The measurement properties and acceptability of a new parent-infant bonding tool ('Me and My Baby') for use in UK universal healthcare settings: A psychometric, cross-sectional, study

1   **Bywater, T[1*]., Dunn, A[5], Endacott, C[2]., Smith, K[3]., Tiffin, P. A[1], Blower, S[1]., Price, M[4].**
2   [1] Department of Health Sciences/Hull York Medical School, Seebohm Rowntree Building,
3   University of York, Heslington, York, YO10 5DD. SB is the Study Manager, TB is the Chief
4   Investigator, PAT is the Psychometrician.
5   [2] Bradford Institute for Health Research, Bradford Teaching Hospitals NHS Foundation Trust,
6   Bradford, BD9 6RJ, UK.
7   [3] Rotherham Doncaster and South Humber NHS Foundation Trust, Woodfield House, Tickhill
8   Road Site, Doncaster, DN4 8QN. KS is the Children's Care Group Transformation &
9   Integration Lead.
10   [4] Little Minds Matter: Bradford Infant Mental Health Service, Bradford District Care NHS
11   Foundation Trust, Bowling Hall Medical Practice, Rooley Lane, BD4 7SS
12   [5] Department of Social Policy and Social Work, Church Lane Building, University of York,
13   YO10 5DD. AD is a Research Fellow.
14
15   ***Correspondence:**
16   Tracey Bywater
17   tracey.bywater@york.ac.uk

18   **Keywords: Bonding[1], Parent[2], Baby[3], Measure[4], Psychometrics[5].**

19   **Abstract**

20   NICE guidelines acknowledge the importance of the parent-infant relationship for child
21   development but highlight the need for further research to establish reliable tools for assessment,
22   particularly for parents of children under one year.
23   This study explores the acceptability and psychometric properties of a co-developed tool, 'Me
24   and My Baby' (MaMB).
25
26   **Study design**
27   A cross-sectional design was applied. The MaMB was administered universally (in two sites)
28   with mothers during routine 6–8-week Health Visitor contacts. The sample comprised 467
29   mothers (434 MaMB completers and 33 'non-completers').
30   Dimensionality of instrument responses were evaluated via exploratory and confirmatory ordinal
31   factor analyses. Item response modelling was conducted via a Rasch calibration to evaluate how
32   the tool conformed to principles of 'fundamental measurement'. Tool acceptability was
33   evaluated via completion rates and comparing 'completers' and 'non-completers' demographic
34   differences on age, parity, ethnicity, and English as an additional language. Free-text comments
35   were summarised. Data sharing agreements and data management were compliant with the
36   General Data Protection Regulation, and University of York data management policies.
37
38   **Results**
39   High completion rates suggested the MaMB was acceptable. Psychometric analyses showed the
40   response data to be an excellent fit to a unidimensional confirmatory factor analytic model. All
41   items loaded statistically significantly and substantially (>0.4) on a single underlying factor
42   (latent variable). The item response modelling showed that most MaMB items fitted the Rasch

43 model. (Rasch) item reliability was high (0.94) yet the test yielded little information on each
44 respondent, as highlighted by the relatively low 'person separation index' of 0.1.
45
46 **Conclusions and next steps**
47 MaMB reliably measures a single construct, likely to be infant bonding. However, further
48 validation work is needed, preferably with 'enriched population samples' to include higher-
49 need/risk families. The MaMB tool may benefit from reduced response categories (from four to
50 three) and some modest item wording amendments. Following further validation and reliability
51 appraisal the MaMB may ultimately be used with fathers/other primary caregivers and be
52 potentially useful in research, universal health settings as part of a referral pathway, and clinical
53 practice, to identify dyads in need of additional support/interventions.

54 **1 Introduction**

55 As mothers are typically primary caregivers, the current study evaluated the MaMB for use by
56 mothers. Maternal bonding can be defined as a mother's emotional connection and feeling
57 towards her child (Condon, 1993). Bonding is often conflated with attachment. Whilst the
58 constructs are related, they are distinct (Bowlby, 1982; Redshaw and Martin, 2013). Maternal
59 bonding refers to a mother's (typically self-reported) emotional connection and feelings towards
60 their child. Attachment on the other hand, refers to an infant's expectations of their caregiver's
61 responses and the pattern of their own behaviour, e.g., when activated in response to a perceived
62 threat. Attachment typically develops from six months, whereas a mother's bond to the infant
63 begins to develop during pregnancy. Stronger bonding is theoretically linked to more frequent
64 expression of behaviours such as maternal sensitivity and emotional availability (Feldman et al.,
65 1999), which in turn foster positive interactions within the dyad and promote social and
66 emotional development, including the development of secure attachment in the infant (Ainsworth
67 et al., 1978; Le Bas et al., 2019).
68 Two systematic reviews (Branjerdporn et al., 2017; Le Bas et al., 2019) indicate that strong
69 maternal bonding in pregnancy is associated with optimal child developmental outcomes. The Le
70 Bas et al. (2019) review also suggested that higher affective postnatal parent-infant bond was
71 predictive of positive child development outcomes. Both reviews suggested the findings should
72 be interpreted with caution due to the relative paucity of studies in this area and highlighted the
73 need for more robust self-report measures of bonding.
74 There are currently no agreed, standardised, methods for identifying mother/parent-infant dyads
75 who may benefit from additional support around bonding and relationships in England. Although
76 Health Visitors (HVs) work directly with parents some research suggests that they may struggle
77 to consistently identify problems in the parent-infant relationship (Appleton et al., 2013; Elmer et
78 al., 2019; Kristensen et al., 2017; Wilson et al., 2010). Relevant NICE guidelines acknowledge
79 the importance of parent-infant relationship for child development and parent mental health but
80 highlight the need for further research to establish reliable tools for assessment, particularly for
81 parents of children under the age of 1 year (NICE, 2012, 2015).
82 There is a distinct need for validated, robust measures to be administered universally to identify
83 and support families who may struggle with their parent-infant relationship. Parent-infant
84 relationship is a key focus in the Early Years High Impact Area 2: supporting good parental
85 mental health (PHE, 2020) due to the risks to subsequent child social and emotional development
86 arising from poor parent-infant relationships (Cassidy et al., 2013; Fearon et al., 2010). A
87 reliable, valid, identification tool could allow services to more confidently signpost parents who
88 may benefit to one of the emerging evidence-based interventions (Barlow et al., 2010; Barlow et
89 al., 2016; Facompre et al., 2018; Wright et al., 2015).

90 A very limited number of brief parent self-report tools exist that assess maternal-infant bonding,
91 are freely available, and have some reliability and validity (Blower et al., 2019; Gridley et al.,
92 2019; Kane, 2017; Wittowski et al., 2020), for example; Maternal Attachment Inventory (MAI;
93 Müller, 1994); Maternal Postnatal Attachment Scale (MPAS) (Condon and Corkindale, 1998);
94 Postpartum Bonding Questionnaire (PBQ) (Brockington et al., 2006); Mother Infant Bonding
95 Scale (MIBS) (Taylor et al., 2005). However, most are not widely used, or have been validated
96 with a small sample (for further discussion see Wittowski et al., 2020; Le Bas et al., 2019). A
97 further two reviews, Blower et al., 2019 and Gridley et al., 2019 were undertaken to explore
98 which measures would be acceptable, reliable, and valid for a large randomised controlled trial
99 of a parenting intervention for parents of infants and toddlers and it was found that choice of
100 measures was very limited (the trial was led by TB, the first author. For the protocol see Bywater
101 et al., 2018).
102 The 19-item MPAS, which has preliminary evidence of reliability and validity (Kane, 2017;
103 Wittowski et al., 2020) is the most used tool when linking maternal-infant bonding to later child
104 development outcomes (Le Bas et al., 2019). The MPAS was piloted (with the involvement of
105 the first and second authors) with 347 mothers in universal health visiting services (Dunn et al.,
106 submitted; Bird et al., submitted) as part of Better Start Bradford - a 10-year National Lottery
107 Community Fund project aimed at improving the socio-emotional development, nutrition and
108 communication skills of children aged 0-3 living in deprived multi-ethnic communities
109 (Dickerson et al., 2016). The pilot concluded that the MPAS could not be recommended for use
110 in health visiting services in Bradford to assess parent-infant relationship due to; little variation
111 in the responses of the 225 who completed the MPAS in English; an unexpected ceiling effect;
112 issues with scoring, parental acceptability and understanding. The E-SEE trial found similar
113 findings, with lack of variation in scores on a sample of 341 (Bywater et al., 2021 (submitted)).
114 Using the learning from the MPAS pilot the study team co-developed a new tool, "Me and My
115 Baby" (MaMB), in an iterative process via workshops and interviews with Health Visitors,
116 Clinical Psychologists, service staff, Managers and parental input, to address the issues
117 highlighted in the MPAS pilot. Prior to a measure being recommended for use in any context,
118 evidence of the measurement properties should be established (Cooper, 2019). Psychometric
119 properties comprise two overarching dimensions - validity and reliability. Validity is defined as
120 the degree to which an instrument measures the construct(s) it purports to measure, and
121 reliability is the degree to which a measure is free from measurement error (de Vet et al., 2015).
122 Acceptable reliability is thus a necessary, though not sufficient, condition for achieving valid
123 scores from an instrument. 'Reliability' also relates to the important concept of 'test
124 information'; that is, the trait level at which the instrument is most capable of discriminating
125 between test takers/respondents. Thus, a test's 'information curve' has important implications for
126 how it is optimally used in practice; for example, when identifying a screening cut-off score.
127 This study was therefore intended to evaluate the measurement model for the MaMB and
128 acceptability when implemented in routine practice, as a prerequisite to further studies aiming to
129 establish validity of the tool. The main aim was to address previous paucity and quality of
130 available tools to assess parent (mother)-infant relationship, specifically bonding, by developing
131 a measure for use in research as well as universal health settings as part of a referral pathway,
132 and potentially clinical practice, to identify dyads in need of additional support or interventions.
133 The research objectives for this study were:
134 1. To explore MaMB pilot data to determine the item and test properties in relation to
135 dimensionality and reliability, in terms of both internal consistency and test information; and
136 2. To identify any necessary revisions to MaMB following the results of our psychometric
137 analysis.

