confirmed by the CFA on the other half of the sample. Because the items mainly referred to baby movement, the process was repeated in a sub-sample of women pregnant 20 weeks or more (n = 502), with EFA and CFA conducted on half of the sub-sample. In the EFA, 21 items were reduced to 13, with three factors identified. In the CFA, we accepted the higher-order factor model with three first-order factors: Affection towards the foetus, Familiarity with foetal movement and behaviour, and Fantasising about the foetus. The total scale and three subscales demonstrated high reliability, good divergent validity, and adequate discriminant validity. Prenatal Attachment Inventory with 13 items has good psychometric properties when applied after 20 weeks of pregnancy. Further research is needed to establish valid measures for early maternal-foetal bonding.

Keywords: Prenatal Attachment Inventory, maternal-foetal bonding, factor structure, validity, reliability, Croatia

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Introduction

Attachment is a well-known construct that refers to the relationship a child develops with their primary caregiver, typically the mother, during the first year of life, which forms a secure base for development (Bowlby, 1969). This early relationship is a significant predictor of various psychopathological outcomes (Sutton, 2018) and attachment styles in adulthood (Kim et al., 2021). The parent-child relationship is bidirectional, involving an interplay of maternal sensitivity, responsiveness, mother-infant bonding, child attachment, and child outcomes (Deans, 2018; Nakić Radoš, 2021; Shin et al., 2008). The bond between parent and infant develops before birth and predicts the quality of later parent-child bonding (Brekalo et al., 2025; Daglar & Nur, 2018; Tichelman et al., 2019). Developing a relationship with the unborn child is a crucial developmental task for every expectant mother, especially for primiparous women. Although many scholars and clinicians have contributed to understanding this concept, the formal creator of the term "prenatal attachment" is Mecca Cranley (1981), a nurse who defined it as maternal behavioural interactions with the unborn child.

The antenatal relationship of a pregnant woman towards the foetus can be described as the mother's affective responses towards the foetus (Cranley, 1981), and should not be confused with attachment as initially defined by Bowlby, which refers to the relationship from the child towards the caregiver (1969). To avoid perpetuating this misconception, we use the term maternal-foetal bonding to reflect the maternal relationship towards the foetus. According to a recent definition of maternal bonding, it reflects not only affective responses towards the foetus, but also cognitive, behavioural, and neurobiological aspects (Nakić Radoš et al., 2024). Furthermore, its procedural nature has been emphasised, as bonding develops from pregnancy to the postpartum period. Research has found that bonding during pregnancy predicts lower rates of postpartum bonding disorders in both healthy and at-risk pregnancies, as well as a secure attachment style in childhood (Trombetta et al., 2021).

Maternal-foetal bonding has primarily been measured using self-report questionnaires, although projective measures have also been used at times (Taffazoli et al., 2015; van Bakel et al., 2013). Because there has been no uniform theoretical framework or model of bonding during pregnancy to date (Nakić Radoš et al., 2024), a dozen instruments with different rationales have been constructed and used with some variations (Wittkowski et al., 2020). Self-report scales are constructed under the assumption that the relationship with the foetus is manifested in behaviours, attitudes, thoughts, and feelings that demonstrate care and commitment to the foetus. These may include nurturance (such as eating well and abstaining from smoking and alcohol), comforting actions (like stroking the belly), verbal interactions with the baby, physical preparation (such as buying baby clothes and furniture), discussing the baby and the future with the partner, choosing a name, and seeking information about the developing baby (Van den Bergh & Simons, 2009). Thoughts and feelings

may include attempts to visualise the developing baby, experiencing tender, loving thoughts, and feeling emotionally close, as opposed to feelings of irritation and distance towards the baby (Condon, 1993; Cranley, 1981). It is assumed that women are aware of these behaviours, attitudes, thoughts, and feelings, and can rate them on a scale. The most frequently used scales include the Maternal Fetal Attachment Scale (MFAS; Cranley, 1981), Maternal Antenatal Attachment Scale (MAAS; Condon, 1993), Maternal Attachment Inventory (MAI; Müller, 1994), and Prenatal Attachment Inventory (PAI; Müller, 1993).

The unidimensional PAI was developed, as Müller (1993, 1996) argued, in contrast to the multidimensional structure of the MFAS. The PAI was validated in a sample of 336 women with low-risk pregnancies, with gestational ages ranging from 14 to 41 (Müller, 1993). Most studies have shown a unidimensional structure consistent with the original conceptualisation (Arafah et al., 2021; Foley et al., 2021; Gau & Lee, 2003; Jurgens et al., 2010; Omani Samani et al., 2016), but contradictory findings have emerged. Some studies have revealed a three-factor structure (Letot et al., 2024; Pallant et al., 2014), bi-factor structure (Fujita & Otsuki, 2021), while others found the best fit in a five-factor structure (Busonera et al., 2017; Siddiqui et al., 1999; Vedova et al., 2008).

