Neuroscience and Biobehavioral Reviews 150 (2023) 105160

Contents lists available at ScienceDirect

Neuroscience and Biobehavioral Reviews

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

Observational measures of caregiver's touch behavior in infancy: A systematic review

Juliana F. Serra [a,*,1], Isabel C. Lisboa [a,b], Adriana Sampaio [a,c,**,2], Alfredo F. Pereira [a,b]

[a] Psychology Researcher Centre (CIPsi), School of Psychology, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
[b] Center of Technology and Systems (UNINOVA-CTS), NOVA School of Science and Technology, NOVA University Lisbon, 2829-516 Lisbon, Portugal
[c] Psychological Neuroscience Lab, Campus de Gualtar, CPsi, School of Psychology, University of Minho, 4710-057 Braga, Portugal

ARTICLE INFO

Keywords:
Touch behavior
Parent-infant interaction
Observational instruments
Measurement
Systematic review

ABSTRACT

The caregiver's touch behavior during early infancy is linked to multiple developmental outcomes. However, social touch remains a challenging construct to operationalize, and although observational tools have been a gold standard for measuring touch in caregiver-infant interactions, no systematic review has been conducted before. We followed the PRISMA guidelines and reviewed the literature to describe and classify the main characteristics of the available observational instruments. Of the 3042 publications found, we selected 45 that included an observational measure, and from those we identified 12 instruments. Most of the studies were of infants younger than six months of age and assessed touch in two laboratory tasks: face-to-face interaction and still-face procedure. We identified three approaches for evaluating the caregiver's touch behavior: strictly behavioral (the observable touch behavior), functional (the functional role of the touch behavior), or mixed (a combination of the previous two). Half of the instruments were classified as functional, 25% as strictly observational, and 25% as mixed. The lack of conceptual and operational uniformity and consistency between instruments is discussed.

1. Introduction

Touch is the primordial sense, the first sensory system to develop prenatally, and a bridge between the prenatal and the post-natal world (Hepper, 2015). By the 8th week of gestation, the fetus responds to touch around the lips, and by 14 weeks in all other areas of the body save the back of the head (Hooker, 1952; Humphrey and Hooker, 1959; Hepper, 2008). In the third trimester, fetuses respond to human touch on their mother's abdomen by moving or touching the wall of the uterus (Marx and Nagy, 2015, 2017). Born altricial into a highly social species, the human infant, like other mammals, requires touch to thrive (Field, 2010, 2019; Ardiel and Rankin, 2010) – in the words of Montagu (1986), touch is "a basic behavioral need as much as breathing" (page 46).

After birth and during early infancy, frequent tactile stimulation is almost inevitable, as the baby depends on others for the regulation of basic physiological functions (Moore et al., 2016), and for all everyday activities and routines, such as feeding, sleeping, hygiene, and soothing (Faust et al., 2020). A particular aspect of touch that sets it apart from other distal modalities, such as vision or audition, is that touch involves a partner in close proximity which touches but is also touched. An infant's tactile experience of others is therefore inherently relational and always occurs in a social context (Montagu, 1986; Hertenstein, 2002), whether or not partners have communicative intentions (or, indeed, are aware of them).

Touch behavior interacts with multiple developmental domains, as a consequence of the caregiver's use of multiple types of touch, in the service of a variety of purposes. There are the immediate utilitarian demands of caregiving, where the adult uses touch to carry, cradle the infant, or adjust an infant's body posture in space (Beebe et al., 2010; Mercuri et al., 2019). But there are other important functions beyond these: soothing, comforting or demonstrating love and affection, for instance, when the adult uses affectionate/nurturing touch to help the infant down-regulate high-intensity emotional states and/or with negative valence (e.g., Beebe et al., 2010; Jean and Stack, 2009; Moreno et al., 2006; Peláez-Nogueras et al., 1996; Weiss, 1992); promoting emotional states with positive valence, as when using playful or

* Correspondence to: Psychology Researcher Centre, School of Psychology, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal
** Corresponding author at: Psychology Research Centre (CIPsi), School of Psychology, University of Minho, Campus de Gualtar, 4710-057 Braga, Portugal.
E-mail addresses: julianaserra23@gmail.com (J.F. Serra), adriana.sampaio@psi.uminho.pt (A. Sampaio).
[1] https://orcid.org/0000-0001-8312-8656
[2] https://orcid.org/0000-0001-7347-1282

https://doi.org/10.1016/j.neubiorev.2023.105160
Received 18 August 2022; Received in revised form 28 March 2023; Accepted 2 April 2023
Available online 23 April 2023

stimulating touch:behaviors such as tickling, lifting, moving the arms or legs (e.g., Beebe et al., 2010; Provenzi et al., 2020; Moreno, Posada, and Goldyn, 2006; Egmose et al., 2018; Jean and Stack, 2009); creating, sustaining or recapturing attentional states (Jean et al., 2009; Mantis and Stack, 2018; Paradis and Koester, 2015); offering the infant support and physical contact, using static or passive touch, the strongest safety signal for the attachment-behavioral system (Beebe et al., 2010; Crucianelli et al., 2019; Mercuri et al., 2019; Stack et al., 1996).