138 These findings would have implications for which items would be retained in a final version of
139 instrument, and how the scores might be best summarised and used in practice. The work also
140 paves the way for validation studies.
141 **2   Materials and Methods**
142 **The tool under investigation**
143 The MaMB questionnaire (for further information see Appendix 2, and the protocol at
144 https://osf.io/q3hmf/) has 11 items presented in a user-friendly format. Responses are indicated
145 using a four-point Likert scale ('never', 'sometimes', 'often', or 'always', scored 0-3 with four
146 reversed scored items). The language of items is simple to understand with a reading age of
147 approximately 12, similar to that for popular magazines. A free text box is also included to give
148 mothers the opportunity to record any comments or concerns they have about their relationship
149 with their infant. Lower scores indicate a stronger affective bond.
150
151 **Research questions**
152 RQ1: Is the MaMB acceptable to mothers of infants (aged 6-8 weeks) and HVs when
153 administered in a universal healthcare setting?
154   a) As a proportion of all eligible dyads, how many complete the MaMB?
155   b) What are the reasons given for non-completion?
156   c) Are the free text boxes completed by parents and what information is being
157   recorded/reported in them?
158 RQ2: What are the measurement properties of the MaMB?

159   a) What is the most plausible dimensionality (factor structure) of the MaMB?
160   b) Does the scale (or subscales if applicable) of the MaMB demonstrate acceptable
161   levels of internal consistency?
162   c) According to item response modelling, do the items demonstrate an acceptable fit to
163   the Rasch model, implying that the summed scores from the instrument can be used
164   as a 'sufficient summary statistic'?
165   d) What is the relative level of information yielded for respondents by the test (or
166   putative scales), and where might a potential cut-off score be best placed that most
167   accurately differentiates between two groups of test-takers?

168 **Design**
169 A cross-sectional design was applied.
170 A briefing was prepared in partnership with Rotherham Doncaster and South Humber NHS
171 Foundation Trust (RDaSH) to support the training of HVs in the use of the tool. The briefing
172 covered the purpose of the tool, how to introduce it to families, how to score it and how to
173 interpret the scores.
174 The MaMB was implemented universally (in two RDaSH localities) with eligible mothers during
175 the 6–8 week routine HV contact following completion of the core mandated elements of the
176 visit.
177 HVs asked mothers to complete a paper version of the tool, with support if needed or requested.
178 During tool completion HVs were expected to use their professional skills to discuss with parents
179 their relationship with their infant. If HVs were unable to complete the tool (e.g., due to time
180 constraints) they would record the reason(s) for non-completion.
181 HVs inputted the responses electronically into the case management software (SystmOne) co-
182 developed template to include; if tool administration was attempted, and if not why, and if tool
183 administration had been abandoned prior to completion. The template also captured responses to
184 all 11 items, and the free text responses to the open question on the back page of the paper tool,

185 and HVs comments on the interaction. Key demographic variables were also recorded to
186 adequately describe the sample's characteristics and to support subgroup analyses.
187 The research team received anonymised (numerical and free text) data extracted from SystmOne,
188 and a small number of key demographic characteristics such as age, ethnicity, and parity.
189 **Study setting**
190 Two RDaSH sites in Northern England implemented the MaMB at the 6-8 week universally
191 mandated HV contact.
192
193 **Inclusion/exclusion criteria**
194 All mothers of a child aged 6-8 weeks living in the sites were eligible for the study.
195 If a parent had opted out of NHS digital they may have completed the MaMB but were not
196 included in the study (in England, NHS patients can choose to opt out of their confidential
197 patient information being used for research and planning).
198
199 **Consent**
200 This study received ethical approval on 21st August 2020 by South Central - Berkshire B
201 Research Ethics Committee, UK, Ref: 20/SC/0266, Integrated Research Application System
202 (IRAS) 201, project ID: 273708.
203 Parents were given a MaMB Participant Information Sheet (V2.0 17th August 2020; See
204 Appendix 1) at a visit prior to the 6-8-week check to give them time to read and understand why
205 they will be asked to complete the MaMB.
206 Written consent from mothers completing the MaMB, and for the non-identifiable fully
207 anonymized, data to be shared with the research team, was not required. This was because:
208   (1) The research team only accessed anonymised data. Data were restricted to the minimum
209   needed to describe the sample and to conduct the proposed analyses of measurement
210   properties and acceptability. Free text boxes, where completed, and were screened by an
211   authorised RDaSH employee to remove any identifiable information prior to data sharing.
212   (2) There was no risk of harm to participants from completing the MaMB. The tool was one
213   of several used by HVs to conduct a broad needs assessment, as is standard at the 6–8-
214   week contact. The MaMB supplemented existing tools and was implemented in addition
215   to standard care. HVs are trained and well equipped to support mothers who may be
216   struggling to bond with their baby.
217   (3) It was deemed essential that the MaMB sample was representative of mothers of young
218   infants in the research site so that the study findings are generalisable. Introducing an
219   informed consent process would likely have led to selection bias, arising from parent and
220   practitioner characteristics and attitudes.
221   (4) There is a clear value and benefit from doing the research, i.e., a need for a short, easy-to-
222   administer, valid and reliable measure to support practitioners to identify families
223   experiencing difficulties in their parent-infant relationship. The MaMB has been co-
224   developed by academics, psychologists and HVs with parental input to address this gap,
225   it is vital that this measure is tested before it can be recommended for use more widely.

226
227 **Sample size**
228 The average number of live births per year in the year prior to the study was 3460 in Site 1
229 (Doncaster) and 3000 in Site 2 (North Lincolnshire), which would yield approximately 538
230 births per month. Assuming a conservative 50% completion rate (allowing for potential
231 implementation/uptake barriers such as time constraints, parent refusal or practitioner non-
232 compliance, time lag in implementation and data entry) we anticipated 269 MaMBs would be

233   completed per month. To construct a sample large enough to support the analysis of
234   psychometric properties we proposed a sample of 673 over a ten-week period. Based on a 50%
235   completion rate, the overall sample would include a further 673 non-completers to explore
236   acceptability (total n=1346). Please note this sample size was calculated pre-COVID-19.
237
238   **Psychometric analyses**
239   **RQ1**
240   To assess acceptability of the tool reported the proportion of participants who were recorded as
241   being offered the tool but either refused, or failed to complete, it. Where data were available
242   descriptive analysis of the reasons for refusal was to be produced.
243   Key demographic characteristics (age, parity, ethnicity, English as an additional language) of
244   completers and non-completers were to be presented in contingency tables as either frequency
245   counts or means for descriptive purposes.
246   A frequency count was intended to determine the proportion of completers who used the free-
247   text box to expand on their answers. Free-text comments were to be summarised in a brief
248   narrative.
249   **RQ2**
250   *Dimensionality and internal consistency reliability*
251   The sample was originally intended to be randomised into exploratory and confirmatory
252   ('validation') datasets, if the data obtained were sufficient to support this approach. Initially
253   dimensionality was planned to be explored in the former data subset using parallel analysis (see
254   below for details) (Horn, 1965). Once this had been established, it would be followed by an
255   exploratory factor analysis (EFA) of exploratory portion of the response data. The potential
256   factor structures elicited would then be tested using confirmatory factor analyses (CFA) on the
257   confirmatory (validation) dataset. Internal reliability consistency of the postulated subscales
258   would then be examined. The findings of these analyses were intended to indicate whether it is
259   appropriate to summarise bonding via several subscales or simply by a single total overall score
260   for the MaMB.
261   The parallel analysis would be performed using unweighted least squares (ULS) as the
262   estimation method (Horn, 1965; Lorenzo-Seva and Ferrando, 2006). In a parallel analysis the
263   maximum plausible number of factors to be retained is indicated at the point where the
264   eigenvalues of the randomly generated data exceed those of the actual data. A series of EFAs
265   was expected to be then performed to aid interpretation of any factors underlying the response
266   patterns observed. Oblique (geomin) rotations were to be used in the factor analyses, assuming
267   that, as in almost all psychological measures, underlying latent traits would be correlated with
268   each other to some extent. The EFAs will be repeated, again using a geomin rotation, to derive
269   standard errors (and thus standardised Z scores) for the factor loadings to evaluate their relative
270   statistical significance (Asparouhov and Muthén, 2009). All EFAs and CFAs were to be
271   conducted in Mplus version 6.1 employing robust weighted least squares (WLSMV) as the
272   estimation method, or 'full information maximum likelihood', as appropriate.
273   Internal reliability consistency for the putative subscales based on the CFA structure was to be
274   evaluated using Cronbach's alpha and McDonald's omega. Cronbach's alpha may be a poor index
275   of internal reliability where tau-equivalence (equality of factor loadings across items in a scale)
276   does not hold (Raykov, 1997). In this respect McDonald's omega is reported to represent a more
277   accurate estimate of the extent to which items in a scale measure a unidimensional underlying
278   construct.
279   *Item response modelling*
280   Item response modelling and theory (IRT) is based on the modified factor analysis of binary and
281   categorical data. Within the family of IRT models Rasch analysis was originally developed for
282   the exploration of dichotomous responses to test items (Rasch, 1960), though was subsequently

