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Meta-Analysis

Parental Posttraumatic Stress Disorder and Attunement: Meta-Analysis

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ABSTRACT

Background: Attunement between a primary carer and their infant plays a crucial role in infant brain development, attachment, sense of self and personality development, with long-term effects on the risk of future psychopathology. The present study aimed at 1) identifying a comprehensive definition of attunement and 2) investigating parent-infant attunement in the context of parental posttraumatic stress disorder (PTSD).
Subjects and Method: Following PRISMA guidelines, a systematic review of the literature was conducted on parental PTSD and parent-infant attunement. Eligible studies were prospective, quantitative, published in peer-reviewed journals, included normal samples and samples with PTSD along with attunement variables, reporting correlational data, with mothers aged 16 or older and infants aged 0-18 months. Forty-eight articles were examined in full-text and 18 selected for analysis. The National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool was used to assess the quality of selected studies. Pooled effect sizes were calculated separately for positive and negative attunement variables under the random effects model, using comprehensive meta analysis Comprehensive Meta-Analysis (CMA).
Results: Analysis failed to reach statistical significance. The pooled effect size for parental PTSD and negative attunement was positive and small. The pooled effect size for parental PTSD and positive attunement was negative and small.
Conclusion: Due to the high heterogeneity among the included articles and statistically non-significant effect sizes, results need to be interpreted with caution. However, the results indicate that the presence of PTSD symptoms is likely to influence parents' capacity to attune to their infants. Limitations and implications for future research and clinical practice are discussed.

Keywords: attunement, parental posttraumatic stress disorder

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BACKGROUND

The construct of attunement has been subject of psychological research for several decades in broadly two different contexts: (1) In the context of parent-infant bonding, where research has made significant contributions to inform clinical practice, whilst particularly focusing on mothers as the main source of attunement (e.g. Atkinson et al., 2016; Bernard et al,, 2017; Rutherford et al., 2015), and (2) in the context of therapist-client relationship as a critical element and catalyst for promoting positive change in clients (Day, 2016; Rocco et al., 2017; Tufekcioglu and Muran, 2015). Research on neurobiology has provided

support for the application of attachment theory by understanding brain development in infancy and childhood as it sets the framework for regulating affect and the development of self (Cozolino, 2014; Schore, 2003c). In their work, both Siegel (2012) and Schore (2017) highlight that the capacity to regulate emotions is dependent on social interactions and early attachment experiences. According to Schore (2003b), infant development is transactional within the dialectical mother-infant relationship, with emotional exchange between them being nonverbal. The environmental input, essential for healthy development during infancy and early childhood, comes mainly from the relationship to the primary caregiver, with the caregiver being a co-regulator for affect by modulating the infant's arousal states (Schore, 2017). This occurs through the primary caregiver engaging with the infant with interest, curiosity, and understanding.

Clinical relevance of attunement: Risk of Psychopathology. A lack of attunement of the primary caregiver towards the infant leads to the infant's needs not being met, which can cause attachment trauma. In this context, the primary caregiver, who should serve as a source of safety, contrarily becomes a source of dysregulation through abuse or neglect (PsychAlive, 2014). Especially if paired with the absence of repair, attachment ruptures negatively impact the development of the right brain, whose initial trajectory is set up in the attachment relationship, and can further increase the risk for developing psychopathology in the affected child (PsychAlive, 2014).

The Diagnostic and Statistical manual of mental disorders (American Psychiatric Association [DSM-5], 2013) lists early relationship ruptures and lack of attunement as risk factors for the manifestation of psychopathology in a number of disorders: Reactive Attachment Disorder, Disinhibited Social Engagement Disorder, Personality Disorders such as Borderline Personality Disorder, and Post-traumatic Stress Disorder (PTSD).

It is critical to investigate the various factors that can jeopardise a parent's capacity to positively influence the development of affect regulation in an infant. It is beyond the scope of this meta-analysis to cover all such factors, and thus, it was limited to reviewing literature on parent-infant attunement amongst parents with symptoms of PTSD.

Social Learning theory points in the direction of the detrimental impact of childhood abuse on future parenting practices (Ammerman et al., 2012). Although there is research on the link between a history of childhood trauma and its relationship with parenting in adulthood, studies focusing on the relationship between PTSD and parenting are few (Ammerman et al., 2012). Mothers with a history of childhood trauma are challenged by their child's developmentally appropriate behaviour, interpreting it as threatening (Muzik et al., 2009), hence, compromising their capacity to attune. Studies investigating parental PTSD suggest a link especially with emotional numbing and avoidance, and poorer relationships with their children (Muzik, et al., 2009).

Affect regulation goes beyond childhood and is essential for healthy adjustment throughout the lifespan (Schore, 2003b, 2017). The critical factor behind affect regulation capacity, i.e. early interactional patterns between infant and primary caregiver, remain insufficiently researched. Cozolino (2014, p. xvii) stated a joint focus of research in this regard on "the neural systems that organise attachment, emotion, attunement, and social commu-

nication". Schore (2017), and Schore & Schore (2014) propose an expanded modern attachment theory, called regulation theory, which, informed by neuroscience and research on infant attachment, emphasises the direct relevance of developmental attachment studies for therapists to apply in the treatment process, whilst working with clients from all ages. Empirical evidence confirms the right brain's involvement during early childhood in the development of affect regulation and sense of self (Siegel, 2012; Schore 2017), and in adulthood in the process of therapist-client attunement, facilitating processes of neuroplasticity (Siegel, as cited in Llosa, 2011; Schore, 2017). Based on attachment theory as a regulation theory, a clinical model of treatment called affect regulation therapy (ART) was developed, which also highlighted that through the process of attunement, brain plasticity can be affected and the client's social intelligence expanded (Schore and Schore, 2014), exactly like in parent-infant dyads. Sensorimotor Psychotherapy, developed by Pat Odgen, is a body-based psychological intervention, utilising the therapist's attunement to the client to facilitate affect regulation and integration of traumatic past experiences (Ogden and Minton, 2000).