Despite major advances in touch research – see Field (2010, 2019); Cascio et al. (2019) for a review – and in contrast to the importance of touch in early infant development, the study of touch continues to be relatively neglected when compared with other domains of perception, such as the distal senses of vision or audition, an omission repeatedly highlighted by touch researchers (Botero et al., 2020; Hertenstein, 2002; Hertenstein, Verkamp et al., 2006; Montagu, 1983; Herring, 1949). For example, studies of caregiver-infant interactions typically focus on the examination of distal behavioral indices, such as gaze and affect, while disregarding the specific contribution of proximity behaviors, including touch (Mantis et al., 2014; Stack, 2001).

A confluence of historical, cultural, and methodological reasons has been offered as the explanation for the overlooking of touch in infancy research (Hertenstein, 2002; Hertenstein, Keltner et al., 2006; Andersen, 2011). Some factors are evident, such as the long tradition in Western philosophy of favoring the study of vision over other sensorial modalities (Hertenstein, 2002; Hertenstein et al., 2006). Others, such as cultural assumptions regarding touch and the prioritization of touch as a research question are more nuanced and, to the best knowledge, less examined. Together, these have likely delayed the focus on touch as an object of research. A revealing comparison can be made with olfaction, where the hypothesis of poor sense of smell in humans, developed in the 19th century, does not match with empirical data, such as anatomical measurements across mammalian species (McGann, 2017).

Touch may be a primary sense in early human interactions, but the frequency, duration, types of touch, and nature of tactile exchanges differ significantly across cultures (Andersen, 2011; Sorokowska et al., 2021), shaping how parents use touch to communicate with their infants (e.g., Lowe et al., 2016; Stepakoff, 1999). Although challenging to conduct, descriptive studies on tactile contact in various contexts are crucial for identifying similarities and differences between cultures and determining how well the currently available instruments can accurately measure touch in specific cultural contexts (Hertenstein, 2002).

Another significant reason for ignoring these behaviors in infancy was methodological considerations regarding how touch-related behavior in early interactions should be analyzed. Therefore, developing methods that accurately measure touch in parent-infant interactions can be demanding since touch is a multidimensional construct which encompasses several actions, i.e., it may potentially be applied at different intensities, velocities, body locations, durations, and frequencies. These multiple actions also serve multiple purposes in the interaction flow (Geldard, 1960; Weiss, 1992; Jean and Stack, 2009). Some of these specificities and parameters of touch are also difficult to measure, for instance, velocity or intensity of touch, considering that the most widely used method for assessing tactile stimulation is the video recording of mother-infant interactions (Hertenstein, 2002).

In parallel, there is a growing interest in detailed studies of caregiver's touch patterns, and their association with developmental outcomes (e.g., Crucianelli et al., 2019; Ferber et al., 2008; Jean and Stack, 2009; Mantis et al., 2019; Polan and Ward, 1994; Weiss et al., 2000, 2004; Beebe et al., 2010, 2016; Koester, 2000; Paradis and Koester, 2015). Observational tools have played an important part in advancing our knowledge of caregiver's touch in adult-infant interactions, with several instruments developed in the last three decades. These tools were explicitly designed to capture the detailed patterns of caregiver touch behaviors. When compared with self-report instruments, e.g., questionnaires or diaries, observational instruments allow for a more detailed and objective assessment of the features of touch that occur in the flow of the interaction, e.g., action, location, duration, and function (Beebe et al., 2010; Brzozowska et al., 2021). In addition to this, the interactions are typically video recorded, thus, behavioral coding can use slow motion playback and/or repeated observations to allow measurement of touch dimensions that are challenging to measure in real-time, for example, the function of a specific touch behavior, its duration or how often it is used in the interaction (Weiss and Niemann, 2011).

Nevertheless, the different observational instruments are fragmented across different research teams, each independently assessing touch in specific contexts and tasks, making direct comparisons difficult. Additionally, the last detailed review of observational instruments was by Weiss and Niemann (2011) but this study did not use a systematic review methodology. The present work has aimed to identify observational coding systems of caregiver touch behavior (following PRISMA guidelines), describe each instrument's main characteristics, and summarize how they have been used in the literature. We have also divided the extracted instruments into three groups based on commonalities, and we highlighted each category's key strengths and limitations, outlining possible directions for future research.

Before systematically reviewing the available observational instruments for measuring caregiver touch patterns, we first present a summary background context, drawn from a selection of relevant touch studies in infancy. This overview revisits some important therapeutic interventions that are touch-based (such as massage and kangaroo care), as well as seminal work in touch research and its contribution to the development of instruments for assessing touch behaviors in caregiver-infant interactions.

1.1. A historical overview of touch research on infants

The association between the infant's healthy development, and social proximity and contact offered by a caregiver, has been consistently demonstrated by touch research (Cascio et al., 2019; Dunbar, 2010; Field, 2010, 2014, 2019; Jablonski, 2021). An important part of the evidence comes from work with non-human primates that has reported the effects of severe caregiver separation and provided valuable insights for human research about the importance of touch in the baby's physical, emotional, and social development (for detailed information regarding animal studies see the following reviews: Barnett et al., 2022; Botero, 2018; Erica and Carol, 2018; Hertenstein, Verkamp et al., 2006; Harlow and Suomi, 1970). We then briefly review some key research conducted on humans that has enhanced our understanding of the relation between a caregiver's touch behavior and the development and well-being of the infant.