283 extended to accommodate polytomous data. Rasch analysis can be used to create interval metrics
284 of both item difficulty and respondent ability from ordinal (ordered categorical) or binary
285 (dichotomous) response data. The Rasch model assumes that all items are identical in terms of
286 their ability to discriminate between respondents according to ability/trait (i.e., equality of item
287 factor loadings in classical factor analytic terms). For the present Rasch analysis the software
288 package Winsteps version 4.01 was used (Linacre, 2017). A partial credit model was applied to
289 the categorical MaMB item responses. In a Rasch analysis reliability can be appraised in several
290 ways. Specifically, the person reliability coefficient relates to the replicability of the ranking of
291 abilities while the person separation index represents the signal to noise ratio and estimates the
292 ability of a test to reliably differentiate different levels of ability within a cohort (Wright and
293 Masters, 1982).
294 Power issues in Rasch analysis are a matter for debate with some authors suggesting that around
295 200 respondents are required to accurately estimate item difficulty whilst others suggest as few
296 as 30 participants may be required in well-targeted tests (i.e. those where difficulty is well
297 matched to ability) (Baur and Lukes, 2009; Goldman and Raju, 1986; Linacre, 1994). Thus, this
298 study should be adequately powered to estimate item properties from both Rasch analysis as well
299 as the factor analyses, the latter of which could be considered re-parameterized two parameter
300 logistic regression IRT models. Thus, the fit of items to the Rasch model was to be assessed and
301 any potential sources of misfit diagnosed. This will be important in deciding whether it is
302 appropriate to summarise the scores on the scale/s as summed totals. Moreover, the Rasch
303 calibration was intended to allow the evaluation of test information, which would indicate to
304 what extent the test is able to differentiate test-takers across the putative trait levels under
305 evaluation (assumed to be 'perceived bonding with baby').
306 **Data handling and sharing**
307 Fully anonymised data was exported from SystmOne and shared with the study team via the
308 University of York secure drop off service, which securely encrypts data. Data management is
309 compliant with the General Data Protection Regulation (GDPR) and University of York data
310 management policies. The custodian of data, Professor Tracey Bywater (Chief Investigator), is
311 the contact point for any data management queries.
312
313 **3.   Results**
314 The pilot ran 10th September 2020 to 1st December 2020, and the MaMB was administered either
315 face to face or over the telephone depending on COVID-19 restrictions at the time of
316 administration.

317 See Figure 1 for a flow of participants through the study.

318

319 **INSERT FIGURE 1 HERE**
320

321 The 434 response rate from the eligible 928 women equates to a 47% response rate, close to the
322 predicted 50%.
323 The target sample size of 673 for MaMB completion was not achieved, and we only have data
324 for 33/494 women who did not complete the MaMB rather than the proposed 673. The birth rate
325 was lower than expected, and HVs changed to telephone rather than face to face visits during the
326 study due to COVID.
327 Results will be presented in order of the research questions.
328 **RQ1:** Is the MaMB acceptable to mothers of infants (aged 6-8 weeks) and HVs when
329 administered in a universal healthcare setting?

330   a) As a proportion of all eligible dyads, how many complete the MaMB?
331   b) What are the reasons given for non-completion?
332   c) Are the free text boxes completed by parents and what information is being
333   recorded/reported in them?
334

335 Table 1 shows the characteristics of the sample who completed the MaMB. The sample appears
336 to represent the local population regarding ethnicity (83% white British, 10% White other, 7%
337 Black, Asian, Multi-ethnic and other) and language (80% English as a first language, 6%
338 missing). Although the numbers are small and we cannot draw conclusions from them, the 33
339 non-completers appeared to differ on ethnicity and language, which may be a reason for not
340 completing the MaMB, e.g., 24% were white 'other' in the non-completers, compared to 10% in
341 the completers. Likewise, 38% of non-completers needed an interpreter compared to 14% from
342 the completers. Although 461 cover sheets for non-completers were missing, there was minimal
343 missing data at item-level for those that were returned.
344 **INSERT TABLE 1 HERE**
345

346 From the 434 respondents who completed a MaMB 50 had one or more missing items. Scores
347 from the 384 who fully completed the MaMB tool suggest that the sample had positive
348 relationships with their baby, mean = 1.2 (SD 1.6), with a median summed score of 1 (inter-
349 quartile range 0 to 2) from a possible 33 (the lower the score indicating the more positive the
350 perception of the mother-baby relationship), and a range of 0-15.
351 Twenty-nine respondents (parents and HVs) completed the free-text box with some mothers
352 saying they felt guilty that they could not give more time to their baby or felt less than positively
353 to toward their child at times, e.g;
354   *"I feel guilty for having less positive feelings especially when he is screaming"*
355   *"I feel I need time by myself sometimes, but feel guilty that I feel like that as a mum"*
356 Four mothers mentioned that they had not been separated from their baby yet, so items 8 and 10
357 were not applicable.
358 **RQ2:** *What are the measurement properties of the MaMB?*
359 From 467 mothers 33 had no MaMB questionnaire data whatsoever, leaving 434 participants
360 with some response data. The original plan was to divide up the data, randomly, into a training
361 and validation set (see Methods). However, due to lack of variance in some of the item responses
362 this was not possible. That is, dividing the dataset into two portions created items where little or
363 no variation in responses were observed in some cases, rendering estimation of factor models
364 impossible. Therefore, the entire dataset was explored in relation to its dimensionality.
365 *Dimensionality*
366 Firstly, a parallel analysis was conducted using the software FACTOR. This generates
367 pseudorandom data, with the same dimensions as the real data. This process was adapted for use
368 with the ordinal response data using polychoric matrices. Missing data values were handled
369 using hot deck multiple imputation (Lorenzo-Seva and Van Ginkel, 2016). The results of the
370 parallel analysis are shown in Table 2. These clearly indicate that there is a maximum of one
371 factor (latent variable) underlying the response structure. This is evidenced clearly by the fact
372 that the first latent variable explains around 60% of the variance in the indicators (item
373 responses). However, a second postulated latent variable explains less variance than that found in
374 a second latent variable for the pseudorandom data. The reliability, as indexed by Cronbach's
375 alpha was 0.64 (standardised Cronbach's alpha 0.92) and McDonald's Omega value of 0.92. The
376 goodness of fit index for the one factor EFA was 0.985 (95% confidence intervals, derived via
377 bootstrapping, 0.985 to 0.989). The psychometric properties of the items are shown in Table 3.
378 For the standardised covariance matrix (polychoric correlations) as estimated from an ordinal

8

379 factor analysis of the items of the MaMB scale, using the FACTOR software package see *Table*
380 *S1* in the supplementary material provided.
381
382
383   **INSERT TABLE 2 HERE**
384
385 This unidimensional structure was confirmed by examining the fit to a single factor confirmatory
386 factor analytic model within the Mplus v8.4 software environment. This confirmatory factor
387 analysis (CFA) was adapted for the ordinal nature of the response data, using robust weighted
388 least squares as the estimation method (WLSMV). There were technical difficulties estimating a
389 one factor model due to the low variance in items 4 and 5 and their collinearity with responses to
390 items 10 and 11 respectively (that is, responses to the latter items were almost wholly associated
391 with response to the former). Specifically, the correlation between item 4 ('difficult') and item
392 10 ('apart') was 0.987. That between item 5 ('need') and item 11 ('play') was also 0.987.
393 Consequently, items 4 and 5 (which exhibited the lowest variance of the pairs were dropped from
394 the CFA. When the CFA was repeated with the remaining nine items the one factor model
395 showed a good fit to the data; the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) fit
396 indices were 0.94 and 0.92 respectively ($\geq$0.90 usually is taken as acceptable fit, whilst values
397 over 0.95 indicate good fit). Combining positive and negative worded items in a single scale can
398 sometimes artificially lead to method effects. That is, these item types can sometimes show
399 dependency on each other that manifest as correlated model residuals or 'artefactors' (Marsh,
400 1996). For this reason the residuals from negatively worded items were permitted to correlate
401 within the CFA model to evaluate if this resulted in improved fit. However, this was not the case,
402 with fit, if anything, deteriorating slightly (the TLI reduced from 0.92 to .91). Moreover, the
403 modification indices did not suggest that fit would be significantly improved by permitting
404 correlated residuals between items. The issue of dependency between items was also evaluated
405 as part of the Rasch calibration (see below).
406
407   **INSERT TABLE 3 HERE**
408
409 The factor loadings demonstrate a substantial (>0.4), positive and significant (p<0.01) magnitude
410 of loadings for all nine MaMB items included. Negative items were reverse coded so that the
411 latent variable and the item factor loadings were interpretable. Having established the
412 unidimensional structure of the data it appeared appropriate to progress to a Rasch calibration of
413 the MaMB items.
414
415 *Rasch analysis*
416 The Rasch calibration results yielded much useful diagnostic information on the MaMB
417 questionnaire. As highlighted earlier the scale reliability itself was moderate to high. Indeed, the
418 item reliability estimated by the Rasch calibration was .94. However, the person separation index
419 (which include 'extreme' and 'non-extreme' persons) was only .10. The person separation index
420 reflects the number of groups that can be plausibly differentiated by the scale with acceptable
421 precision. It represents a signal to noise ratio in the scale. Thus, the MaMB scale had virtually no
422 ability to differentiate respondents. This was no doubt a reflection on the lack of observed
423 variance in responses in the study sample. Nevertheless, in terms of scale development and
424 future research it is useful to explore the item 'difficulties' (or 'endorsibility' in this case), as
425 well as the fit statistics. These are shown below in Table 4. The z standardised fit, along with the
426 difficulty/endorsibility and standard error (reflected in the diameter of each bubble) are also
427 shown in the 'bubble plots' in Figures 2 and 3. In the Rasch context 'fit' in this sense refers to
428 which the item responses follow a Guttman sequence (Rasch, 1960). That is, as the ability or trait

429 increases the respondent or test-taker tends to be observed to give a higher scoring category of
430 response, allowing for the play of chance, e.g., 001010111222122122223323333. Items where
431 responses are too predictable 'overfit' the model. Those that are more erratic are described as
432 'underfitting'. The former tends to indicate redundant items, that may be dependent on responses
433 to other items. Underfitting items can distort or degrade the measurement properties of the scale.
434 'Infit' refers to fit where an item 'difficulty' is well matched to the level of trait or ability in a
435 test taker. That is, for example, for a right/wrong maths question the person who is well matched
436 would have a 50:50 chance of either a correct or incorrect answer. In this case 'well targeted'
437 items would tend to show a reasonable spread of responses for a set of test takers with trait levels
438 that are matched to the item endorsibility. Conversely, 'outfit' refers to fit (conformity to the
439 Rasch model) where item difficulty is not well matched to the test taker's trait or ability level.
440 These distinctions between infit and outfit tend to be more pertinent to knowledge tests, than trait
441 assessments, however. As can be seen from Table 4 and Figures 2 and 3 overall, the MaMB
442 items tend to conform reasonably well to the Rasch model. However, there are four key issues.