In light of the above, attunement can be seen as a factor highlighting aspects of the quality of important early relationships on the one hand, and adult/ therapeutic relationships on the other hand, which have the potential to facilitate successful affect regulation.

Literature on Attunement

Numerous theoretical texts on attunement have been published, demonstrating the link of the concept with attachment theory and describing attunement as an attachment process (Spiegel, 2016). Literature highlights its relevance in understanding the mother-infant adaptation process within the psychoanalytical framework (Kestenberg, 1999). Research has also focused on biomarkers to measure attunement in relationships (Riess, 2011). Findings in the field of neurobiology have discussed the importance of attunement in play therapy (Wheeler, and Taylor, 2016). Individual studies have approached the measurement of attunement in parent-infant dyads from different angles, resulting in a varied range of methods as further outlined below.

Definition. The lack of a uniform definition and operationalisation of the construct in current attunement research is evident (Bernard et al., 2017), thus making it challenging to apply the findings of different studies across diverse contexts. In mother-infant dyads, some studies investigate behaviour (Lin and Green, 2009), or emotions and facial expression (Kokkinaki et al., 2017). Other studies focus on language (Meins, 2013; Savelkoul et al., 2007), joint attention or intersubjectivity (Bartling et al., 2010; Rollins and Greenwald, 2012), or cortisol and respiratory sinus arrhythmia (RSA) (Laurent et al., 2011; Ostlund et al., 2017).

This warrants viewing attunement as a multidimensional construct, with behavioural, emotional, psychophysiological, and neurobiological aspects (Cozolino, 2014; Shore, 2003a, 2003b; Porges, 2001; Porges and Furman, 2011, Wagner, 2015). The present review attempted to synthesise the various ways in which attunement could be defined within the context of parent-infant relationship, with a stronger emphasis on the mother-infant dyad.

Methodological differences across studies. Studies vary greatly with regards to research designs and methods applied. Many studies investigated attunement in non-experimental settings by observing

mother-infant interactions (Jonsson et al., 2001; Kokkinaki, 2003; Kokkinaki et al., 2017), by interviewing parents to collect data on attunement (Easterbrooks and Biringen, 2000; Flacking et al., 2007; Matta and Knudson-Martin, 2006), or by administering questionnaires (Fuchs et al., 2016). Studies on attunement are difficult to compare due to high heterogeneity in terminology, conceptualisation, and statistical analysis (Bernard et al., 2017).

Measures of attunement. In the context of different studies, several scales were developed to measure attunement: the Maternal Affect Attunement Scale (MAAS) (Bartling et al., 2010), the Level of Intersubjective Attunement Scale (LISA) (Brugué and Burriel, 2016), and the Affect Attunement Protocol (AAP) (Haft, 1989).

Sample characteristics. Most studies used convenience sampling with varying sample sizes, for example Fuchs et al. (2016), Jonsson et al. (2001), and Vallotton (2012). Overall, most studies are limited to mother-infant dyads, with fathers being under-represented, pointing in the direction for further research to include fathers as well. Generally, a distinction can be made between studies examining attunement in at-risk populations versus low-risk or normal populations. The characteristics of at-risk populations are diverse, including parents at risk for parenting problems (e.g. Ostlund et al., 2017), economically disadvantaged (single) parents (e.g. Porcerelli, Huth-Bocks, Huprich, and Richardson, 2016), parents with history of abuse, with or at risk for depression (e.g. Ostlund et al., 2017). Studies with clinical samples are limited, indicating the need for further research.

SUBJECTS AND METHOD

1. Study Design

Two systematic literature searches and one systematic review and meta-analysis were conducted following the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) (Moher et al., 2009) focusing on 1) parent-infant attunement, and 2) parental PTSD and attunement variables.

2. Search Strategy

For the systematic search on mother-infant attunement, four electronic databases (PsycInfo, PsycArticles, PsycExtra, and ERIC) were searched in December 2017 using the terms 'mother* AND infant* AND attunement' as present in titles or abstracts. Additionally, articles were hand-searched in three selected journals, and an email alert was set for the systematic search so that future publications could be included. For the second systematic search on maternal PTSD and attunement, five electronic databases (PsycInfo, PsycArticles, PsycExtra, ERIC, and PubMed) were searched in July 2018 using the terms 'mother*, infant*, and PTSD' as present in titles or abstracts. Search strings can be provided upon request. Additional sources of records included the database Scopus, reference lists of selected studies, and hand search. Limiters applied in both searches were: Articles published in peer-reviewed journals in English or German language. No publication date limit was applied.

3. Inclusion Criteria

Inclusion criteria consisted of, a) a study meeting the definition of being "a set of data collected under a single research plan from a designated sample of respondents" (Lipsey & Wilson, p. 76), b) published in peer-reviewed journals in English or German language, c) investigating normal samples or samples with psychopathology, specifically PTSD and attunement variables, d) infant age 0 to 18 months, e) mothers aged at least 16 years, and f) reported correlational data. Exclusion criteria were:

a) qualitative studies, reviews, dissertations, b) studies in languages other than English or German, c) studies that did not include measures of maternal PTSD, d) infants older than 18 months, e) mothers younger than 16 years, and f) studies that did not report or provide correlational data upon request.

4. Data Ekstrasion

Data from eligible studies was extracted by J.A. and N.R. and inconsistencies resolved in discussion. Information extracted consisted of descriptors of the study sample including maternal psychopathology and sample size, predictor and outcome variables, and results including correlation coefficients.