1.1.1. Seminal research on touch in pediatric care

The work of Klaus, Kennell, and colleagues in the 1970s is a significant historical reference for studying tactile contact in early mother-infant interactions (e.g., Kennell and Klaus, Kennell, 1976; Kennell et al., 1975; Kennell et al., 1974; Klaus et al., 1972). They performed a longitudinal study with 28 mother-infant dyads split into two groups: those who had extra contact with their newborns in the first three days after giving birth (experimental group) and mothers who only had routine contact with their babies in the days right after birth (control group). The authors found that mothers in the experimental group exhibited more "bonding" or affectionate behaviors towards their babies (such as strokes, and eye contact) when the infant was one month of age. When infants turned one, in addition to these affectionate behaviors, mothers in the experimental group reported missing their babies more when they left for work, and infants in this group also scored higher in the Bayley development test (Kennell et al., 1974; Klaus et al., 1972). In light of these findings, the authors argued that a sensitive period, which is in the first few minutes and hours after birth, was essential for mother-infant bonding – for a more detailed summary of Klaus and Kennell's studies see Hertenstein, Verkamp et al. (2006) and Kostandy

and Ludington-Hoe (2019). Although the validity of the original studies by Klaus and Kennell was later brought into question (Myers, 1984), this work played an important role in changing obstetric care practices, making skin-to-skin contact a common practice. They also helped establish the importance of researching tactile contact immediately after birth to foster mother-infant bonding and, ultimately, how this affected later child development (Kostandy and Ludington-Hoe, 2019).

1.1.2. Kangaroo care and massage therapy

In parallel with Klaus and Kennell's investigations, two neonatologists, Rey and Martinez, began researching a similar form of care with preterm infants, so-called "Kangaroo Care" (Kostandy and Ludington-Hoe, 2019). In kangaroo care interventions, parents (typically the mother) are encouraged to hold their neonates continuously against their naked chest during a period of the day. Numerous studies have been conducted since its inception to examine its advantages and safety, for both parents and infants (e.g., Campbell-Yeo et al., 2015; Charpak et al., 2005; Conde-Agudelo and Díaz-Rossello, 2016; Feldman and Eidelman, 2003; Feldman et al., 2014; Furman, 2017). It is currently commonly acknowledged that this touch-based procedure promotes physiological and neuroprotective advantages for low birth weight and preterm infants, including an improvement in sleep quality, pain control, support for neurodevelopment, increased physical growth, and promotion of parental bonding and breastfeeding exclusivity and duration (Campbell-Yeo et al., 2015; Moore et al., 2016; Conde-Agudelo and Díaz-Rossello, 2016; Johnston et al., 2017). The practice of skin-to-skin contact is also beneficial for full-term infants and their parents. Benefits include enhancing parent-infant positive interaction, attachment and well-being, lowering the levels of anxiety, stress, and pain in both parents and infants, as well as stimulating the mother's milk production and the newborn's growth, weight gain, and development (Moberg et al., 2020; Norholt, 2020; World Health Organization, 2022).

Another comprehensively documented touch-based intervention is that of infant massage therapy. Massage therapy is the targeted application of tactile stimulation to the skin, muscles, tendons, ligaments, and fascia utilizing manual and structured techniques (Esfahani et al., 2013). Recent literature reviews conducted over the past 10 years have shown that massage therapy has several positive benefits for both preterm infants and their caregivers, including increased weight and reduced hospitalization time; increased bone density; better neurodevelopment scores; decreased risk of neonatal sepsis; pain relief for infants; and less stress, anxiety, and depression for parents (e.g., Field, 2018; Field, 2019; Field et al., 2010; Mrljak et al., 2022; Álvarez et al., 2017; Chen et al., 2021; Li-Chin et al., 2020; Pados and McGlothen-Bell, 2019). Similarly, studies with full-term newborns, although less common, also found several benefits, including lowering bilirubin levels, reducing crying, colic, and sleep difficulties, promoting infant development, enhancing parent-infant interactions, and lowering parental stress; for a detailed review see Field (2016, 2018, 2021); Norholt (2020)). Altogether, research on the effects of skin-to-skin contact has improved our knowledge of parent-infant interactions, showing the unique contribution of proximity behaviors, such as tactile contact and stimulation (Mantis et al., 2014; Stack, 2001; Botero, 2016; Botero et al., 2020).

1.1.3. The adapted still-face paradigm

Another seminal line of research is composed of experimental studies that used an adapted version of the still-face paradigm (Tronick et al., 1978). In its original form, the still-face procedure consists of three brief parent-infant interactions: normal interaction, still-face, and reunion periods (Tronick et al., 1978). The classic still-face effect (measured in the second moment of the procedure) is categorized by a decrease in gaze and smiling at mothers, and an increase in neutral to negative affect and vocalizations, compared with normal face-to-face interaction (e.g., Ellsworth et al., 1993; Gusella et al., 1988; Lamb and Malkin, 1986; Stack and Muir, 1990; Mesman et al., 2009). The still-face episode is more stressful for 4-month-old infants than a brief separation from the mother (Field et al., 1986). Infants demonstrate more motor activity, gaze aversion, furrowed brow, crying, and less smiling during the still-face episode compared with the brief separation period. Of relevance to understanding touch, mothers also use more tactile-kinesthetic behavior after the still-face period (Field et al., 1986). These findings highlighted the importance of touch in the interaction by suggesting that mothers adapt their touch behavior to the infant's soothing and comforting needs.