1. The items seem very easy (or in the case of negatively worded items- very hard) to
   endorse. This can be seen by the 'measure' estimates that tend to be around or above the
   zero point- a standardised trait (estimate) derived from the item responses.
2. A couple of items tend to overfit the model: 'enjoy' (item 1) and 'irritated' (item 2)).
   These tend to be somewhat overly predictable from the responses to the other items.
   However, this observation should be viewed cautiously as only the z standardised fit
   showed misfit, and this can be sensitive to relatively large numbers of observations (e.g.
   >300).
3. One items ('I feel like I'm looking after my baby for someone else' -item 9) tends to
   show poor outfit. This suggests some erratic ratings, by those respondents whose
   estimated trait level was some distance from the item 'measure' (endorsibility').
4. One item showed poor infit and outfit, at least on the 'z' fit statistics ('I can work out
   what my baby needs from me'). This suggests this item may have been relatively
   erratically answered. It may have been different respondents read or interpreted the item
   differently from each other. For example, some may have interpreted it in terms of basic
   needs, whilst others, more in terms of emotional needs. It may be useful to explore
   whether this item showed any item bias or differential item functioning in relation to
   demographic factors.

461 In terms of 'person fit'; only 16 of the 438 (3.7%) participants showed marked underfit to the
462 Rasch model, as indicated by a standardised infit or outfit of greater than 2.0. That is, their
463 responses were more erratic than the Rasch model would have predicted. In contrast, only one
464 respondent showed marked overfit, as defined as a standardised infit and/or outfit of less than -
465 2.0.

466 The potential for item responses to be dependent on each other was investigated by examining
467 the matrix of correlated residuals from the Rasch model, between pairs of items. In general, the
468 magnitude of these were very small (average 0.08). The only more substantial correlated residual
469 (≥3.0) was observed for that between item 5 ('I can work out what my baby needs from me') and
470 item 6 ('I feel like I can't do things I enjoy because of my baby'). These two items had a
471 correlated residual of -0.31. It is not clear why this dependency was observed, though given only
472 one paired correlation out of 55 pairs exceeded 0.3 in magnitude this could be a chance finding

473

10

474 **INSERT TABLE 4 HERE**

475

476 **INSERT FIGURE 2 HERE**

477

478 **INSERT FIGURE 3 HERE**

479

480 *Item category probabilities*

481 It was apparent that most of the items were not operating as four-point Likert scales. That is, in

482 many items not all four categories of response were observed in this sample of respondents.

483 Moreover, some intermediate categories of response were rarely observed. In effect this means

484 that even if a respondent is higher on a trait level a lower category of response may still be

485 observed. This is sometimes referred to as 'Rasch-Andrich threshold suppression'. This effect is

486 nicely illustrated below, by the item category probability curves for item 11. Although some

487 respondents selected a response with a score of '2' had higher trait levels than those who scored

488 '1' ('0' was not observed), in practice they were more likely to be seen to choose a '1' category,

489 as so few chose the '2'. These findings suggest, at least for the kind of general population

490 sample used in this study, the use of four Likert scale points may be too many; that is, they may

491 not lead to more information on a test-taker and introduce some risk of extreme responses style

492 (ERS) bias. *Figure S1*, in the supplementary material, refers to probability of observing a

493 respondent choosing a particular response category according to their overall trait level ('baby

494 bonding'). Note that curves do not always correspond to the ordered responses (0→1→2→3).

495 *Test information*

496 As would be expected for a test mainly composed of easily endorsed items, most of the area

497 under the test information curve was for test takers whose traits were defined as slightly below

498 the average. That is, those who were likely to give midrange responses to easily endorsed items.

499 This can be seen by the fact the peak of the test information curve is just below the zero on the x-

500 axis. This suggests the item calibration is not ideal to pick out mothers who may be struggling to

501 bond with their babies (i.e., those who are likely to be observed with a lower total score on the

502 MaMB scale). The test information curve is depicted in *Figure S2* in the provided

503 supplementary material.

504 **Discussion**

505 There is a paucity of high-quality tools to assess parent-infant relationships. The MaMB was co-

506 developed to address this gap and act as a tool to measure bonding for use in research and

507 universal health settings.

508 The results suggest that it is feasible for HVs to administer the MaMB with mothers in universal

509 services. HVs successfully completed the MaMB with approximately 50% of the universal

510 population at the 6-8-week visit in the context of highly pressured services due to the Covid-19

511 global pandemic. Given low rates of missing data the MaMB appears to be acceptable to parents.

512

513 The psychometric analyses suggest the MaMB tool responses, in this sample of test takers, were

514 unidimensional. The MaMB showed relatively high levels of internal reliability consistency and

515 the items generally fitted the Rasch model. However, the high reliability may be partly an

516 artefact of the lack of variation in responses observed – almost all respondents gave high-scoring

517 categories on the items. The items did not generally behave as four-point response format

518 questions, as it was common for some response categories to go unobserved. Consequently, test

519 information was relatively low and was much less than may be required to identify at least two

520 separate groups of respondents, e.g., if the MaMB were to be used as a screening tool.

521

522   For the 29 parents that completed the free text it appeared a useful part of the MaMB to expand
523   on item completion with an opportunity to voice feelings or concerns. Responses suggest parents
524   were engaging in a meaningful discussion about bonding with their health visitor. This suggests
525   the MaMB could be considered a potential catalyst in opening discussions about sensitive
526   aspects of parenting such as experiencing guilt for wanting some 'alone' time, or for feeling less
527   positive when their baby is screaming. Such open conversations suggest that the tool could fit
528   well within a pathway for accessing specialist services, such as infant mental health services.
529
530   **Strengths**
531   The MaMB was co-developed over a series of workshops and interviews, using an iterative
532   process with HVs, Clinical Psychologists, service staff and managers from different localities,
533   and included parental input. It was piloted within routine HV contacts and, although the pilot
534   was delivered during the COVID-19 pandemic with many visits taking place remotely, or with
535   restrictions, completed MaMBs were obtained from 50% of the eligible population. The pilot
536   study was classed as research as opposed to service design and had ethical approval as such.
537   Previously psychometric analyses focused on exploratory and confirmatory factor analysis;
538   however, this study also included IRT, which affords additional rigour and confidence in the
539   results.
540
541   **Limitations**
542   Some HV teams would have conducted some core 6-8-week contacts over the telephone rather
543   than in the family home due to COVID-19. However, we do not have data to report how many.
544   This may have led to lower completion rate of the MaMB.
545
546   A much smaller than anticipated comparison group of non-completers was achieved. This was
547   because HVs appeared not to complete, or partially complete, a cover sheet with demographic
548   information if a mother did not wish to complete the MaMB. The pilot was conducted during the
549   COVID-19 pandemic, during which time HVs were under enormous pressure to continue
550   delivering statutory support to families despite adverse circumstances which likely contributed to
551   the non-completion of cover sheets.
552
553   **Deviations from the registered protocol**
554   Due to the limited information on non-completers we were unable to conduct planned statistical
555   analyses of the characteristics of completers compared to non-completers. The amount of data
556   contained within the free-text responses of completed MaMBs also prevented a planned thematic
557   analysis of these data, though it was sufficient to provide useful information in a descriptive
558   summary.
559
560   **Future research**
561   The findings of this study suggest that the MaMB is a promising tool to assess parent-infant
562   relationships. Future research directions fall across three domains (1) understanding practitioner
563   experiences, (2) expanding sample of users, and (3) refining approach to measurement.
564   *Understanding Practitioner Experiences*
565   Practitioners such as health visitors are a key component of using a measure of parent-infant
566   relationships. A better understanding of their experience supporting mothers to complete the
567   MaMB tool would help to further refine the tool. Obtaining ethical approval to ask HVs from the
568   current study their views on completing the MaMB would be a priority for future research.
569   *Expanding Sample of Users*
570   This study found that most participants responded similarly to items on the MaMB. Further
571   piloting of the tool with an expanded sample of users would help to understand the reason for