Previous studies have shown that some predictors are related to maternal-foetal bonding. Mental health issues are related to bonding, with depression and anxiety having a low effect size when predicting maternal-foetal bonding (Yarcheski et al., 2009). Additionally, women who have at least one child tend to experience lower maternal-foetal bonding than pregnant women without children (Condon & Corkindale, 1997), but according to meta-analyses, parity has a low effect size on maternal-foetal attachment (Tichelman et al., 2019; Yarcheski et al., 2009). Additionally, women who have previously experienced miscarriage tend to have lower maternal-foetal bonding in the first trimester of subsequent pregnancies (Tsartsara & Johnson, 2006), although findings are mixed according to the integrative review (Lee et al., 2017).

The PAI had not previously been validated in a sample of Croatian pregnant women; hence the aim of this study was to examine the PAI's factor structure, reliability, and divergent and discriminant validity. Unfortunately, convergent validity could not be tested in this study because no other questionnaire on maternal-foetal bonding had been translated and validated. According to the literature, the PAI did not consistently show a uniform factor structure. Therefore, we aimed to test one-factor, three-factor, five-factor, and bi-factor structures, with no firm expectations. We expected the inventory to demonstrate good reliability. Additionally, we anticipated that the PAI would show low to moderate correlations with peripartum depression, general anxiety symptoms, and specific pregnancy concerns. Finally, we expected differences in maternal-foetal bonding scores regarding parity and history of previous spontaneous pregnancy loss.

Method

Participants and Procedure

This was part of the longitudinal study with online follow-up of women throughout pregnancy and postpartum. Participants were recruited through personal contact or social media (advertising in groups or profiles related to peripartum topics) to complete the online questionnaire. All participants read the informed consent and agreed to participate before proceeding. They participated voluntarily and could withdraw at any time without consequences. Participants provided the code they used at each time-point assessment. There was a small incentive for participation - each month, two women were randomly selected to receive a gift card from a well-known drugstore. Data collection for the first time-point took place from October 2022 to January 2023. Ethical approval was obtained from the Ethics Committee of the Catholic University of Croatia.

The inclusion criteria were being in the second trimester of pregnancy (between 13 and 28 weeks), fluency in Croatian, and being 18 years of age or older. Data from 850 women, collected at the first time-point, were used for this study. Participants were on average 30 years old and 21 weeks pregnant (Table 1). Around half of the women were primiparous, and almost all were married or cohabitating with their partner. Also, three-quarters had college or university degrees. Around half of the women perceived their income as average, while only a small proportion perceived it as below average. The majority were from urban areas (large or small cities) and reported no current mental health issues. Around one-quarter of the participants had experienced a previous pregnancy loss.

Table 1

Socio-Demographic Data for Participants (N = 850)

Maternal characteristics		*M* (*SD*)
Maternal age (years)		30.54 (4.50)
Pregnancy weeks		20.88 (4.91)
		n (%)
Parity	Primiparous	484 (56.9)
	Multiparous	366 (43.1)
Marital status	Married	657 (77.3)
	Cohabiting	172 (20.2)
	Other	21 (2.5)
Education	Elementary or secondary school	204 (24.0)
	College or university	646 (76.0)
Socio-economic status	Below average	44 (5.2)
	Average	491 (57.7)
	Above average	315 (37.1)
Place of residence	City (>100,000 citizens)	493 (58.0)
	City (<100,000 citizens)	183 (21.5)
	Rural area	174 (20.5)
Current mental health issues[a]		39 (4.6)
Previous spontaneous pregnancy loss[a]		200 (23.5)

Note. [a] responses "yes".

Instruments

The *Prenatal Attachment Inventory* (PAI; Müller et al., 1993) is a 21-item self-report scale measuring maternal-foetal bonding in line with Müller's (1993) original conceptual definition. Items are rated on a 4-point scale from 1 (*almost never*) to 4 (*almost always*). The total score ranges from 21 to 84, with higher scores indicating higher levels of bonding during pregnancy. Previous studies have shown good reliability, with Cronbach's α ranging from .81 to .93 (Van den Bergh & Simons, 2009).

The *Edinburgh Postnatal Depression Scale* (EPDS; Cox et al., 1987; Croatian translation: Nakić Radoš et al., 2013) is a 10-item scale assessing the frequency of depressive symptoms in the peripartum period over the previous week. Items are scored on a four-point scale, ranging from 0 to 3. The total score ranges from 0 to 30, where higher score indicates more severe depressive symptoms. The scale showed high reliability, with McDonald's ω = .88 in this study.

The *Depression, Anxiety, and Stress Scale* - Anxiety subscale (DASS-21; Lovibond & Lovibond, 1995; Croatian translation: Reić Ercegovac & Penezić, 2012) is a shorter version of the full DASS-42-item version, and it consists of seven items measuring anxiety symptoms over the past week. Items are scored on a scale ranging from 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*). The anxiety subscale score is multiplied by two to make it comparable to the long-version results, i.e., from 0 to 42, with higher scores indicating higher anxiety levels. This subscale showed high reliability in our study with McDonald's ω = .82.