In their adapted version, Stack and colleagues allowed mothers to touch the infant in the still-face period. Stack and Muir (1990) tested 3-, 6-, and 9-month-old infants and compared the standard still-face period (where touch is not allowed) with the still-face period where mothers could touch the infant. They found that, across the age range, infants who received touch smiled more, grimaced less, and were more content than when exposed to the standard still-face procedure. In the absence of other modalities of communication, the presence of touch (operationalized as the total amount of touch provided by the caregiver to their infant during the interaction) can elicit positive affect and attention from infants and can decrease the negative effects of the still-face episode (Stack and Muir, 1990). In a follow-up study, the same authors also demonstrated that the increase in the infant's positive affect during the still-face period was uniquely related to the tactile stimulation and could not be explained by the visual stimulation of the adult's hands (Stack and Muir, 1992).

These results suggest that infants are sensitive to touch and that maternal touch can support the infant's emotional regulation and attentional state. However, these studies provided only limited information on infant sensitivity to more subtle changes in maternal touch, and if mothers could use touch to achieve specific responses from their infants. To address these questions, Stack and LePage (1996) designed a study where they observed mothers interacting with their 5.5-month-old infants in an adapted still-face design composed of four periods: (1) normal face-to-face interaction; (2) still-face while touching (i.e., mothers could touch their infants without restrictions); (3) still-face where mothers were asked to touch and encourage the most smiles from the infant; and (4) still-face while touching only one chosen part of the infant's body. The authors found that mothers modified their touching behavior according to the instructions per condition, and, of relevance, that those changes were reflected in the infant's affect and attention across different periods. For example, infants smiled more in the still-face period in which mothers were instructed to elicit smiling from the infant, than in both other still-face conditions (Stack and LePage, 1996). In a similar study Stack and Arnold (1998) observed how the mother's touch behaviors and gestures impact the infant's specific responses. These authors showed that infants smiled more in the still-face period when mothers were allowed to touch, compared with the normal still-face period. Maternal touch and gestures in the still-face period could draw the infant's visual attention to the mother's face. Together, these findings suggested that (1) infants are sensitive to the specificities of different maternal touch and hand gestures; (2) mothers use touch and hand gestures to elicit specific infant responses, (3) touch-only interactions had a positive effect on infants, in periods of maternal unavailability; (4) when mothers were asked to touch only specific areas of their infant's bodies, they use the same touch types consistently (Stack et al., 1996; Stack, 2004; Stack and Arnold, 1998; Stack and Muir, 1992; Stack and Muir, 1990). This work provided empirical support to the general hypothesis that mothers adapt their touch patterns to communicate different messages to their infants (Góis-Eanes et al., 2012; Hertenstein, 2002). This research, which employed the adapted still-face approach, was critical in demonstrating the influence of diverse touch types on infant behavior, revealing that social touch may serve multiple purposes (Hertenstein, 2002; Jean and Stack, 2009).

In sum, touch-based interventions (like massage and kangaroo care) were critical to expanding our understanding of the link between social touch and the infant's early physical, emotional, and social

development. Meanwhile, research using the modified still-face procedure was key to revealing how distinct touch behaviors performed by the parents elicited different affects in the infant, which prompted methodological advances in how social touch was measured in infancy and led to the development of instruments for assessing touch behaviors in caregiver-infant interactions.

1.2. Measuring social touch in caregiver-infant interactions

Throughout this review, we consider a broad definition of "social touch" as any type of touch performed by a partner in a social context. This enabled us to accommodate different uses of the term "social touch", namely, from two distinct fields of study (Cascio et al., 2019; Gliga et al., 2018; Saarinen et al., 2021): (1) an older one, that consists of behavioral studies, concerned with examining the interpersonal and interactional features of touch behavior, such as "who" is delivering the touch, the types of touch used or the function of the touch behavior (e.g., Field, 2019; Hertenstein, 2002; Stack and Jean, 2011; Stack, 2004); and (2) a more recent, neurophysiology-oriented field, concerned with affective touch and focused on the sensory characteristics of touch. In this second more recent account, touch is defined as social when it activates a particular class of skin mechanoreceptors – the C tactile fibers (CTs) that are activated by light pressure, slow, and caress-like stroking, which is experienced as gentle touch (Ackerley et al., 2014; Fairhurst et al., 2022; McGlone and Spence, 2010; Olausson et al., 2008).