5. Quality Assesment

The NHLBI Quality Assessment Tool (n.d.) was used to assess the methodological quality of the studies. Studies were rated (yes = 1, no/ not applicable = 0) on nine quality criteria. A score between 7 and 9 indicated good quality, a score between 4 and 6 indicated fair quality, and a score between 0 and 3 indicated poor quality.

6. Meta-Analysis Procedure

The meta-analysis estimated the pooled effect sizes for the association between maternal PTSD symptoms and attunement variables using Comprehensive Meta-Analysis (CMA) (Version 3).

7. Effect Size Computations

Correlation coefficients were selected as these were the most commonly reported effect size. In order to code outcome variables for data synthesis, variables associated with the parent infant relationship in the context of parental PTSD were classified (Lu and Huffman, 2017) as either positive attunement or negative attunement variables. Positive attunement variables were defined as indicators or moderators of healthy attunement, such as attachment security, dyadic synchrony, or infant cooperation. Likewise, negative attunement variables were defined as indicators/ moderators of impaired attunement in the dyad, such as poor parent infant bond, avoidant or insecure attachment, or infant disorganisation during play. To handle non-independence of effect sizes and prevent undue weighting in studies that delivered more than one effect size for each outcome category, all positive/ negative attunement variables were pooled within studies, and then pooled across studies in meta-analytic synthesis (Cuijpers, 2016).

Multiple outcome analyses were run using the random-effects model due to the high variability between studies regarding study design, sample characteristics, measures, and outcome variables (Cuijpers, 2016). To classify the strength of the pooled effect sizes, Cohen's criteria were applied with r = 0.10 indicating a small effect, r = 0.30 indicating a medium effect, and r = 0.50 indicating a large effect (Cohen, 1988, as cited in Rosenthal, 1996).

8. Assessment of Heterogeneity

Heterogeneity between studies was assessed by screening the studies' confidence intervals as compared to the pooled effect sizes' confidence intervals in the forest plots. The *Q*-test was applied, and I^2 statistic used to quantify heterogeneity with 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively (Higgins, as cited in Cuijpers, 2016). The studies' residuals were examined for outliers, i.e. residuals outside the -1.96 to 1.96 range (Field, 2013). Conspicuous studies were re-examined for potential errors in data extraction or data entry, as well as qualitatively assessed for outstanding characteristics that could explain their deviant values.

Publication bias. Publication bias was assessed by examination of funnel plots and by using Duval and Tweedie's (2000) 'trim and fill' method.

Subgroup analysis. The outcome variables of positive and negative attunement were analysed separately.

RESULTS

The first systematic search (see Figure 1) identified 58 articles selected from the systematic search on attunement. Full-text review of the articles resulted in exclusion of 37. The remaining 21 articles were assessed and deemed unfeasible for sound statistical analysis due to their high methodological heterogeneity.

The second systematic search (see Figure 2) on maternal PTSD and attunement variables identified 18 eligible articles published between January 1994 and July 2018, which were selected for systematic review and meta-analysis. Overall, 49 associations between maternal PTSD and attunement variables were included. The selected studies included the association of PTSD with either the positive attunement variables only or with negative attunement variables only, along with some reporting associations with both negative and positive attunement variables.