The *Pregnancy Concerns Scale* (PSS; Nakić Radoš et al., 2015) is a 16-item scale that measures cognitive aspects of pregnancy-specific anxiety, such as specific worries, fears, and concerns during the last month. Items are rated on a scale from 0 (*not concerned at all*) to 3 (*concerned a lot*). The total score ranges from 0 to 48, with higher scores indicating greater pregnancy-specific anxiety. In the present study, McDonald's ω was .88.

Statistical Analyses

Descriptive statistics and normality of the distribution were calculated. Univariate and multivariate outliers (using Mahalanobis distance) were examined, and no outliers required removal. To test the factor structures, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted. For EFA, the principal axis factoring method with Direct Oblimin rotation was used. For CFA, the Maximum likelihood estimator (MLM) was used. We reported the following model fit indices: Chi-square with Satorra-Bentler correction, Root Mean Square Error of Approximation (RMSEA), Standardised Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). McDonald's ω coefficient was calculated to assess reliability. Divergent validity of the PAI was examined using Pearson's correlations with depressive symptoms, general anxiety,

and pregnancy-specific anxiety. Discriminant validity was examined using known-groups differences via *t*-tests. SPSS Statistics 28.0 for Windows and Mplus 8.1 (Muthén & Muthén, 1998–2017) were used.

Results

Descriptive Statistics

Descriptive data and normality test results are presented in Table A1 in the Appendix. All inventory items obtained a full range from 1 to 4. Skewness and kurtosis for all items were below the cut-off scores of 3 for skewness and 10 for kurtosis (Kline, 2011).

Factor Structure

We conducted confirmatory factor analyses on different factor structures from the literature, as shown in Table 2. Model fit indices for all tested models indicated an unacceptable fit.

Since none of the previously obtained structures were acceptable, we randomly split the sample in half. In the first subsample ($n_1 = 425$), we conducted EFA. First, the correlation between items was examined to avoid correlations that were too low or too high, as proposed by Field (2009). All items were suitable for further analyses as correlation coefficients ranged from .30 to .60. Principal axis factoring analysis with Oblimin rotation was conducted. The data was adequate for factor analysis (KMO = .935). Bartlett's test of sphericity was significant, $\chi^2(210) = 4399.01$, $p < .001$. Four factors were extracted according to eigenvalues (8.868; 1.517; 1.222; 1.060) and parallel analysis, but the scree plot suggested a two-factor structure. Therefore, EFA was conducted again with a restriction to two factors (Factor 1: 1, 2, 3, 4, 6, 7, 13, 14, 15, 16, 18, 19, 20, and 21; Factor 2: 5, 9, 10, 11, and 12; Table A2 in Appendix). Items 8, and 17 had cross-loadings on both factors, so they were excluded. After that, to confirm the two-factor structure obtained from EFA, we conducted a CFA on the other half of the subsample ($n_2 = 425$). However, the model did not fit the data well and, therefore, could not be accepted, $SBS\text{-}\chi^2(151) = 630.147$, $p < .001$; RMSEA = .086 (90% CI = .079-.093); CFI = .837; TLI = .815; SRMR = .071.

As all factor structure models fitted the data poorly, and after examining the content of the items, we observed that the items mainly referred to foetal movements, which could be felt from the 20th week of pregnancy for most women. Therefore, we excluded women who were less than 20 weeks pregnant and conducted analyses on a selected sample of 502 pregnant women. Again, we randomly split the sub-sample

Table 2

The Results of the CFA Examination of Previously Published Factor Structures (N= 850)

Models	Factors and Items	SBS-χ^2 (*df*)	RMSEA	SRMR	CFI	TLI
1-factor model	All items	1486.95 (188) p = .000	.090 [.086-.094]	.064	.817	.796
3-factor model Letot et al. (2024)	Representations of the baby: 1, 2, 5, 7, 8, 12, 14, 16, 17 Maternal–foetal relationship: 3, 4, 6, 13, 15, 18, 19, 20, 21 Proprioceptive feeling: 9, 10, 11	1455.62 (186) p = .000	.090 [.085-.094]	.065	.822	.799
3-factor model Pallant et al. (2014)	F1: 1, 2, 7, 9, 12, 14, 16, 19, 21 F2: 4, 6, 10, 11, 17, 20 F3: 3, 5, 8, 13, 15, 18	1510.93 (186) p = .000	.092 [.087-.096]	.067	.814	.790
	With standard error correlation 3/13, 15/18, 10/11	1299.56 (183) p = .000	.085 [.080-.089]	.060	.843	.820
5-factor model Busonera et al. (2017)[a]	F1: 1, 2, 12, 14 F2: 3, 13, 15, 18, 21 F3: 16, 17, 19 F4: 4, 6, 7, 20 F5: 5, 8, 9, 10, 11	1530.65 (180) p = .000	.094 [.090-.098]	.107	.810	.779
5-factor model Vedova et al. (2008)[a]	F1: 15, 16, 19, 21 F2: 9, 10, 11, 17 F3: 3, 13, 14, 18 F4: 1, 2, 5, 7, 8, 12 F5: 4, 6, 20	1191.87 (179) p = .000	.082 [.077-.086]	.061	.858	.833
Bi-factor model (Fujita & Otsuki, 2021)	F1: 1, 7, 12, 2, 8, 10, 5, 9 F2: 3, 13, 14, 15, 18 F3: 4, 16, 21, 6, 17, 20, 11, 19	1029.31 (167) p = .000	.078 [.073-.083]	.058	.879	.848
	F1: parcel11 (1, 7, 12), parcel12 (2, 8, 10), parcel13 (5, 9) F2: parcel21 (3, 18), parcel22 (13, 15), parcel23 (14) F3: parcel31 (4, 16, 21), parcel32 (6, 17, 20), parcel33 (11, 19)	The model could not converge.				