1.2.1. Conceptual frameworks of touch behavior

To our knowledge, very few conceptual frameworks have sought to operationalize the properties of infant-oriented touch behavior. In this context, we highlight three major conceptual frameworks. First, Hertenstein (2002); as cited in Weiss and Campos (1999) considered four dimensions of touch qualities: duration, location, action, and intensity. Second, the Weiss and Campos (1999) model was extended by Hertenstein (2002) to provide a broader understanding of how specific types of touch communicate different messages to the infant – this framework proposed the distinction between qualities and parameters of touch. For simplicity, we will use the terminology 'properties' or 'features' to refer to both. In Hertenstein (2002), qualities of touch include features of the actual tactile stimulus that is administered to the infant: action (i.e., what are the specific touch behaviors used to interact with the partner: e.g., stroking, rubbing, holding, or squeezing), intensity (i.e., level of pressure applied to the social partner's skin), velocity (i.e., the speed of the touch movement used by the caregiver to touch the infant's skin), abruptness (i.e., the level of acceleration used in the act of touching the other) and temperature. Parameters of touch refer to where and how much touch is administered: location, frequency, duration, and extent of the surface area touched. The author notes that this systematization is only useful for conceptual purposes because, in the flow of the interaction, all of these touch dimensions act together. Finally, and in addition to this structural operationalization highlighting the role of the features of touch (Hertenstein, 2002), a third and functional approach appeared, focused on exploring the purposes and consequences of touch within dyadic interactions (Hertenstein, Verkamp et al., 2006, as cited in Burgoon et al., 1996). Specific touch actions provided by caregivers can elicit unique infant responses; as such, touch may serve a variety of purposes within caregiver-infant exchanges, such as nurturing/affectionate, playful, and caregiving/instrumental touches (Jean and Stack, 2009; Stack, LePage, Hains and Muir, 1996).

1.2.2. The challenge of measuring touch

Accurately studying the caregiver's behavior within naturalistic interactions is a demanding task (Beebe, 2006, 2017; Lourenço et al., 2021). For touch behaviors, designing an instrument that captures the phenomenon to its fullest extent is still a challenge (Hertenstein, 2002; Hertenstein, Verkamp et al., 2006). There are numerous parental touch behaviors of interest: holding the infant in the lap, tickling, caressing, kissing, etc. Indeed, the Maternal Touch Scale (MTS; Beebe et al., 2010; Stepakoff, 1999) defines 21 individual touch behaviors and the Caregiver Infant Touch Scale (CITS; Stack et al., 1996) defines 8 touch behaviors. Touch also varies across a set of dimensions such as intensity, velocity, abruptness, temperature, location, frequency, duration, and he extent of the surface area touched (Hertenstein, 2002; Weiss, 1992). Hence, there is a wide range of degrees of freedom to consider when measuring a single touch action where specific combinations of touch action with particular values in each dimension can convey different messages to the infant or serve different functions (Hertenstein, 2002; Jean and Stack, 2009; Tronick, 1995). For instance, infants can experience a caressing touch as affectionate or intrusive, depending on the intensity of the parent's touch (Beebe et al., 2010; Stepakoff, 1999). As in other domains of perception, the meaning of touch is context-dependent, underscoring the importance of observing a specific dyad at a particular moment in order to measure touch. As such, beyond identifying the act of touching itself, collecting accurate information about the touch behavior also requires examining how it is delivered to the infant in the context of where it occurred. Consider the example of an abrupt holding touch: if it is performed when the infant is frightened, it may be perceived as affectionate for both mother and infant. In parallel, it is also important to consider who touches and who is touched, the parent's intentionality when using touch, and the infant's response to it. Caressing a baby can be used to convey affection, but if it stops the baby from playing with an object, it may be intrusive.

Finally, there are also large cross-cultural variations regarding parenting practices that range from almost constant proximity between infants and other group members to frequent physical separation, an important dimension if we consider that most of the empirical data comes from WEIRD nations - Western, Educated, Industrialized, Rich, and Democratic (Henrich et al., 2010; Montagu, 1986; Rad et al., 2018; Tronick, 1995).

To address the challenges in measuring the touch behavior of the caregiver during parent-child interactions, a variety of methods to assess the quantity and types of contact have been developed, including self-report instruments and observational instruments, which will be addressed in more detail.

Using self-report instruments, which include parent-report questionnaires and diaries, the parents provide the measurement. Parent-report questionnaires can be used to rate, often using a Likert scale, how frequently parents engaged in specific touch-related actions (such as rocking, kissing, and holding) with their infants - e.g., the Parent-Infant Caregiving Touch Scale – PICTS, Koukounari et al. (2015)). These measurements are important for collecting data about the parents' self-perception of how they touch their infants. There are also self-report questionnaires that do not specifically address the caregiver's touch behavior toward the infant but are instead intended to assess the parent's social touch attitudes and experiences (e.g., the Social Touch Questionnaire – STQ, Wilhelm et al., 2001; the Touch Experiences and Attitudes Questionnaire – TEAQ, Trotter et al., 2018) - For a more extensive review of self-report methods see Brown et al. (2011) and Weiss and Niemann (2011).

In self-report diaries, parents are asked to complete a paper or electronic diary recalling their recent touch behavior and/or the infant's behavior, once or more per day and during a fixed time period (e.g., Barr et al., 1988; Lam et al., 2010). Diaries can be used to record the behavior of interest over extended periods of time and in different contexts (Brzozowska et al., 2021).