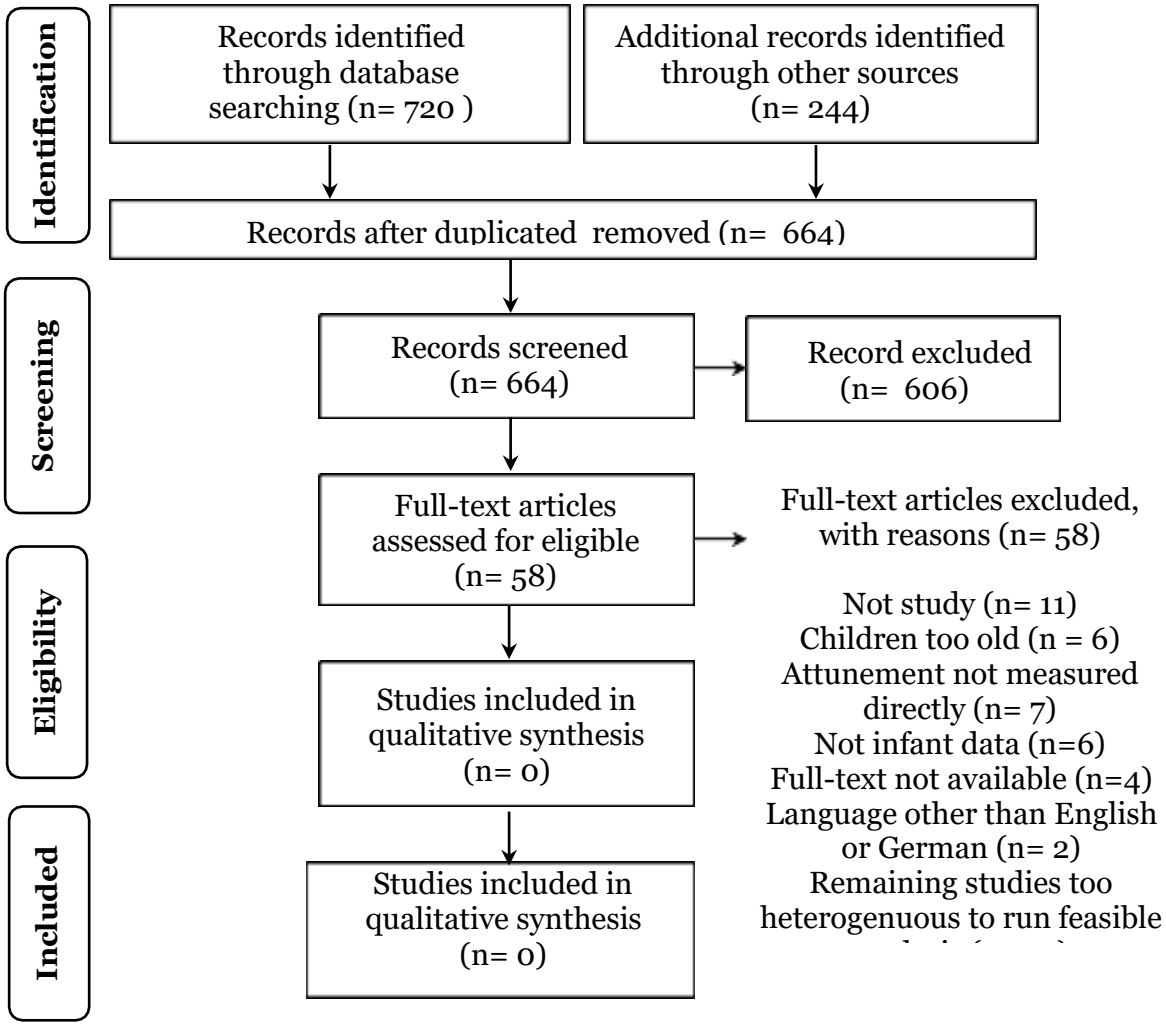

Figure 1. PRISMA flow diagram of the systematic search of attunement

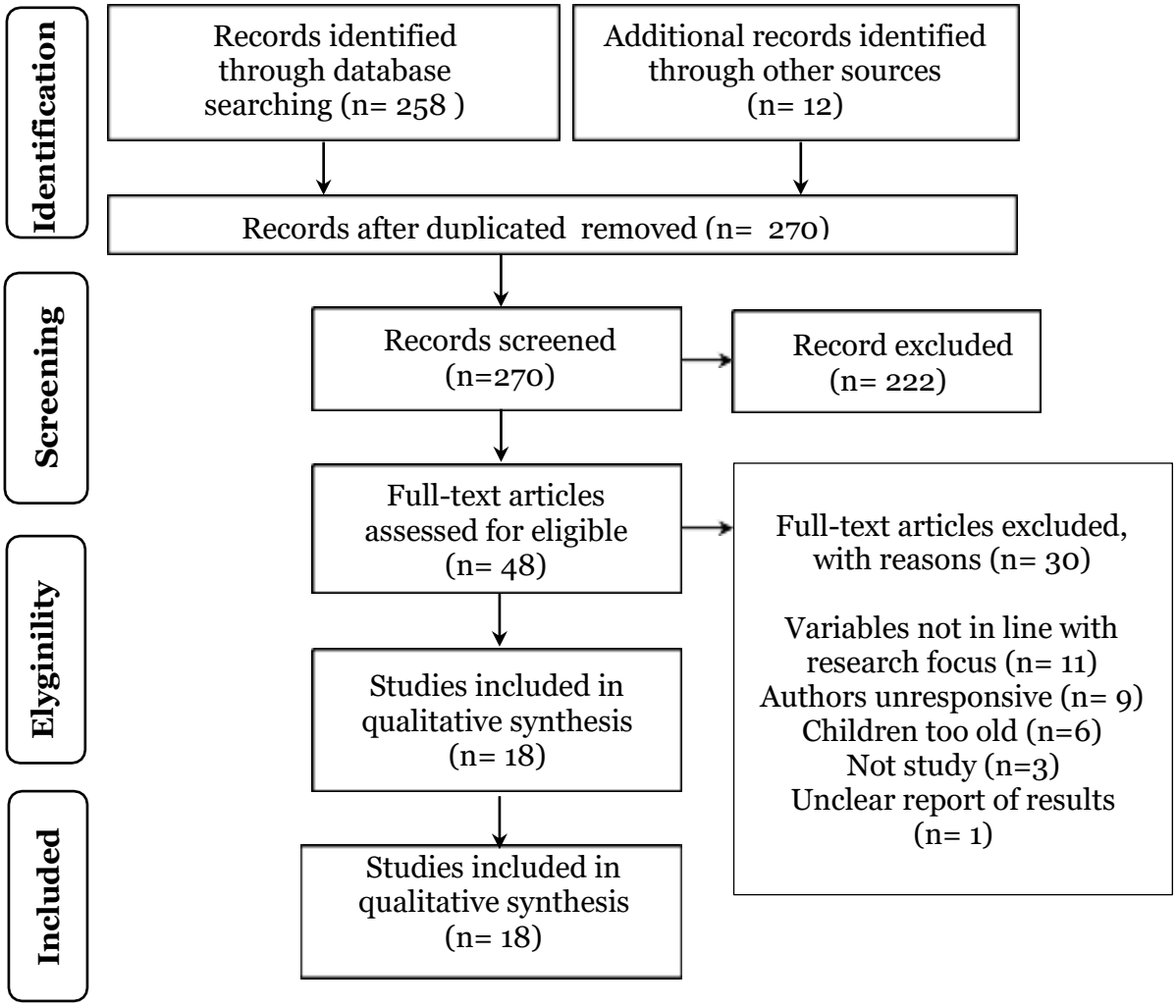

Figure 2. PRISMA flow diagram of the systematic search of parental PTSD

Characteristics of Included Studies

A table 1 shows the characteristics of the 18 included studies and extracted correlations between parental PTSD and attunement variables is available. Studies were published between 2005 and 2018 and were conducted in the following countries: United States (*n*= 9), United Kingdom (*n*= 5), Israel (*n*= 2), Germany (*n*= 1), and Italy (*n*= 1). Sample sizes ranged from 12 to 1,472 with a total pooled sample of *N*= 3,413. All studies investigated mothers and their infants, except one study that had included mothers and fathers.