572　this limited range of responses. For example, use with mothers experiencing mental health
573　difficulties in the perinatal period would be particularly valuable. We might hypothesise that
574　those within the clinical range of depression measures may respond differently when asked about
575　their bond with their baby. This is highly likely to result in observing more variance in the items.
576　It may also be able to show whether the tool is able to discriminate, with any precision, between
577　at least two different groups of respondents. Note, in theory, a Rasch model is based on a sample
578　free distribution (that is the estimates should be the same irrespective of the sample of test takers
579　used for the calibration). However, in practice, precise estimates of item fit and difficulty may
580　not be achieved, even with large samples, if some categories of response are rarely or never
581　observed.
582　It was appropriate for this first pilot to target mothers, who are typically primary caregivers.
583　However, we know that there is increasing variability in those who take on the primary caregiver
584　role across society. Piloting the MaMB tool with a diverse range of caregivers would enable
585　exploration of differences and similarities across responses for wider parent-infant relationships.
586　It would also support use of the tool in practice, where fathers, same sex parents, or other kinship
587　carers may be caring for a baby.
588　*Refining Approach to Measurement*
589　To enable the tool to have a greater degree of variation across responses, future research could
590　test the MaMB tool with amended items (as highlighted in the results) to make them more subtle.
591　This could be helpful in picking up difficulties and bonding and attachment in parents or
592　caregivers. Moreover, future research could evaluate the tool as a three-point Likert scale, as
593　opposed to the four-point scale used in the current study. This could help to increase variation
594　across items.
595　**Conclusions**
596　HVs successfully administered the MaMB in universal services and the MaMB appears to be
597　acceptable to parents. The MaMB demonstrated good internal consistency and may support HV
598　signposting decisions for additional support, however, as the more robust analysis shows, if the
599　MaMB was to be used as a screening tool, with a cut-off, or ranges of 'concern' then additional
600　work is needed, which will need to include more families with risk factors such as depression in
601　an enriched sample.
602　Regarding our objectives, we consider the MaMB to be feasible for use in routine practice with
603　some amendments, and future piloting of such amendments.
604

'Me and My Baby' (MaMB)

ASSOCIATED PROTOCOL:

Version 2, 7th December 2020 – to access the protocol for further information please visit:
https://osf.io/q3hmf/
Bywater, T., Blower, S. L., Dunn, A., Endacott, C., Smith, K., & Tiffin, P. (2020, December 7). Me and My Baby Protocol: The measurement properties and acceptability of a new mother-infant bonding tool designed for use in a universal healthcare setting in the UK. Retrieved from osf.io/6br2e

STUDY SPONSOR

The University of York. Data sharing agreements and data management were compliant with the General Data Protection Regulation (GDPR) and University of York data management policies.

RESEARCH REFERENCE NUMBERS

- IRAS Number: 273708
- This study received ethical approval on 21st August 2020 by South Central - Berkshire B Research Ethics Committee, UK, Ref: 20/SC/0266, Integrated Research Application System (IRAS) 201, project ID: 273708.
- Funder References: HEIF - H0026802, ARC-YH: NIHR200166, The National Lottery Community Fund (previously the Big Lottery Fund) - 0094849, National Institute for Health Research (NIHR) Public Health Research (PHR) (ref 13/93/10).
- OFS Study Registration Number: osf.io/6br2e

CONFLICTS OF INTEREST

TB and SB are supported by the NIHR Yorkshire and Humber Applied Research Collaboration (ARC - YH). KS is an employee of RDaSH. All other authors do not declare any potential conflicts of interest

AUTHOR CONTRIBUTIONS

TB secured funding, TB and AD conceived the study, TB, AD, CE, KS, PAT, SB designed various aspects of the study. TB and SB provided supervision of the study from the academic perspective (UoY) and KS from the practitioner perspective (RDaSH). PAT conducted the statistical analysis and provided psychometric expertise, and KS and MP participated in co-developing the tool and provided clinical and practitioner expertise. AD and CE were research fellows on this study and coordinated and conducted various activities.
TB wrote the initial draft, and all authors have contributed and commented on subsequent drafts of this paper. TB, corresponding author, will act as guarantor and affirms that the manuscript is an honest, accurate, transparent, and full account. All listed authors meet authorship criteria and no others meeting the criteria have been omitted.

14

651   • RDaSH provided their staff time and other in-kind costs.
652   • The National Lottery Community Fund (previously the Big Lottery Fund) funded some
653   staff time, and other in-kind costs (Ref 10094849)
654

667   **SUPPLEMENTARY MATERIAL**
668   Supplementary material is provided for this study.

669
670   **DISCLAIMER**
676
677
678

679   **References**
680   Ainsworth, M., Blehar, M., Waters, E., and Wall, S. N. (1978). Patterns of attachment: a
681   psychological study of the strange situation. Psychology Press.
682   Appleton, J. V., Harris, M., Oates, J., and Kelly, C. (2013). Evaluating health visitor assessments
683   of mother-infant interactions: a mixed methods study. Int J Nurs Stud. 50(1), 5-15.
684   doi:10.1016/j.ijnurstu.2012.08.008
685   Asparouhov, T., and Muthén, B. (2009). Exploratory Structural Equation Modeling. Structural
686   Equation Modeling: A Multidisciplinary Journal. 16(3), 397-438.
687   doi:10.1080/10705510903008204
688   Barlow, J., McMillan, A. S., Kirkpatrick, S., Ghate, D., Barnes, J., and Smith, M. (2010). Health-
689   Led Interventions in the Early Years to Enhance Infant and Maternal Mental Health: A
690   Review of Reviews. Child and Adolescent Mental Health. 15(4), 178-185.
691   doi:doi:10.1111/j.1475-3588.2010.00570.x
692   Barlow, J., Schrader-McMillan, A., Axford, N., Wrigley, Z., Sonthalia, S., Wilkinson, T.,
693   Rawsthorn, M., Toft, A and Coad, J. (2016). Review: Attachment and attachment-related
694   outcomes in preschool children – a review of recent evidence. Child and Adolescent
695   Mental Health. 21(1), 11-20. doi:doi:10.1111/camh.12138
696   Baur, T., and Lukes, D. (2009). Evaluation of IRT Models through Monte Carlo simulation.
697   University of Wisconsin - La Crosse Journal of Undergraduate Research. 12, 1-7.

698 Bird, P. K., Hindson, Z., Dunn, A., de Chavez, A. C., Dickerson, J., Howes, J & Bywater, T.
699   (2021). Implementing the Maternal Postnatal Attachment Scale in universal services:
700   Qualitative interviews with health visitors. (Submitted)
701 Blower, S. L., Gridley, N., Dunn, A., Bywater, T., Hindson, Z., and Bryant, M. (2019).
702   Psychometric Properties of Parent Outcome Measures Used in RCTs of Antenatal and
703   Early Years Parent Programs: A Systematic Review. Clin Child Fam Psychol Rev. 22(3),
704   367-387. doi:10.1007/s10567-019-00276-2
705 Bowlby, J. (1982). ATTACHMENT AND LOSS: Retrospect and Prospect. American Journal of
706   Orthopsychiatry, 52(4), 664-678. doi:doi:10.1111/j.1939-0025.1982.tb01456.x
707 Branjerdporn, G., Meredith, P., Strong, J., and Garcia, J. (2017). Associations Between
708   Maternal-Foetal Attachment and Infant Developmental Outcomes: A Systematic Review.
709   Maternal and child health journal. 21(3), 540-553. doi:10.1007/s10995-016-2138-2
710 Braun, V., Clarke, V., Hayfield, N., and Terry, G. (2019). "Thematic Analysis." In Handbook of
711   Research Methods in Health Social Sciences, ed P. Liamputtong (Singapore: Springer
712   Singapore), 843-860.
713 Brockington, I. F., Fraser, C., and Wilson, D. (2006). The Postpartum Bonding Questionnaire: a
714   validation. Arch Womens Ment Health. 9(5), 233-242. doi:10.1007/s00737-006-0132-1
715 Bywater, T.J., Berry, V., Blower, S.L., Cohen, J., Gridley, N., Kiernan, K., Mandefield, L.,
716   Mason-Jones, A., McGilloway, S., McKendrick, K., Pickett, K., Richardson, G., Teare,
717   M.D., Tracey, L., Walker, S., Whittaker, K., & Wright, J. (2018). Enhancing social-
718   emotional health and wellbeing in the early years (E-SEE). A study protocol of a
719   community-based randomised controlled trial with process and economic evaluations of
720   the Incredible Years infant and toddler parenting programmes, delivered in a
721   Proportionate Universal Model. *BMJ Open*, 8. doi: 10.1136/bmjopen-2018-026906

722 Cassidy, J., Jones, J. D., and Shaver, P. R. (2013). Contributions of attachment theory and
723   research: a framework for future research, translation, and policy. Development and
724   Psychopathology, 25(4 Pt 2), 1415-1434. doi:10.1017/s0954579413000692
725 Condon, J. T. (1993). The assessment of antenatal emotional attachment: development of a
726   questionnaire instrument. The British journal of medical psychology. 66 (Pt 2), 167-183.
727   doi:10.1111/j.2044-8341.1993.tb01739.x
728 Condon, J. T., and Corkindale, C. J. (1998). The assessment of parent-to-infant attachment:
729   Development of a self-report questionnaire instrument. Journal of Reproductive and
730   Infant Psychology. 16(1), 57-76. doi:10.1080/02646839808404558
731 Cooper, C. (2019). Psychological Testing: Theory and Practice. London: Routledge.
732 de Vet, H. W. W., Terwee, C. B., Mokkink, L. B., and Knol, D. L. (2015). Measurement in
733   Medicine. Cambridge: Cambridge University Press.
734 Dickerson, J., Bird, P. K., McEachan, R. R., Pickett, K. E., Waiblinger, D., Uphoff, E., Mason.
735   D., Bryant, M., Bywater, T., Bowyer-Crane, C., Sahota, P., Small, N., Howell, M.,
736   Thornton, H., Astin, M., Lawlor, D.A. and Wright, J. (2016). Born in Bradford's Better
737   Start: an experimental birth cohort study to evaluate the impact of early life interventions.
738   BMC Public Health. 16(1), 711. doi:10.1186/s12889-016-3318-0
739 Dunn, A., Bird, P., Bywater, T., Dickerson, J., & Howes, J. (2021). An exploration of the
740   psychometric properties and clinical utility of the Maternal Postnatal Attachment Scale in
741   routine healthcare in a diverse British population (submitted).
742 Elmer, J. R. S., O'Shaughnessy, R., Bramwell, R., and Dickson, J. M. (2019). Exploring health
743   visiting professionals' evaluations of early parent-infant interactions. Journal of
744   Reproductive and Infant Psychology. 37(5), 554-565.
745   doi:10.1080/02646838.2019.1637831