One shortcoming of self-report instruments is the possibility of participants "faking good" or performing for the researcher (Field, 2019). In contrast, observational measures of touch allow for a more objective measurement of the caregiver's touch behavior. Typically, parent-infant interactions are recorded, and touch behavior events coded using a microanalytic scheme, wherein the granular unit of analysis is the individual touch action (Brzozowska et al., 2021; Weiss and Niemann, 2011). Coding is done by first segmenting each behavior (by coding the

onset and offset of every touch) or alternatively observing the interaction for a fixed time interval (e.g., one second). Then, depending on the measure, each event or time window can also be categorized using the specific criteria defined by the observational tool. Examples of these measures include the Maternal Touch Scale (Beebe et al., 2010; Stepakoff, 1999) or the Touch-Scoring Instrument (Polan and Ward, 1994). Microanalytic observational tools have a higher coding cost but enable the measurement of social interactions on their natural time scale (Beebe, 2006, 2017; Lourenço et al., 2021), and allow the study of the fine-grained details of touch (e.g., intensity, type of touch) that occur during dyadic interaction (Weiss and Niemann, 2011).

1.2.3. Observational instruments of caregivers touch behavior

Several observational instruments have been designed to capture different levels of abstraction of touch behavior (Brzozowska et al., 2021): some are more focused on low-level, descriptive touch features, such as touch actions (e.g., hold, tap, pat) – e.g., Polan and Ward (1994) and Stack et al. (1996) – while others measure the higher level touch characteristics of parental touching behavior by coding the functional role of each touch pattern in the flow of the interaction, such as "affectionate/nurturing touch", "playful touch", or "instrumental touch" – e.g., Goldyn and Moreno (2002) and Jean and Stack (2009). Other authors combine both and include both lower and higher levels of abstraction in the instrument (e.g., Beebe et al., 2010; Stepakoff, 1999; Weiss, 2000).

1.2.4. Observable touch behaviors and functional roles of touch

We propose a three-category classification for observational instruments measuring social touch, designed to describe and aggregate current observational tools according to their similarities: (1) strictly behavioral instruments; (2) functional instruments; (3) mixed tools. This categorization into three groups was used to structure the information in the article. The instruments are either strictly behavioral in the sense that only the observable touch behavior is coded – e.g., a tap or a hold behavior is coded as such – or they are functional in that what is coded is the functional purpose of the observable touch behavior – e.g., what is coded across many events of the tap or hold behavior is the functional purpose of the behavior in the context of the interaction. This categorization is also consistent with existing conceptual frameworks for touch (Hertenstein, 2002; Hertenstein, Verkamp et al., 2006, as cited in Burgoon et al., 1996; Hertenstein, 2002, as cited in Weiss and Campos, 1999). Some instruments use both approaches, and we have labelled them as mixed.

Next, we define each category by presenting examples of instruments that fall within each category and review major findings associated with each category/instrument.

1.2.4.1. Strictly behavioral instruments. These instruments consider the characteristics of touch behavior that can be directly observed in the context of the interaction: how do parents touch their infants? The constructs are designed to capture surface-level features of touch behavior, such as whether the parent touches the infant passively or actively, what type of touch is used (e.g., tickle, caress), how intensely it is applied, or where on the body it is applied. Studies using strictly behavioral tools, such as CITS (Stack et al., 1996) have revealed that the mother's use of touch adapts to the instructions in the adapted still-face paradigm with touch: when asked to maximize their infant's smiling, mothers used more active types of touch (lifting, tickling), larger surface areas, and greater intensity and speed, but when told to touch only one area of the infant's body, mothers used more stroking, less shaking, and the touching was slower and less intense (Stack and Jean, 2011). Moreover, mothers also adapt the frequency and diversity of their touch behavior depending on the infant's age and the interactional context (Ferber et al., 2008; Jean et al., 2009). For instance, Ferber et al. (2008) observed that the amount of maternal touch decreased during the first year of life. Additionally, Jean et al. (2009) found that mothers touch their infants more in the lap context than in the floor context when they are requested to play with them.

Mercuri et al. (2019), using an adapted form of CITS, compared how much touch each parent applied to the infant during the first interaction after birth, noting disparities in the quantity, but not in the types of touch used: mothers were more likely than fathers to employ kissing, stroking/caressing, utilitarian/instrumental, holding, massage/rubbing, palmar grasp reflex, and other types of touch. These measures were also used to describe dyads in clinical groups. For instance, Koester (2000) observed both deaf and hearing mothers during a still-face procedure with their 6-and 9-month-old infants (deaf or hearing) and observed that dyads with the same hearing status (both deaf or both hearing partners) increased their tactile contact when the interaction resumed to normal, following the still-face episode, and exhibited a similar touch profile. Likewise, Mantis et al. (2019) examined the effect of maternal depressive symptomatology on maternal touch behavior towards their infants instill-face (maternal emotional unavailability) and separation (maternal physical unavailability). This study found that mothers with higher levels of depressive symptoms touch less and use considerably fewer stimulating types of touch during the reunion period of the still-face procedure, and both the normal and reunion-normal periods of the separation procedure.