Quality Assessment

In general, 61% of studies received ratings of good quality, and the remaining 39% received ratings of fair quality. The majority of studies (56%) collected data without interventions or the manipulation of variables. Half of the studies had used a longitudinal study design.

Synthesis of Results

Overall, 49 correlations between parental PTSD symptoms and attunement variables, from 18 studies (N_{total}= 4,100) were analysed. Two separate analyses were run: 1) for positive and 2) for negative attunement variables. Table 1 reports the summary of meta-analytic findings that are discussed below.

Table 1. Study Characteristics and correlation coefficients for the association between parental PTSD and attunement variables

Study	Country	N	Sample description	Instruments and variables		r
				Predictor	Outcome	
Ammerman et al. (2012)	USA	35	age mother: >/= 16 years; age infant: approx. 3 months; mothers unmarried, low income, and inadequate prenatal care	**DTS**	**PSI**	
				Intrusion	Dysfunctional interaction	0.23
				Avoidance/ numbness	Dysfunctional interaction	0.13
				Hyperarousal	Dysfunctional interaction	0.19
				Intrusion	Difficult child	0.21
				Avoidance/ numbness	Difficult child	0.28
				Hyperarousal	Difficult child	0.22
Ayers et al. (2007)	UK	64	mean age mother *M*=32.4 years (*SD*=5.87); age infant: approx. one month; ethnically diverse, 25% complications affecting infant during birth, 11% complications affecting mother peri-/postpartum birth	**IES**	**Bethlehem Mother–Infant Interaction Scale Self-report version**	
				Intrusions	Mother-baby bond	0.00
				Avoidance	Mother-baby bond	0.09
Bosquet Enlow et al. (2011)	USA	52	mean age mother: approx. 27 years (*SD* approx. 6.5) years; age infant: approx. 6 months; follow-up: when infant aged 13 months; sample urban, primarily low-income, varied SES	**PCL-C**	**ITSEA**	
				PTSD symptoms	Infant dysregulation	0.45
Brand et al. (2006)	USA	53	mean age mother: not reported; age infant: 9 months; mothers pregnant and present in exposure zone of WTC attack on September 11, 2001	**PCL**	**IBQ**	
				PTSD symptoms	Infant distress	0.45
Davies et al. (2008)	UK	211	age mother: > 16 years; infant age: 6 weeks; no birth trauma affecting mother or infant	**PTSDQ**	**MPAS**	
				PTSD symptoms	Quality of attachment	0.41
					Absence of hostility	0.43
					Pleasure in interaction	0.18
					ICQ	
					Infant unadaptable	0.14
					Infant dull	0.25
					Infant fussy/difficult	0.34
					Infant unpredictable	0.18
					Infant total difficultness	0.30
					MORS	-0.22
					Maternal warmth	
					Maternal invasion	0.37
Garthus-Niegel, et al. (2017)	Germany	1472	age mother: not reported; age infant: 8 weeks	**IES**	**Infant Characteristics Questionnaire:** 10-item adapted version of the 'fussy/difficult' subscale	0.15
				PTSD symptoms		

Study	Country	N	Sample description	Instruments and variables		r
				Predictor	Outcome	

Hairston et al. (2018)	USA	114	mean age mother: *M*=31.73 (range: 22–41); mean age infant: *M*=7.6 months (range: 4–12); 78% of mothers working full-time, 100% Jewish, varied SES	**mPPQ** PTSD symptoms	**PBQ** Anxiety **Adult Attachment Style Questionnaire** Maternal avoidant attachment style Maternal anxious avoidant attachment style	 0.06 0.20 0.21
Ionio and Blasio (2014)	Italy	19	age mother: *M*=32.23 years (*SD*=4.63); age infant: 3 months; 94.7% delivery complications	**PPQ** PTSD symptoms	**IRSS** Infant cry (play) Infant disorganisation (play) Infant looking away (still) Infant arch position (play)	 0.54 0.54 0.50 0.54
Levendosky et al. (2016)	USA	182	mean age mother: between 22 and 25 depending on group (range from approx. 18 to 30); age infant: 11–13 months; sample ethnically diverse	**MPSS-SR** PTSD symptoms	**ITSEA** Infant externalising behaviour Infant internalising behaviour **Saliva Cortisol** Infant Cortisol Reactivity	 0.30 0.20 0.03
Morelen et al. (2016)	USA	192	mean age mother: *M*=28.88 (*SD*=5.66 years); age infant: 6 months; sample ethnically diverse; 69% mothers with childhood maltreatment history	**NWS-PTSD**	**MACY infant-parent coding system** Maternal baseline play	 –0.04
Noyman-Veksler et al. (2015)	Israel	96	age mother: *M*=28.7 years (*SD*=4.50); age infant: approx. six weeks	**PDS** PTSD symptoms	**PBQ2** Bonding Bonding	 0.58 0.35
Parfitt and Ayers (2009)	UK	148	Mean age mother *M*=30.92 years (*SD*=4.8); mean age father (17.1% of total sample): *M*=32.58 (*SD*=6.84); mean age infant: *M*=10.76 months (*SD*=56.62), sample 95.4% Caucasian, and level of education varied	**PDS** PTSD symptoms	**PBQ** Bonding	 0.36
Parfitt et al. (2013)	UK	44	mean age mother: *M*=33.12 years (*SD*=4.79); age infant: approx. 3 months; sample 85% Caucasian, and 97% with higher education	**PDS** PTSD symptoms	**CARE-Index Procedure** Infant cooperation Infant difficulty Infant compulsiveness Infant passivity	 -0.08 0.19 -0.01 -0.08
Parfitt et al., (2014)	UK	14	age mother: *M*=33.41 years (*SD*=5.08), mean age infant: *M*=17.17 months (*SD*=0.73), sample 86% Caucasian, and 85% with higher education	**Birmingham Interview of Maternal Mental Health** PTSD symptoms	**CARE-Index Procedure**	-0.05
Schechter	USA	56	mean age mother: *M*=34.0 (*SD*=5.7); mean	**CAPS**	**CARE-Index Procedure**	