746 Facompre, C. R., Bernard, K., and Waters, T. E. (2018). Effectiveness of interventions in
747   preventing disorganized attachment: A meta-analysis. Development and
748   Psychopathology. 30(1), 1-11. doi:10.1017/s0954579417000426
749 Fearon, R. P., Bakermans-Kranenburg, M. J., van Ijzendoorn, M. H., Lapsley, A. M., and
750   Roisman, G. I. (2010). The significance of insecure attachment and disorganization in the
751   development of children's externalizing behavior: a meta-analytic study. Child Dev.
752   81(2), 435-456. doi:10.1111/j.1467-8624.2009.01405.x
753 Feldman, R., Weller, A., Leckman, J. F., Kuint, J., and Eidelman, A. I. (1999). The nature of the
754   mother's tie to her infant: maternal bonding under conditions of proximity, separation,
755   and potential loss. Journal of child psychology and psychiatry, and allied disciplines.
756   40(6), 929-939.
757 Goldman, S. H., and Raju, N. S. (1986). Recovery of One- and Two-Parameter Logistic Item
758   Parameters: An Empirical Study. Educational and Psychological Measurement. 46(1), 11-
759   21. doi:10.1177/0013164486461002
760 Gridley, N., Blower, S., Dunn, A., Bywater, T., and Bryant, M. (2019). Psychometric Properties
761   of Child (0-5 Years) Outcome Measures as used in Randomized Controlled Trials of
762   Parent Programs: A Systematic Review. Clin Child Fam Psychol Rev, 22(3), 388-405.
763   doi:10.1007/s10567-019-00277-1
764 Horn, J. L. (1965). A Rationale And Test For The Number Of Factors In Factor Analysis.
765   Psychometrika, 30, 179-185. doi:10.1007/bf02289447
766 Kane, K. (2017). Assessing the parent-infant relationship through measures of maternal-infant
767   bonding. A concept analysis and systematic review. [Dissertation thesis]. York (England,
768   UK): University of York.
769 Kristensen, I. H., Trillingsgaard, T., Simonsen, M., and Kronborg, H. (2017). Are health visitors'
770   observations of early parent-infant interactions reliable? A cross-sectional design. Infant
771   Ment Health J. 38(2), 276-288. doi:10.1002/imhj.21627
772 Le Bas, G. A., Youssef, G. J., Macdonald, J. A., Rossen, L., Teague, S. J., Kothe, E. J.,
773   McIntosh, J.E., Olsson, C.A., and Hutchinson, D. M. (2019). The role of antenatal and
774   postnatal maternal bonding in infant development: A systematic review and meta-
775   analysis. Social Development, 29(1). doi: http://dx.doi.org/10.1111/sode.12392
776 Linacre, J. (1994). Sample Size and Item Calibration (or Person Measure) Stability.
777   https://www.rasch.org/rmt/rmt74m.htm [Accessed 27.10.2021]
778 Linacre, J.M. (2017). Winsteps Rasch Measurement Computer Programme (Version 4.0.0),
779   Portland, Oregon. Available from https://www.winsteps.com/.
780 Lorenzo-Seva, U., and Ferrando, P. J. (2006). FACTOR: a computer program to fit the
781   exploratory factor analysis model. Behavior research methods, 38(1), 88-91.
782   doi:10.3758/bf03192753
783 Lorenzo-Seva, U. and J. R. Van Ginkel (2016). Multiple imputation of missing values in
784   exploratory factor analysis of multidimensional scales: estimating latent trait scores.
785   Anales de Psicología/Annals of Psychology. 32(2): 596-608.
786 Marsh, H.W. (1996). Positive and negative global self-esteem: a substantively meaningful
787   distinction or artifactors? J Pers Soc Psychol. 70(4), 810-9.
788 Müller (1994). A questionnaire to measure mother-to-infant attachment. J Nurs Meas. 2(2), 129-
789   41. PMID: 7780768
790 NICE. (2012). Social and emotional wellbeing: early years. NICE guidelines PH40.
791   https://www.nice.org.uk/guidance/ph40
792 NICE. (2015). Children's attachment: attachment in children and young people who are adopted
793   from care, in care or at high risk of going into care. NICE guidelines NG 26.
794   https://www.nice.org.uk/guidance/ng26

795 Public Health England. (2020). Early years high impact area two: Supporting good parental
796   mental health.
797   https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_
798   data/file/942475/Maternity_high_impact_area_2_Supporting_good_parental_mental_heal
799   th.pdf
800 Rasch, G. (1960). Probabilistic models for some intelligence and attainment tests. Chicago, The
801   University of Chicago Press
802 Raykov, T. (1997). Scale Reliability, Cronbach's Coefficient Alpha, and Violations of Essential
803   Tau-Equivalence with Fixed Congeneric Components. Multivariate behavioral research.
804   32(4), 329-353. doi:10.1207/s15327906mbr3204_2
805 Redshaw, M., and Martin, C. (2013). Babies, 'bonding' and ideas about parental 'attachment'.
806   Journal of Reproductive and Infant Psychology. 31(3), 219-221.
807 Taylor, A., Atkins, R., Kumar, R., Adams, D., and Glover, V. (2005). A new Mother-to-Infant
808   Bonding Scale: links with early maternal mood. Arch Womens Ment Health. 8(1), 45-51.
809   doi:10.1007/s00737-005-0074-z
810 Wilson, P., Thompson, L., Puckering, C., McConnachie, A., Holden, C., Cassidy, C., and
811   Gillberg, C. (2010). Parent-child relationships: are health visitors' judgements reliable?
812   Community Practitioner. 85(2), 22-25.
813 Wittkowski, A., Vatter, S., Muhinyi, A., Garrett, C., and Henderson, M. (2020). Measuring
814   bonding or attachment in the parent-infant-relationship: A systematic review of parent-
815   report assessment measures, their psychometric properties and clinical utility. Clinical
816   Psychology Review. 101906.
817 Wright, B., Barry, M., Hughes, E., Trépel, D., Ali, S., Allgar, V., Cottrill, L., Duffy, S., Fell, J.,
818   Glanville, J., Glaser, D., Hackney, L., Manea, L., McMillan, D., Palmer S., Prior, V.,
819   Whitton, C., Perry, A and Gilbody, S. (2015). Clinical effectiveness and cost-
820   effectiveness of parenting interventions for children with severe attachment problems: a
821   systematic review and meta-analysis. Health Technology Assessment. 19(52).
822 Wright, B., and Masters, G. (1982). Rating Scale Analysis. Chicago,IL: MESA Press.

823 **Appendix 1: The MaMB Participant Information Sheet**
824 **(To include logos)**

Information on the 'Me and My Baby' questionnaire

825

826 ### What will happen at your next Health Visitor visit?
827 When your baby is between 6 and 8 weeks old your Health Visitor will talk to you about how you
828 and your baby are getting along. At this visit your Health Visitor will ask if you have any questions
829 about the information in this leaflet, and if you're willing to complete some questions about your
830 relationship with your baby.

831 ### Why are you asking about my relationship with my baby?
832 The Me and My Baby questionnaire is short and has been developed by Health Visitors and
833 researchers, with other NHS staff, and with input from parents.
834 Not everyone finds it easy to get on with their new baby. Some mums, even if they have other
835 children, sometimes feel they don't understand their new baby, or that their baby is being difficult
836 on purpose.
837 Also, when things are going well, many mums find it useful to reflect on their feelings about their
838 baby. If you feel like things aren't going how you want them to your Health Visitor can help you. We
839 are asking all mums in your area to complete the questionnaire. For now, we are only asking
840 biological mums who are the main carers of their new baby.

841 ### Why are you asking these questions?
842 In partnership with the Department of Health Sciences at the University of York, we are exploring
843 how useful these questions are in showing when relationships between mum and baby are going
844 well and not so well. You don't have to answer these questions if you don't want to, and you can
845 stop completing the questionnaire at any time – your decision will not affect your relationship with
846 your Health Visitor or the support they offer you.

847 ### What will happen to my answers?
848 Your Health Visitor will look at your answers and talk to you about your relationship with your baby.
849 Health Visitors are highly trained and understand that being a mum is different for everyone.
850 If the questionnaire is useful, it may help Health Visitors in offering future support and training to
851 parents around forming a good relationship with their baby. Your answers will be shared with
852 colleagues in the Department of Health Sciences at The University of York (the university are
853 partnering with Rotherham Doncaster and South Humber NHS Foundation Trust to explore the
854 usefulness of the questionnaire).

855 ### 1.1.1 How will we use information about you?