1.2.4.2. Functional and mixed instruments. On the other hand, functional measures were designed to assess the functional role of each touch behavior performed by the adult towards the infant. Examples of scales that fill this category are the FTS (Jean and Stack, 2009) and the Functions of Mother-infant Mutual Touch Scale (FMTS; Mantis et al., 2013; Mantis and Stack, 2018). When using mixed instruments, such as the Maternal Touch Scale (MTS; Beebe et al., 2010), the directly observable touch behaviors are first collected, and in a second step are aggregated into categories according to their functional role. For example, the touch actions caress, kiss, stroke, nuzzle and pat, when applied to the extremities of the infant's body, with light or moderate intensity, are classified as affectionate touch by the MTS instrument. As studies using mixed instruments typically only report functional categories and not directly observable touch behaviors (for example, types of touch: stroke, kiss, hold), we did not make a distinction between functional and mixed measures in the brief literature review of studies on the functional role of touch presented next – finer differences will be addressed later in the methods and discussion sections.

Concerning the quality of tactile stimulation within caregiver-infant interactions, the purpose/function of touch in infancy has also been addressed in touch research. In a number of studies, observational measures were employed to examine how caregivers use touch for specific functional purposes. For instance, Jean and Stack (2009) measured the infant's distress levels considering behavioral markers (e.g., duration and intensity of the infant's fretting and motor agitation) in a still-face procedure. They found that after the still-face period, mothers used nurturing touch (e.g., stroking, caring) more frequently when the infant was displaying high levels of distress. This is consistent with other studies that reported the mother's use of affectionate/nurturing touch to relax and soothe the infant and reduce the level of distress (Moreno et al., 2006; Peláez-Nogueras et al., 1996). In addition to this role in modulating the infant's negative emotions, maternal affectionate touch can also elicit positive emotions. Peláez-Nogueras et al. (1997) compared the effects of systematic affectionate touch (e.g., stroking) versus stimulating touch (e.g., tickling and poking) on 2- to 4.5-month--old infants, while the infants maintained eye contact with the experimenter. This study found that infants who were stroked expressed themselves more vocally, smiled more and cried less than those who received tickles/pokes. Furthermore, it has been shown that playful or stimulating touch (e.g., tickling, lifting, moving arms or legs) is significant for the infant's social interactions, reinforcing the infant's social

behavior while also increasing positive affect, eye contact, and activity level (Lowe et al., 2016; Moreno et al., 2006; Egmose et al., 2018). Maternal touching behaviors that are intended to promote the infant's comfort, including repositioning the infant on the carpet or wiping the infant's mouth, have been labeled as caregiving/instrumental touch. Recent research on touch behavior of mothers with and without post-partum depression during a prolonged mother-infant interaction at 4 months found that the infant's negative affect was more likely to stop during periods that included caregiving touch (Egmose et al., 2018). In addition, in both clinical and non-clinical samples, caregiving touch – but not affectionate and static touch – was linked to higher maternal sensitivity (Cordes et al., 2017). Moreover, maternal touch has been shown to be effective at attracting, maintaining, and recapturing the infant's attention (Gusella et al., 1988; Jean and Stack, 2009). In contrast, infants that experience intrusive touch (such as poking, pulling, and scratching) are more likely to display negative affect and behavior (Peláez-Nogueras et al., 1996) and have insecure attachment styles (Beebe et al., 2010).

Along with the effect that particular touch behaviors have on the infant, the infant's and mother's health conditions also have an impact on how parents apply touch behaviors. For instance, compared to a control group, mothers of failure-to-thrive infants delivered less physical touch, including less matter-of-fact, unintentional, and proprioceptive touch (Polan and Ward, 1994). Using the still-face procedure, Jean and Stack (2012) examined mothers and their 5.5-month-old infant in two groups: full-term infants and very-low-birth-weight preterm. They found that mothers touched their infants very frequently (82% of the interaction time), more frequently utilizing attention-getting touch during the normal period and nurturing and playful touches in the reunion normal period. Moreover, mothers of very-low-birth-weight preterm infants employed playful and utilitarian touch types more often than mothers of full-term infants. In addition, mothers of insecure infants, assessed at 12 months, used less affectionate touch to engage with their infants at 4 months (Beebe et al., 2010).

On the other hand, the state of maternal health has also been shown to impact tactile exchanges in mother-infant interactions. A study by Ferber (2004) showed that the number of previous pregnancies (parity) and instances of maternity blues (defined as a transitional depressive state that initiates soon after childbirth and can present a range of symptoms such as crying, anxiety, tension, restlessness and, exhaustion) affected maternal touching behavior towards the infants. Multiparous mothers used more frequent and varied modes of physical contact, whereas mothers with maternity blues provided less touch stimulation to their infants, independently of their parity status. In line with these results, Stepakoff, (1999) found that depressed mothers, when compared with non-depressed mothers, engaged in less affectionate touch and more object-mediated touch. Infants of depressed mothers (who tend to touch less often or use more negative types of touch, such as rough tickling or poking), also exhibit more self-touch behaviors when compared with infants of non-depressed mothers (Beebe et al., 2008; Herrera et al., 2004).