et al. (2015)			age infant: 26.7 (*SD*=8.8), range 12-42 months; 34.6% of mothers with drug or alcohol abuse, 33.9% of mothers history of violence towards others, and 20% of mothers with suicide attempts/ self-harming	PTSD symptoms	Bonding Maternal controllingness Maternal unresponsiveness	-0.51 0.42 0.22
Seng et al. (2013)	Israel	566	age mother: >18 years; age infant: 6 weeks; ethnically diverse; level of education varied	**NWS** PTSD symptoms	**PBQ** Bonding	0.41
Stacks et al. (2014)	USA	83	mean age mother: *M*=30.04 years (range: 20–45 years); mean age infant: 16 months; mothers diverse in socio-demographic risk status, varied socio-economic status (SES), ethnically varied but mainly Caucasian	**NWS** PTSD symptoms	**Ainsworth's Strange Situation Paradigm** Attachment security **MIPCS** Sensitivity Negativity Reflective functioning	0.07 0.36 -0.43 -0.30
Yehuda et al. (2005)	USA	12	mean age mothers: not reported; age infant: 9 months; mothers pregnant during WTC attacks on September 11, 2001	**PTSD Checklist**	**Saliva Cortisol**	-0.61

Note: CAPS=Clinician Administered PTSD Scale, CARE-index procedure, DTS=Davidson Trauma Scale, IBQ=Infant Behavior Questionnaire, ICQ=Infant Characteristics Questionnaire, IES=Impact of Event Scale, IRSS=Infant Regulatory Scoring System, ITSEA=Infant–Toddler Social and Emotional Assessment, MIPCS-MACY Infant–Parent Coding System, MORS=Mother's Object Relations Scales, MPAS=Maternal Parental Attachment Scale, mPPQ=modified postpartum PTSD questionnaire, MPSS-SR=Modified PTSD Symptom Scale – Self-Report, NWS=National Women's Study, NWS-PTSD=National Women's Study PTSD, PBQ2=Post-partum bonding questionnaire, PCL=PTSD Checklist, PCL-C=PTSD Checklist Civillian Version, PDS=Post-Traumatic Diagnostic Scale, PPQ=Perinatal Post Traumatic Stress Disorders Questionnaire, PSI=Parenting Stress Index, PTSDQ=Postpartum Posttraumatic Stress Questionnaire.

Table 2. Summary of Mean Effect Sizes for Random Effects Analysis

Analysis	No. of associations	r	p	Q	I^2	Eggers test two-tailed p
Pos. Attunement	12	-0.14	0.140	150.51	92.7	0.530
Neg. Attunement	12	0.14	0.060	72.17	84.76	0.870

Mean effect size. The analysis was run on 12 averaged correlation coefficients from 19 associations stemming from 12 studies (N_{pos}= 1,770). The averaged effect sizes ranged from -0.51 to 0.39. The pooled effect size indicated a negative, but weak (r= -0.14) association between maternal PTSD and positive attunement variables which did not reach statistical significance (p= 0.530). Figure 3 shows the respective forest plot.

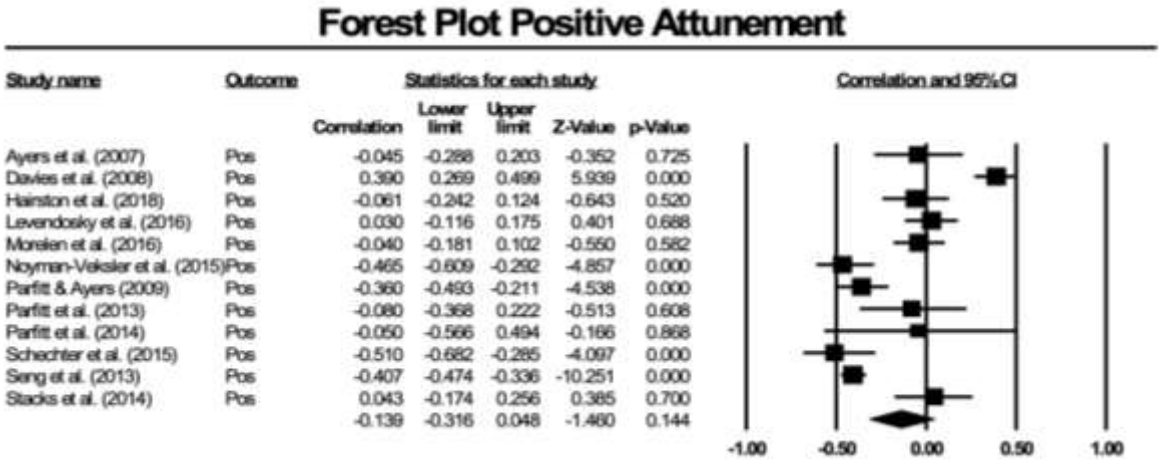

Figure 3. Forest plot for maternal PTSD and positive attunement

Heterogeneity and publication bias assessment. The heterogeneity between studies was very high as indicated by the *Q*-statistic and I^2 (Q= 150.51, p < .000, I^2= 92.69%). Residuals for the random effects model ranged between -1.30 and 1.82. No effect size fell outside the -1.96 to 1.96 range, indicating that no outliers were present.

The funnel plot examination (Figure 4) revealed an asymmetry to the left of the mean. Duval and Tweedie's (2000) 'trim and fill' method was applied. Zero studies were trimmed and filled, indicating that the original sample was subject to publication bias but did not need adjustment.