Note. SBS-χ^2 (*df*) = Chi-square with Satorra-Bentler correction, RMSEA= Root Mean Square Error of Approximation, SRMR = Standardised Root Mean Square Residual, CFI = Comparative Fit Index, TLI = Tucker-Lewis Index.

[a] The latent variable covariance matrix (psi) was not positive definite.

in half, conducting EFA on one half ($n_1 = 255$), and CFA on the other half ($n_2 = 247$). Again, Principal axis factoring analysis with Oblimin rotation was performed.

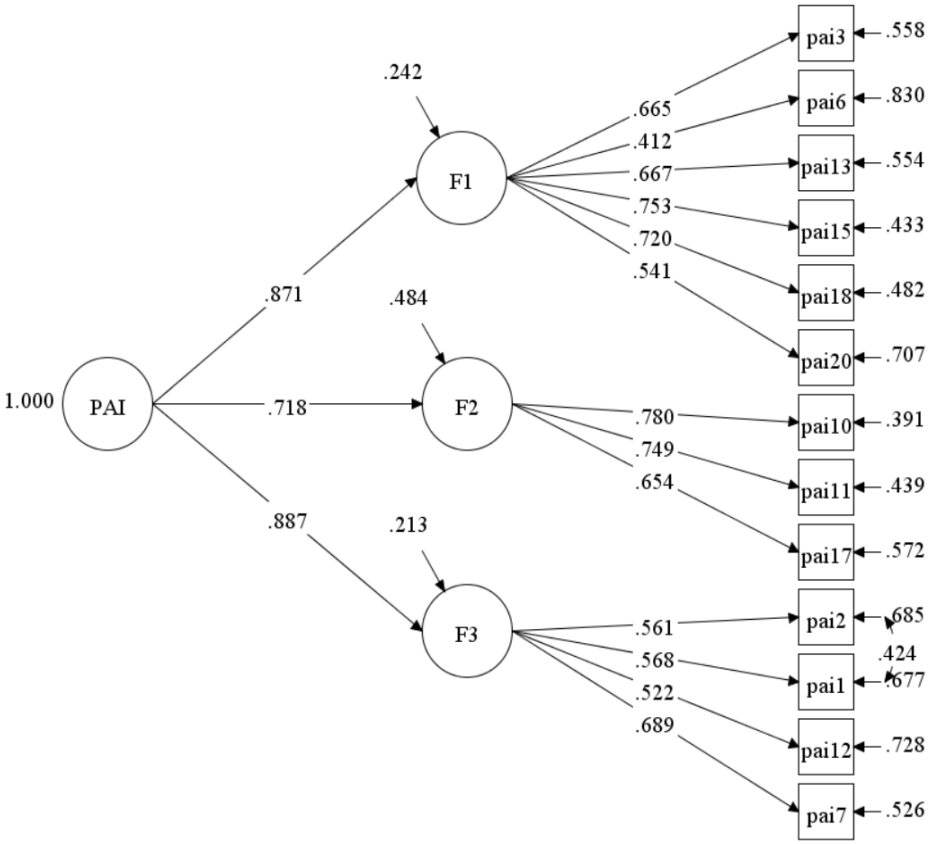
Kaiser-Meyer-Olkin was .918, indicating very good adequacy of the data for factor analysis. Bartlett's test of sphericity was significant, $\chi^2(210) = 2647.42$, $p < .001$, indicating that correlations among variables were adequate for analysis. There were 5 eigenvalues higher than 1 (7.831; 1.496; 1.365; 1.177; 1.079), but according to the scree plot and parallel analysis, three factors were identified. EFA was conducted again, with restriction on three factors (Table A2 in the Appendix). Items 4 and 5 had factor loadings less below .30, and items 8, 9, 16, 14, 19, and 21 had cross-loadings on two factors, so these items were excluded. The first factor referred to Affection towards the foetus (items: 3, 6, 13, 15, 18, and 20). The second factor was related to Familiarity with foetal movement and behaviour (items 10, 11, and 17). Finally, the third factor referred to Fantasising about the foetus (items: 2, 1, 12, 7).