856 1.1.2 Your NHS Trust will not share any identifiable information about you (e.g. your name or address) with
857   the University of York. The University will examine all anonymous answers on the Me and My Baby
858   questionnaire to see if the questions are helpful in identifying where the relationship between mums
859   and their new baby may be difficult or where some support may be helpful. These findings could help
860   to improve the care new mums across your area receive in the future. The findings will be shared in
861   reports, copies of which will be available on the following websites:

862   • If you live in xxxxx see xxxxx
863   • If you live in xxxxx see xxxxx
864   • Research team website: https://www.arc-yh.nihr.ac.uk/home

865 The research team at the University of York will only have access to <u>fully</u> anonymised data, they will
866 not receive any data or codes that can be used to identify you and they will not be able to see your
867 name or contact details.
868 The research team will keep all data safe and secure on University of York servers. Once we have
869 finished the study, the University of York will keep the fully anonymised data for 10 years at which
870 point it will be securely destroyed.

871 ### 1.1.3 What are your choices about how your information is used?

872 - You can stop being part of the study at any time, without giving a reason, but we will keep
873 information about you that we already have.
874 - We need to manage your records in specific ways for the research to be reliable. This means
875 that we won't be able to let you see or change the data we hold about you.
876

877 ### 1.1.4 Where can you find out more about how your information is used?

878 *You can find out more about how we use your information*

879 - *at www.hra.nhs.uk/information-about-patients/*
880 - *by asking a member of the research team **sarah.blower@york.ac.uk***
881 - The sponsor for this study is the University of York
882 https://www.york.ac.uk/staff/research/governance/research-policies/policy-for-clinical-
883 research
884 - at the University of York data protection officer's website: https://www.york.ac.uk/records-
885 management/dp/
886 - *by ringing your Health visiting service on the numbers below*
887

888 **If you would like more information, please contact your Health Visiting service in XXXXX on**
889 **XXXXX, or XXXXX on XXXXX**
890
891

892 **Appendix 2 – The MaMB. NOTE: this measure is under further development. Please contact**
893 **the corresponding author if you wish to use it in the format below.**
894 <div align="center">**Me and My Baby**</div>
895 Having a new baby can bring up lots of different feelings and emotions. This questionnaire is
896 designed to explore how you are feeling about being a parent to your baby.
897 Answering these questions will help us to understand how things are going for you. There is space on
898 the back of this page for you and your Health Visitor to explore why you have answered the way you
899 have if you wish. **Thinking about your feelings about your baby, choose the response for each**
900 **statement that feels right to you…**

		Never	Sometimes	Often	Always
1.	I enjoy looking after my baby				
2.	I feel irritated with my baby when we are together				
3.	I feel affectionate towards my baby				
4.	I feel that my baby is being difficult or trying to upset me on purpose				
5.	I can work out what my baby needs from me				
6.	I feel like I can't do things I enjoy because of my baby				
7.	I feel the changes in my life are worth it to look after my baby				
8.	I miss my baby when we are not together				
9.	I feel like I'm looking after my baby for someone else				
10.	When we've been apart I look forward to seeing my baby again				
11.	I enjoy playing with my baby				

901

Is there anything else you'd like to add about how you feel about your baby?

902
903 **Scoring Sheet:** The score for each response is in the equivalent box below – find the option selected by the parent for
904 each question and add up the scores. Higher scores on this tool suggest that a parent is finding it difficult to develop an
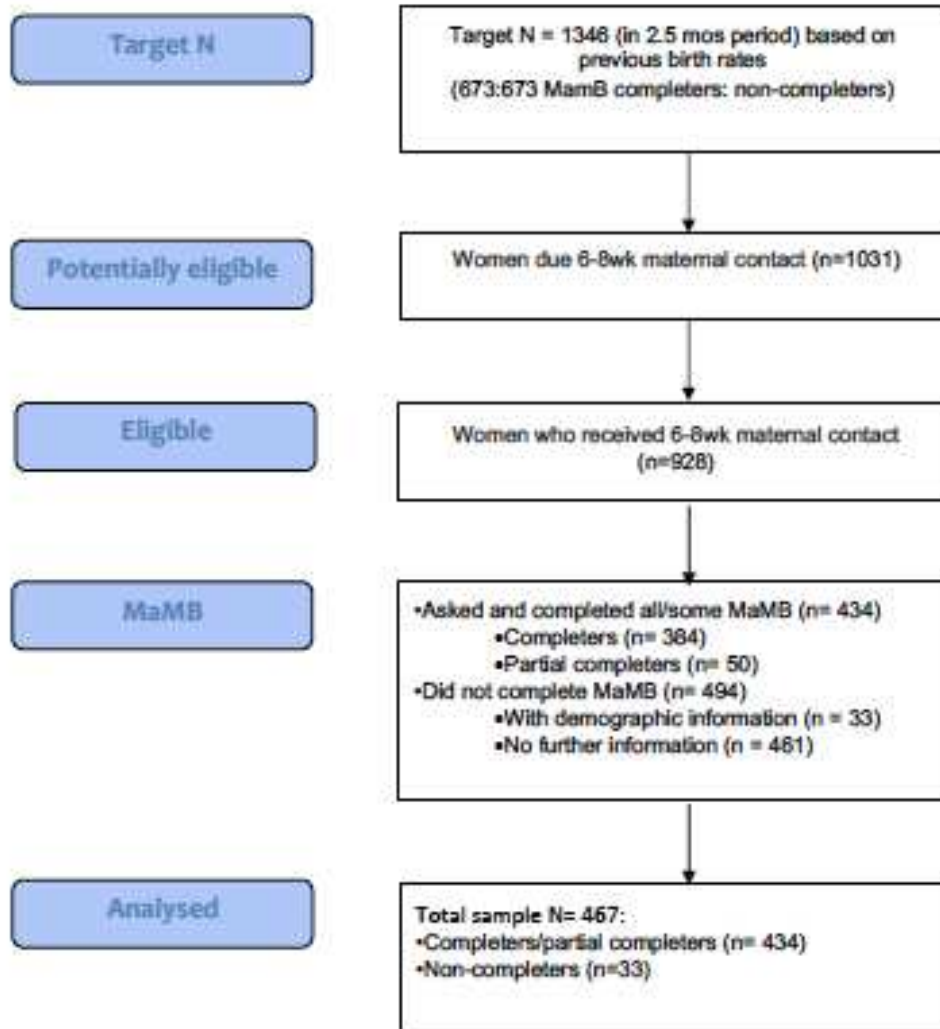
appropriate bond with their infant. **It is important to note that there are no validated cut offs for clinical concern on this tool – so combine scores with your professional judgement when deciding what to do next for a parent.**

		Never	Sometimes	Often	Always
1.	I enjoy looking after my baby	3	2	1	0
2.	I feel irritated with my baby when we are together	0	1	2	3
3.	I feel affectionate towards my baby	3	2	1	0
4.	I feel that my baby is being difficult or trying to upset me on purpose	0	1	2	3
5.	I can work out what my baby needs from me	3	2	1	0
6.	I feel like I can't do things I enjoy because of my baby	0	1	2	3
7.	I feel the changes in my life are worth it to look after my baby	3	2	1	0
8.	I miss my baby when we are not together	3	2	1	0
9.	I feel like I'm looking after my baby for someone else	0	1	2	3
10	When we've been apart I look forward to seeing my baby again	3	2	1	0
11.	I enjoy playing with my baby	3	2	1	0
Total:		+	+	+	
		= Total Score:_____			

Figure 1. Flow chart of participants

Stage	
Target N	Target N = 1346 (in 2.5 mos period) based on previous birth rates (673:673 MamB completers: non-completers)
Potentially eligible	Women due 6-8wk maternal contact (n=1031)
Eligible	Women who received 6-8wk maternal contact (n=928)
MaMB	•Asked and completed all/some MaMB (n= 434) •Completers (n= 384) •Partial completers (n= 50) •Did not complete MaMB (n= 494) •With demographic information (n = 33) •No further information (n = 461)
Analysed	Total sample N= 467: •Completers/partial completers (n= 434) •Non-completers (n=33)