Negative Attunement

Mean effect size. The analysis was run on 12 averaged correlation coefficients from 30 associations stemming from 12 studies (N_{neg}= 2,330). The averaged effect sizes ranged from -0.61 to 0.56. The pooled effect size indicated a positive, but weak (r = -0.14) association between maternal PTSD and negative attunement variables that did not reach statistical significance (p= 0.870). The resulting forest plot is provided in Figure 5.

Heterogeneity and publication bias assessment. The heterogeneity between studies was high as indicated by the *Q*-statistic and I^2 (Q= 72.17, p< .000, I^2= 84.76%). Residuals ranged between -2.59 and 1.39. Two effect sizes fell outside the -1.96 to 1.96 range, indicating the presence of outliers.

The funnel plot examination (Figure 6) revealed an asymmetry to the right of the mean. Duval and Tweedie's (2000) 'trim and fill' method was applied resulting in one study being trimmed and filled. The adjusted estimated effect size of *r*= .12 indicated that the observed effect size was slightly inflated due to publication bias.

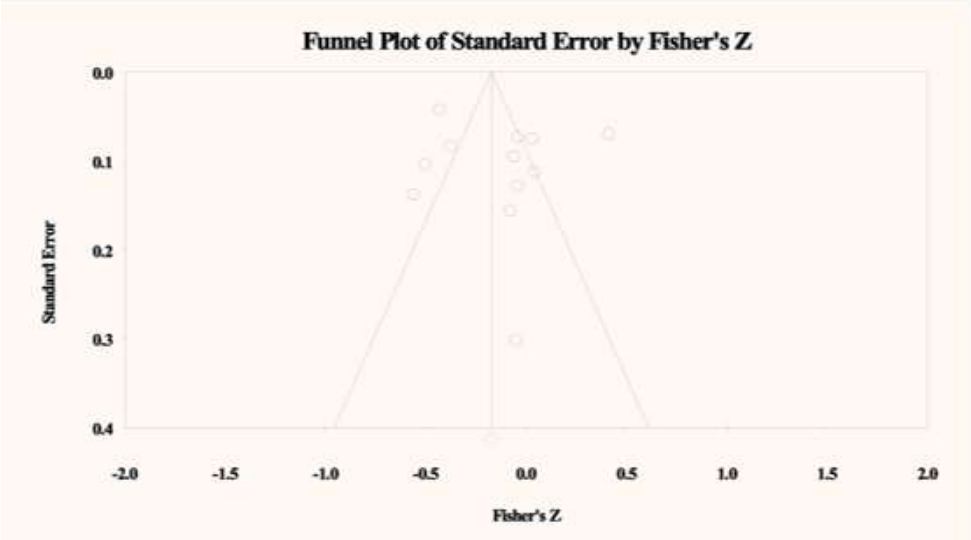

Figure 4. Funnel Plot for Positive Attunement

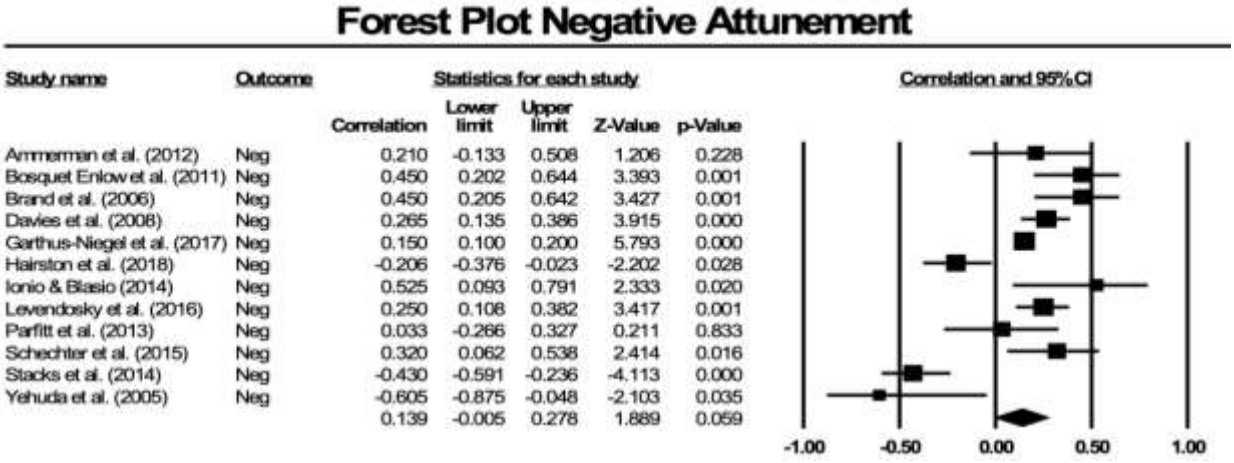

Figure 5. Forest Plot Maternal PTSD and Negative Attunement

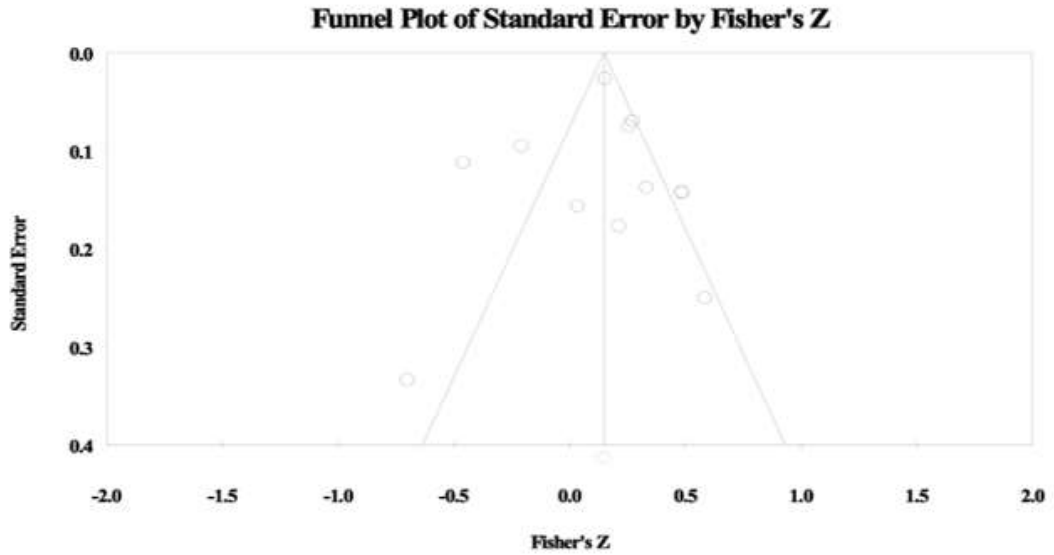

Figure 6. Funnel Plot for Negative

DISCUSSION

Psychological research has investigated the construct of attunement based on a variety of definitions (Bartling et al., 2010; Bernard et al., 2017; Kokkinaki et al., 2017; Laurent et al., 2011; Lin and Green, 2009; Meins, 2013; Ostlund, 2017; Rollins and Greenwald, 2012; Savelkoul et al., 2007), and by applying different methodologies and designs to studies (Fuchs at al., 2016; Easterbrooks and Biringen, 2000; Flacking et al., 2007; Jonsson et al., 2001; Kokkinaki, 2003; Kokkinaki et al., 2017; Lin and Green, 2009; Matta and Knudson-Martin, 2006; Ostlund et al., 2017). The critical role of attunement in parental co-regulation of the infant has been consistently acknowledged by various groups of researchers (Atkinson et al., 2016; Bernard et al., 2017, Cozolino, 2014; Rutherford et al., 2015, Schore, 2003a). Based on the systematic review and meta-analysis, the following definition of attunement is proposed:

Attunement is a continuous and multi-dimensional construct that includes emotional, behavioural, as well as neurobiological dimensions. In the context of parent-infant relationships, attunement is a primary carer's ability to tap into the infant's affect and physical and emotional needs, followed by timely and appropriate co-regulation.

The results from 49 correlations between parental PTSD and attunement variables, stemming from 18 studies (N_{total}= 4,100) were non-significant and small in magnitude for both positive and negative attunement.

The present research suggests that parents with PTSD can lack the capacity to attune to their infants, jeopardizing coregulation, and hence, posing an increased risk among the infants for long-term negative effects on neurobiology, attachment style, psychological well-being, and adaptive behavior (Banneyer et al., 2017; Baradon, 2010, as reviewed by Blizard, 2014; Harwood, 2006; Schore, 2003a; Siegel, 2012). Existing literature indicates that PTSD symptoms may directly and indirectly affect parental co-regulation of the infant (Vignato et al., 2017), increasing maternal negativity and reducing maternal reflective functioning (Stacks et al., 2014), thus, affecting postpartum bonding (Hairston et al., 2018; Muzik et al., 2016; Seng et al., 2013), child development (Garthus-Niegel et al., 2017; Vignato at al., 2017), and infant behaviour (Brand et al., 2006).