This three-factor model was tested using CFA on the second sub-sample of women who were pregnant for 20 weeks or more ($n_2 = 247$). The three-factor model showed a poor fit to the data, *SBS*-$\chi^2(62) = 169.05$, $p < .001$; RMSEA = .084 (90% CI = .069-.099); CFI = .884; TLI = .852; SRMR = .069, and after correlating the error variance of items 1 and 2, the model showed an acceptable fit to the data, *SBS*-$\chi^2(61) = 142.14$, $p < .001$; RMSEA = .073 (90% CI = .058-.089); CFI = .912; TLI = .887; SRMR = .059. All items had high factor loadings. Correlations between factors were moderate to high. Namely, the correlation between Affection towards the foetus and Familiarity with foetal movement and behaviour was .72, between Affection towards the foetus and Fantasising about the foetus was .67, and between Familiarity with foetal movement and behaviour and Fantasising about the foetus was .60.

As correlations between factors were moderate, we examined a higher-order factor model with three first-order factors and a bi-factor model. The higher-order factor model, which included a correlated error variance between items 1 and 2, showed an acceptable fit to the data, *SBS*-$\chi^2(61) = 142.14$, $p < .001$; RMSEA = .073 (90% CI = .058-.089); CFI = .912; TLI = .887; SRMR = .059. As shown by the fit indices, the two models were equivalent. Also, the bi-factor model failed to converge properly due to a non-positive definite latent variable covariance matrix. In addition, items 12 and 20 had significant loadings only on the general factor, not on the specific factors. The most concerning aspect was that only item 6 had a negative factor loading on the factor Affection towards the foetus (although it should not be reverse-coded), so this model could not be accepted. As a result, the model was excluded from further consideration. Since the first-order factors had high correlations and the original conceptualisation of the PAI was unidimensional (Müller, 1993), we accepted the higher-order factor model with three first-order factors (Figure 1). To conclude, the total score and three subscales can be calculated.

Figure 1

One Higher-Order Factor Model With Three First-Order Factors of the Prenatal Attachment Inventory in a Subsample of Pregnant Women Over 20 Weeks of Gestation (n = 247)



Note. All factor loadings were significant. F1 = Affection towards the foetus; F2 = Familiarity with foetal movement and behaviour; F3 = Fantasising about the foetus. Model fit: *SBS*-$\chi^2(61) = 142.138$, $p < .001$; RMSEA = .073 (90% CI = .058-.089); CFI = .912; TLI = .887; SRMR = .059.

Reliability

McDonald's ω for the total scale and three subscales was calculated on a selected sample of women who were pregnant for 20 weeks or more ($n = 502$). The total scale showed high reliability (ω = .87). The subscales demonstrated acceptable to high reliability, with values of .81, .76, and .75 for Affection toward the foetus, Familiarity with foetal movement and behaviour, and Fantasising about the foetus, respectively.

Divergent and Discriminant Validity

Convergent validity could not be estimated because there is no other validated measure of maternal-foetal bonding. Divergent validity was estimated by correlations with depressive symptoms, general anxiety symptoms, and pregnancy-specific anxiety in a subsample of women who were pregnant for 20 weeks or more (Table 3). The total scale was not significantly correlated with depressive symptoms or general anxiety, but there was a low and significant correlation with pregnancy-specific anxiety ($r = .13$, $p < .01$). The Subscales Affection towards the foetus and Familiarity with foetal movement were not correlated with depressive symptoms, general anxiety, or pregnancy-specific anxiety. However, Fantasising about the foetus was correlated with both general and pregnancy-specific anxiety.

Table 3

Correlations Between the Prenatal Attachment Inventory and Mental Health Symptoms in a Subsample of Pregnant Women Over 20 Weeks of Gestation (n = 502)

	1	2	3	4	5	6	7
1. PAI – total scale	-	.89**	.78**	.82**	-.03	.05	.13**
2. PAI – F1 – Affection towards the foetus		-	.55**	.56**	-.08	-.02	-.02
3. PAI – F2 – Familiarity with the foetal movement			-	.47**	.00	.03	.04
4. PAI – F3 – Fantasising about the foetus				-	.01	.11*	.26**
5. Depressive symptoms					-	.63**	.57**
6. General anxiety						-	.59**
7. Pregnancy-specific anxiety							-

Note. PAI = Prenatal Attachment Inventory.
** $p < .01$.

Discriminant validity via known-group differences was examined in relation to parity and history of spontaneous pregnancy loss. Primiparous and multiparous pregnant women had the same mean levels of Affection towards the foetus, $t(500) = 0.90$, $p = .367$, and Familiarity with foetal movement and behaviour, $t(500) = -1.44$, $p = .151$, but primiparous women had higher levels of total PAI score, $t(500) = 2.19$, $p = .029$, and higher levels of Fantasising about the foetus, $t(500) = 5.79$, $p < .001$. Women who had experienced previous spontaneous pregnancy loss showed higher Affection towards the foetus, $t(500) = -2.04$; $p = .042$, and Familiarity with foetal movement and behaviour, $t(500) = -2.47$, $p = .014$, but did not differ in overall foetal bonding, $t(500) = -1.83$, $p = .068$, and Fantasising about the foetus, $t(500) = -.12$; $p = .902$, compared to pregnant women without that experience.