911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929

24
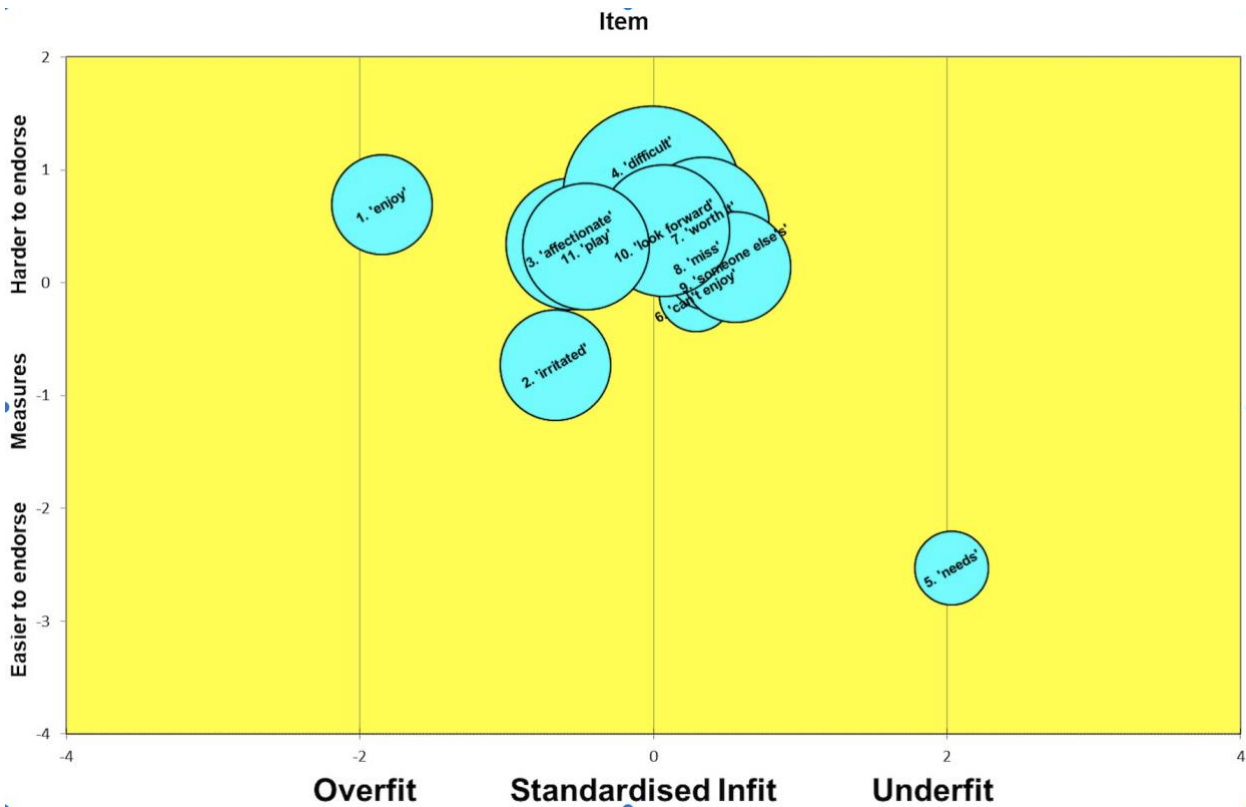
930
931 **Figure 2. Bubble plot of the MaMB items, according to estimated endorsability ('measure'),**
932 **their standard error for this (diameter) and degree of 'infit' according to the Rasch model.**
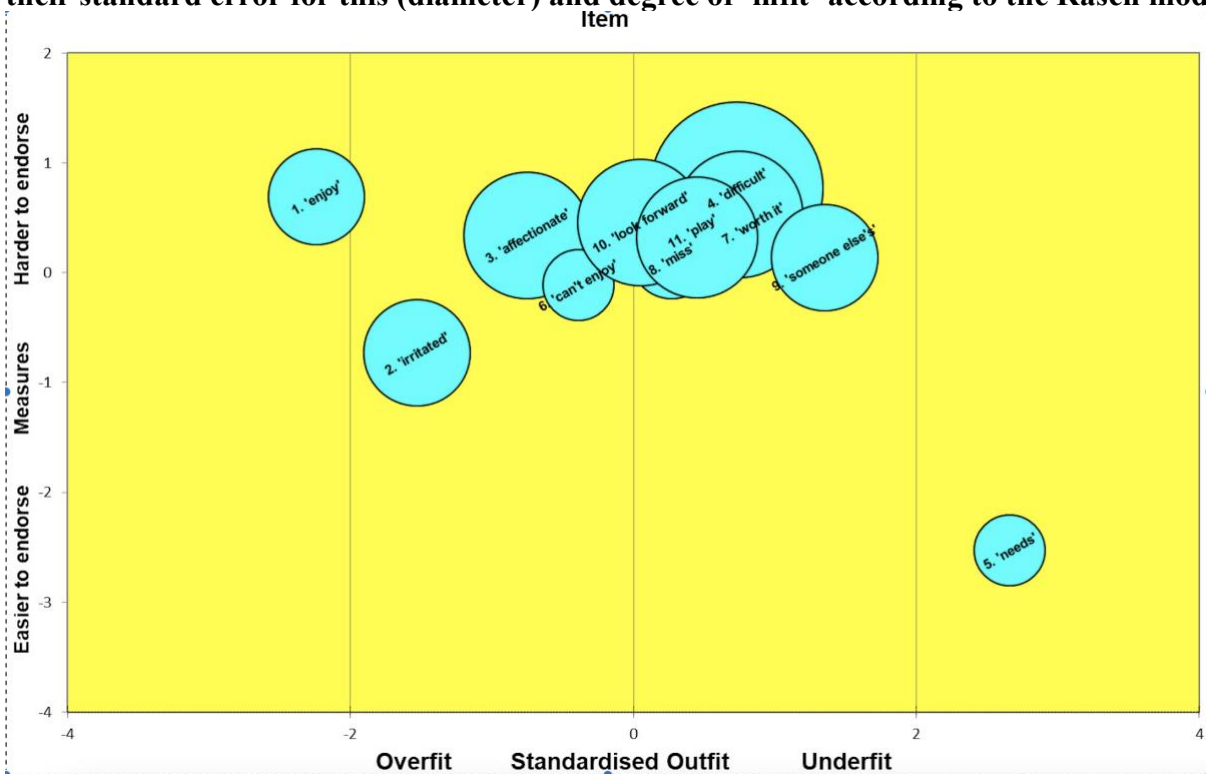
933
934 **Figure 3. Bubble plot of the MaMB items, according to estimated endorsability ('measure'),**
935 **their standard error for this (diameter) and degree of 'outfit' according to the Rasch model.**
936
937

938 **Table 1.** Characteristics of completers (N=434) and non-completers (N=33)

	Completers (N=434)		Non-Completers (N=33)	
	Count	Percent	Count	Percent
Site				
Doncaster (Site 1)	256	59%	21	64%
North Lincolnshire (Site 2)	178	41%	12	36%
Mother age (in years)				
Mean (SD)	28.45 (5.76)	/	29.25 (5.17)	/
Min	16	/	21	/
Max	43	/	43	/
Child age (in weeks)				
Mean (SD)	6.69 (1.69)	/	8	/
Min	4	/	6	/
Max	25	/	31	/
Ethnicity				
White British	359	83%	16	49%
White Other	43	10%	8	24%
Asian/Asian British	13	3%	0	0
Black African /Caribbean/Black British	5	1%	3	9%
Mixed/Multi-ethnic	2	0.5%	1	3%
Other	9	2%	1	3%
Missing	3	0.5%	4	12%
Mother's first language is English				
Yes	348	80%	15	46%
No	59	14%	13	39%
Missing	27	6%	5	15%
Interpreter needed (for non-first lang English)				
Yes	8	14%	5	38%
No	50	85%	7	54%
Missing	1	1%	1	8%
First child				
Yes	195	45%	9	27%
No	235	54%	20	61%
Missing	4	1%	4	12%

939 N.B. Table 1 includes a descriptive summary of available data from the 33 women who did not complete a MaMB but
940 their health visitor completed a cover sheet

941
942
943
944

945

946 **Table 2.** Results from a parallel analysis, adapted for ordinal data. *Note only the percentage of
947 variance explained by the first factor exceeds that observed for the random data.

Factor	Variable Real-data % of variance	Mean of random % of variance	95th percentile of random % of variance
1st	61.4*	18.4	21.9
2nd	10.1	16.2	18.6
3rd	6.7	14.3	16.1
4th	5.8	12.6	14.2
5th	5.0	10.7	12.3
6th	3.1	9.0	10.5
7th	2.6	7.3	9.0
8th	2.3	5.5	7.4
9th	1.9	3.9	5.8
10th	1.2	2.1	4.0
11th	0.0	0.0	0.0

948

949

950
951
952

953

954 **Table 3.** Psychometric properties of the MAMB items, including exploratory factor analysis results,
955 assuming one underlying factor (dimension).

MaMB item (abbreviated wording)	Item mean (SD)	Item-total correlation	Cronbach's alpha with item removed*	Factor loading	Communality
1. Enjoy looking after baby	0.08 (.29)	0.64	0.58	0.849	0.721
2. Feel irritated with baby	0.08 (.27)	0.52	0.60	0.709	0.502
3. Affectionate towards baby	0.04 (0.2)	0.51	0.60	0.835	0.698
4. Feel baby is being difficult	0.02 (.15)	0.33	0.63	0.675	0.456
5. Can work out baby's needs	0.54 (.58)	0.57	0.66	0.489	0.239
6. Can't do enjoyable things because of baby	0.21 (.43)	0.55	0.61	0.635	0.403
7. Life changes worth it	0.04 (.22)	0.35	0.63	0.645	0.415
8. I miss my baby when not together	0.10 (.36)	0.52	0.61	0.705	0.497
9. Feels like someone else's baby	0.04 (.27)	0.35	0.63	0.637	0.406
10. Look forward to seeing baby again	0.03 (.23)	0.43	0.62	0.722	0.521
11. Enjoy playing with	0.04 (0.23)	0.49	0.61	0.797	0.636

956

957 ***** Cronbach's alpha for test with all 11 item responses included was 0.64

959 **Table 4.** Item 'endorsibility' ('measure') of the MaMB scale, along with the Rasch fit statistics.
960 These include both 'infit' and 'outfit' statistics as both the mean squared error and standardised (z)
961 fit.

Item	Item difficulty/ 'Endorsibility'	Infit (mean-squared)	Infit (standardised)	Outfit (mean-squared)	Outfit (standardised)
1. Enjoy looking after baby	0.69	0.76	-1.85	0.53	-2.24
2. Feel irritated with baby	-0.73	0.91	-0.67	0.65	-1.53
3. Affectionate towards baby	0.34	0.82	-0.56	0.53	-0.75
4. Feel baby is being difficult	0.77	0.97	-0.01	1.33	0.73
5. Can work out baby's needs	-2.53	1.20	2.03	1.31	2.66
6. Can't do enjoyable things because of baby	-0.11	1.03	0.29	0.95	-0.39
7. Life changes worth it	0.53	1.07	0.34	1.31	0.75
8. I miss my baby when not together	0.13	1.06	0.37	1.05	0.27
9. Feels like someone else's baby	0.14	1.17	0.56	2.09	1.35
10. Look forward to seeing baby again	0.46	0.98	0.07	0.91	0.05
11. Enjoy playing with	0.32	0.86	-0.46	1.15	0.45

962
963
964
965
966
967
968
969
970