DISCUSSION

With 18 studies of fair and good quality included, and 12 studies in each analysis, the findings of the present study can be considered relatively valid (Cuijpers, 2016). The correlation coefficients for the meta-analysis included significant and non-significant values. Duval and Tweedie's (2000) 'trim and fill' method confirmed that publication bias was present, but only slightly inflated the pooled effect size of the analysis of negative attunement. Due to the inclusion and exclusion criteria, a larger number of studies investigating attunement could not be included in the present study, which on the one hand decreased heterogeneity, but on the other hand, lead to a less representative pool of published literature on attunement.

Furthermore, despite a systematic search of five databases, it is possible that other eligible studies were published elsewhere, but remained undetected. Due to the high heterogeneity of the included studies and statistically non-significant pooled effect sizes, results need to be interpreted with caution. The large magnitude of the I^2 statistic indicates that 84 to 93% of variance is due to variability between studies, rather than being due to error or chance. The reasons for high variance likely includes convenience sampling across all studies leading to variability with regards to 1) type of trauma (interpersonal versus war trauma; developmental versus more recent trauma; birth-related versus trauma unrelated to birth), and 2) socioeconomic status, ethnicity, and cultural background. Moreover, the age range for inclusion (0-18 months), which is a time of rapid development and growth, could have contributed to variability between studies: Due to the fast pace of development in the first two years of life, caregivers' ways of responding to physiological and emotional needs of their infants are likely to change as well, thus changing the process of parent-infant attunement.

Although coding of attunement outcome variables into positive and negative facilitated feasible statistical analysis, it failed to accommodate attunement as a dimensional construct with non-linear association with certain variables. Future studies can focus on the ways in which different types of trauma would impact a parent's capacity to attune, and aim at identifying specific areas in which parents with PTSD would have difficulties attuning to their infants. Whilst mothers are mostly infants' primary caregivers, research should also focus on fathers' role in the attunement process. It is recommended that future research utilises stronger sampling methods and experimental research designs, and compare clinical with non-clinical samples. It will also be useful to investigate factors responsible for the differences between parents who have a good versus poor capacity to attune.

AUTHORS CONTRIBUTIONS

The authors, Julia Asanov and Neelofar Rehman confirm sole responsibility for the following: Study conception, design, analysis, interpretation of results, and manuscript preparation.

CONFLICT OF INTEREST

There are no conflicts of interest.

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