Discussion

The Prenatal Attachment Inventory in a Croatian sample of pregnant women in the second trimester showed a poor factor structure, as none of the structures identified in previous studies could be confirmed. Therefore, the factor structure was examined using EFA and the two-factor structure was obtained; however, one factor was uninterpretable. Also, this structure was not confirmed with CFA. Subsequently, factor structures were examined in a sub-sample of women who were pregnant beyond 20 weeks of gestation, as most items were related to foetal movements, which are rarely felt earlier in pregnancy. In this subsample, we obtained one higher-order factor with three first-order factors, namely: Affection towards the foetus, Familiarity with foetal movement and behaviour, and Fantasising about the foetus, but the final scale consisted of only 13 items compared to the original 21-item scale.

The examination of the PAI factor structure showed inconsistent solutions both in this study and in the literature. We could not confirm previous factor structures, but we obtained one higher-order factor with three first-order factors. Most studies reported a unidimensional structure (Arafah et al., 2021; Foley et al., 2021; Fujita & Otsuki, 2021; Gau & Lee, 2003; Jurgens et al., 2010; Omani Samani et al., 2016), which is consistent from Müller's (1993) original conceptualisation. However, some studies found a three-factor structure (Letot et al., 2024; Pallant et al., 2014), similar to our three factors, although ultimately had fewer items, while others found that a five-factor structure provided the best fit to the data (Busonera et al., 2017; Siddiqui et al., 1999; Vedova et al., 2008). To summarise, some of these solutions are reconciled by our hierarchical model, which includes three lower-order factors and a higher-order factor that allows the total score calculation.

The timing of administration remains debatable because, in this study, the factor structure could not be obtained when women earlier than 20 weeks of gestation were included. Many items refer to foetal movements, which women typically start to feel around 20 weeks of pregnancy. Some studies have shown that the PAI could be used from the first trimester (Fujita & Otsuki, 2021) or early second trimester (14 weeks of pregnancy; Arafah et al., 2021; Müller, 1993), but the majority of studies were conducted in late pregnancy. It is also important to note that higher gestational age was correlated with a higher PAI score, which could explain the consideration of administration in the late second trimester (Barone et al., 2014; Kapisiz et al., 2020). The three-factor structure was obtained in studies of Swedish pregnant women at 32 weeks of gestation (Pallant et al., 2014), and French pregnant women in the second and third trimesters (Letot et al., 2024). Also, although both one- and three-factor structures showed a good fit to the data in a cross-sectional study from 29 to 40 weeks of pregnancy, the one-factor solution was accepted (Foley et al., 2021). After selecting a sub-sample of women beyond 20 weeks of pregnancy, the hierarchical model with a general higher-order factor and three first-order factors was obtained using 13 items. To summarise, the PAI factor structure has been inconsistent so far,

and the timing of administration should be carefully considered in future validations and applications.

The reliability of the three subscales was acceptable, while the total scale demonstrated high reliability. This was consistent with other studies, all of which have shown high reliability (e.g., Arafah et al., 2021; Busonera et al., 2017; Gau & Lee, 2003; Jurgens et al., 2010; Pallant et al., 2014; Siddiqui et al., 1999; Vedova et al., 2008).

In this study, divergent and discriminant validity were examined, while convergent validity could not be examined because there are no other validated measures of maternal-foetal bonding in the Croatian language. Non-significant correlations of the PAI with depressive symptoms and anxiety were established. Only the subscale Fantasising about the foetus showed low but significant correlations with general and pregnancy-specific anxiety. From a psychometric point of view, such low or non-existent correlations indicate high divergent validity of the PAI. Still, this is somewhat contrary to expectations of low to moderate correlations between the PAI subscales and mental health during pregnancy, which might imply that the new structure of the PAI does not adequately reflect the intended construct. Nevertheless, a systematic review found that, contrary to a consistent association between impaired bonding and depression in the postpartum period, the association is less consistent during pregnancy (Tichelman et al., 2019). In a Japanese sample of primiparous women, the total PAI scale and the subscale Vivid image of the foetus were not significantly correlated with depressive symptoms, while the subscales Tactile closeness to the foetus and Perception of the foetus as an individual showed low but significant correlations (Fujita & Otsuki, 2021). No significant relation between the PAI and depression during pregnancy was found in Turkish pregnant women in their third trimester (Kaydirak et al., 2021) and Italian pregnant women in their second and third trimesters (Busonera et al., 2017). However, Barone et al. (2014) have found significant positive correlations between the Fantasy and Sensitivity subscales and depressive symptoms during pregnancy. Furthermore, in this study, only Fantasising about the foetus was weakly but significantly correlated with general anxiety symptoms, whereas a previous study showed that the total PAI was related to general anxiety (Özdemir et al., 2020). On the other hand, pregnancy-specific anxiety has shown associations with both the PAI total score and Fantasising about the foetus. This finding aligns with previous studies demonstrating the distinct predictive value of pregnancy-specific anxiety for specific obstetric outcomes (Blackmore et al., 2016; Dunkel Schetter et al., 2022), which underscores its additional value. Finally, it should be noted that a general sample of pregnant women participated in the current study, so different results might be obtained in samples with clinical depression or severe bonding disorders.

Discriminant validity, examined via known-group differences regarding parity and history of spontaneous pregnancy loss, was modest, as only some differences in the PAI subscales were found. Specifically, primiparous and multiparous pregnant

women had the same levels of Affection towards the foetus and Familiarity with foetal movement and behaviour, but primiparous women had a higher overall bonding score and tended to fantasise and plan about the foetus more. Non-significant differences align with the original study on PAI development (Müller, 1993), which revealed that primiparous mothers experienced the same levels of bonding with their infants and that previous experiences were not relevant in forming this bond. However, it is interesting to note that, in the current study, the only difference in the PAI subscales comes from fantasising. This may suggest that multiparous pregnant women, although equally affectionate towards the foetus, might have less time to engage in future plans for the unborn child due to caring for and being occupied with their older children. Higher maternal-foetal bonding in primiparous women was found in a previous study using the PAI (Arafah et al., 2021) and in meta-analyses, although with a small effect (Tichelman et al., 2019; Yarcheski et al., 2009). Additionally, in this study, women who had previously experienced spontaneous pregnancy loss had higher levels of Affection towards the foetus and Familiarity with foetal movement and behaviour, but had the same levels of Fantasising about the foetus and overall bonding as women without that experience. Previous studies showed that women with and without a history of miscarriage did not differ in bonding during pregnancy (Armstrong, 2002; Tsartsara & Johnson, 2006; Yilmaz & Beji, 2013), and a similar result was found when maternal-foetal bonding was assessed with the PAI (Kapisiz et al., 2020). Some studies found that women who had experienced previous pregnancy loss reported lower levels of bonding in the current pregnancy (Tsartsara & Johnson, 2006). However, in contrast, our study showed that women with previous pregnancy loss reported improved bonding in the aspects of affection and familiarity with the foetus. In line with conflicting findings on pregnancy loss and bonding in subsequent pregnancies, as well as different coping mechanisms at different pregnancy stages (Lee et al., 2017), it may be that pregnant women beyond 20 weeks of gestation begin to worry less about the pregnancy outcome and engage more with the current pregnancy. In any case, from a psychometric perspective, this suggests that different subscales can effectively discriminate between these groups of women, and also supports the multidimensional structure of the bonding construct during pregnancy.

The main limitation of this study was its cross-sectional design and inability to examine convergent validity. Factor structure varies considerably across studies and countries, so modifications to the inventory should be considered, especially for use before 20 weeks of pregnancy. Future studies should focus on conceptualising maternal-foetal bonding in the early stages of pregnancy, before foetal movement can be felt, and propose an adequate measure for early bonding. Longitudinal studies are also needed to examine the development and changes in maternal-foetal bonding from pregnancy to postpartum.

To conclude, the Prenatal Attachment Inventory in a sample of Croatian pregnant women showed a 3-factor hierarchical structure, indicating that both

subscales and the total score can be measured. It is important to note that the PAI is significantly shortened (13 items instead of 21), not all associations with mental health were observed, and in a Croatian sample of pregnant women, the PAI can be administered only after 20 weeks of pregnancy. All these points raise questions about measures of bonding in early pregnancy. Further research is needed to conceptualise the early bond between mother and foetus, which should be followed by the development of adequate measures.

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Kako mjeriti povezivanje majke i fetusa: validacija hrvatske verzije Inventara prenatalne privrženosti

Sažetak

Povezanost majke i fetusa predstavlja vezu koju majka razvija sa svojim fetusom. Cilj ovog istraživanja bio je ispitati psihometrijska svojstva *Inventara prenatalne privrženosti* (*Prenatal Attachment Inventory,* PAI) na uzorku trudnica u Hrvatskoj. Odrasle trudnice ($N = 850$) u razdoblju od 13. do 28. tjedna trudnoće ispunile su PAI, *Edinburški upitnik poslijeporođajne depresivnosti* (EPDS), ljestvicu anksioznosti iz *Skale depresije, anksioznosti i stresa* (DASS-21) te *Ljestvicu zabrinutosti u trudnoći* (LJZT). Konfirmatornom faktorskom analizom (CFA) utvrđeno je da pretpostavljene faktorske strukture iz prethodnih istraživanja ne pokazuju dobro pristajanje modela. Zbog toga je provedena eksploratorna faktorska analiza (EFA) na polovici uzorka ($n = 425$), koja je pokazala dvofaktorsku strukturu, ali ona nije potvrđena CFA analizom na drugoj polovici uzorka. Budući da su se čestice uglavnom odnosile na intrauterine pokrete fetusa, analiza je ponovljena na poduzorku žena koje su trudne barem 20 tjedana ($n = 502$), pri čemu su EFA i CFA provedene na polovicama tog poduzorka. U EFA analizi je 21 čestica reducirana na 13 čestica i izdvojena su tri faktora. U CFA analizi prihvaćen je model višeg reda s tri faktora prvog reda: *Afektivna povezanost s fetusom*, *Poznavanje pokreta i ponašanja fetusa* te *Maštanje o fetusu*. Ukupna ljestvica i tri podljestvice pokazale su visoku pouzdanost, dobru divergentnu valjanost i zadovoljavajuću diskriminantnu valjanost. *Inventar prenatalne privrženosti* s 13 čestica pokazuje dobra psihometrijska svojstva kada se primjenjuje nakon 20. tjedna trudnoće. Potrebna su daljnja istraživanja kako bi se razvile valjane mjere ranog povezivanja majke i fetusa.

Ključne riječi: Inventar prenatalne privrženosti, povezanost majke i fetusa, faktorska struktura, valjanost, pouzdanost, Hrvatska

Primljeno: 28. 3. 2025.

Appendix

Table A1

Descriptive Data for Prenatal Attachment Inventory (N = 850)

	M	*SD*	Min	Max	Skewness		Kurtosis		S-W
					statistic	*SE*	statistic	*SE*	
PAI 1	2.97	0.78	1	4	-0.27	.08	-0.57	.17	.84**
PAI 2	2.56	0.98	1	4	-0.06	.08	-1.01	17	.88**
PAI 3	3.39	0.84	1	4	-1.33	.08	0.99	.17	.72**
PAI 4	2.86	1.00	1	4	-0.41	.08	-0.94	.17	.85**
PAI 5	2.51	1.03	1	4	0.10	.08	-1.15	.17	.87**
PAI 6	3.26	0.77	1	4	-0.64	.08	-0.51	.17	.79**
PAI 7	2.99	0.92	1	4	-0.46	.08	-0.81	.17	.84**
PAI 8	2.37	1.00	1	4	0.22	.08	-1.01	.17	.87**
PAI 9	2.34	1.01	1	4	0.20	.08	-1.23	.17	.86**
PAI 10	2.25	1.04	1	4	0.27	.08	-1.13	.17	.86**
PAI 11	2.01	0.95	1	4	0.60	.08	-0.62	.17	.84**
PAI 12	2.29	1.07	1	4	0.30	.08	-1.17	.17	.86**
PAI 13	3.36	0.65	1	4	-1.67	.08	2.26	.17	.62**
PAI 14	3.15	0.92	1	4	-0.75	.08	-0.46	.17	.84**
PAI 15	3.30	0.85	1	4	-0.98	.08	0.05	.17	.77**
PAI 16	3.36	0.80	1	4	-1.06	.08	0.41	.17	.75**
PAI 17	2.43	1.03	1	4	0.13	.08	-1.11	.17	.87**
PAI 18	3.30	0.84	1	4	-0.94	.08	0.01	.17	.77**
PAI 19	2.18	1.14	1	4	0.47	.08	-1.22	.17	.82**
PAI 20	3.27	0.87	1	4	-0.95	.08	-0.04	.17	.77**
PAI 21	2.64	0.97	1	4	-0.06	.08	-1.00	.17	.82**

Note. S-W = Shapiro-Wilk test of normality distribution.
** $p < .01$.

Table A2

Factor Loadings of the Exploratory Factor Analysis – Principal Factor Axis and Oblimin Rotation – in a Subsample of Pregnant Women and a Subsample of Pregnant Women at 20 Weeks of Gestation or More

Items	Pregnant women $n = 425$		Pregnant women at 20 weeks of gestation or more $n = 255$		
	Factor1	Factor2	Factor1	Factor2	Factor3
PAI 1	**.567**	-.049	**.736**	-.041	-.133
PAI 2	**.509**	.161	**.681**	-.054	-.030
PAI 3	**.383**	.251	.007	**-.776**	-.123
PAI 4	**.361**	.279	.179	-.358	.177
PAI 5	.185	**.301**	.205	-.109	.158
PAI 6	**.417**	.091	.060	**-.422**	.107
PAI 7	**.667**	.064	**.538**	-.258	.003
PAI 8	**.356**	**.410**	.430	-.089	.303
PAI 9	.311	**.520**	.470	-.046	.356
PAI 10	-.087	**.863**	.016	-.115	**.623**
PAI 11	-.070	**.770**	.094	.033	**.677**
PAI 12	.124	**.501**	**.621**	.139	.186
PAI 13	**.710**	-.121	.061	**-.706**	-.109
PAI 14	**.723**	.061	.485	-.349	.026
PAI 15	**.753**	-.007	.150	**-.593**	.096
PAI 16	**.947**	-.177	.326	**-.**592	-.064
PAI 17	**.314**	**.423**	.016	-.182	**.437**
PAI 18	**.653**	.083	-.012	**-.633**	.165
PAI 19	**.484**	.223	.288	-.228	.261
PAI 20	**.469**	.239	-.140	**-.639**	.285
PAI 21	**.714**	-.027	.412	-.330	.060