Altogether, these studies highlight the importance of studying parental touch behavior considering not only the amount of touch but also the different types of touch and the functional role these have in early parent-infant interactions. These findings showed that touch is not only a causal force for an infant's emotional, social, and physiological development (Field, 2010, 2019) and well-being but it is also sensitive to multiple variables, such as the infant's age, cultural context, or the dyads' mental health status (Stack and Jean, 2011; Stack, 2001, 2004). This increased interest in and recognition of touch in infancy is certainly responsible for a diversity of novel findings, but it has also resulted in a wide-ranging heterogeneity in the assessment of touch behavior.

1.3. The present study

Observational measures offer several advantages over other options to assess touch behaviors: they are generally more detailed, objective, and can be used in naturalistic interactions. As such, several observational coding systems have been developed over the past three decades, focusing on different dimensions of touch behavior. There has been a considerable effort to develop observational measures that assess the complexity of parental touching behaviors in the context of dyadic interactions. However, discussions about the variety of ways in which the touch phenomenon has been conceptualized and operationalized are still scarce. The current study addresses these gaps by providing an updated overview that can be used to compare the findings of research conducted using different instruments and to promote the development of new tools that aim to clarify, standardize, and uniformize touch assessment.

Moreover, the selection of one particular observational instrument over another is challenging when designing an observational study, since it depends on several practical and psychometric arguments. It is critical to consider factors such as the availability of the measure, its psychometric qualities, the construct measured, the target population, the interaction context, and/or the popularity of the measure. Collecting and organizing this information may assist researchers in making an informed selection of a particular observational measure, which is one of the contributions of this systematic review. We reviewed available observational instruments and how they were used in the literature. To the best of our knowledge, this is the first systematic review of observational measures of caregiver's touch behavior in parent-infant interactions. Weiss and Niemann (2011) performed a detailed review of different methods of measurement of touch behavior, including observational instruments of caregiver's touch patterns. However, Weiss and Niemann (2011) did not report the eligibility criteria, search strategy, study selection process, or data extraction strategy from the included observation instruments. Besides, several new observational instruments have been designed to measure the caregiver's touch within parent-infant interactions over the past decade—and these are not included in Weiss and Niemann (2011) review.

In summary, the present work has aimed to extend the field by providing an up-to-date overview of existing observational instruments. The study had three main goals: (1) systematically identify available observational instruments, describing and characterizing their main attributes (following PRISMA guidelines); (2) examine how these instruments are used in the literature (namely regarding their target population and experimental settings); and (3) discuss the main strengths and limitations of each category of instruments, and provide tentative guidelines for the design of future observational studies.

2. Methods

This systematic review report has followed the guidelines published in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021). At least two of the authors were involved in each phase of the systematic review process with the objective of minimizing the risk of bias. All the authors of the present study participated in defining the study inclusion criteria and the study search strategy to ensure that they were precise, appropriate, and focused on the study's primary objectives.

2.1. Eligibility criteria

We included instruments that were: (1) designed for microanalytic observation of caregiver-infant touch interactions; (2) rated by an external observer; (3) specifically developed to assess qualitative (e.g., types of touch) and quantitative (e.g., frequency or duration) features of caregiver's touch behavior; (4) applicable before the infant is 24 months of age; (5) published in Portuguese, Spanish or English. The exclusion criteria were: (1) instruments primarily designed for multimodal assessment of caregiver-infant interactions but that only include touch as a sub-scale; (2) self-response measures, such as diaries or

questionnaires; (3) tools only used with infants older than 24 months of age; (4) instruments that only assessed the total amount of caregiver touching behavior; (5) publications in a language other than Portuguese, Spanish, or English.

2.2. Search strategy

The search strategy was conducted on the following databases: APA PsycInfo, Medline, Scopus, APA PsycArticles, and Web of Science. Queries included, per database, the first allowable search date through July 2022. No publication date or publication status restrictions were enforced. The search was limited to title, abstract, and keywords. For searches conducted on the APA PsycInfo, Medline, Scopus, and Web of Science databases we used the following query: *(mother OR father OR caregiver OR parent* OR maternal) AND (touch OR tactile) AND (assessment OR scale OR instrument OR tool OR scoring OR coding OR measure* OR index) AND (infancy OR Infant)*. Since we obtained a very limited number of results using the above query in the APA PsycArticles database, a broader search using the following query was made: *(mother OR father OR caregiver OR parent* OR maternal) AND (touch OR tactile) OR (assessment OR scale OR instrument OR tool OR scoring OR coding OR measure* OR index) AND (infancy OR Infant)*.

2.3. Selection process

All the collected references were uploaded to a database of citations using the EndNote reference manager (The EndNote Team, 2013) and duplicates were automatically removed. The titles and abstracts of the remaining publications were then screened using the Rayyan tool (Ouzzani et al., 2016). The screening process was divided into the following steps: (1) duplicates not found by EndNote were manually removed; (2) the first author conducted a preliminary phase of screening to remove articles that were irrelevant to the subject or that did not use a coding system for assessing caregiver touch behavior; (3) titles and abstracts of the remaining publications were analyzed to determine their eligibility in light of the established inclusion and exclusion criteria; (4) full texts of the selected publications were, whenever available, obtained and read to decide whether to include or exclude them; (5) in order to gather more relevant literature that may have been overlooked during the original search, a manual search of reference sections, full titles, and acronyms of relevant tools was performed using Google Scholar. In the event of relevant citations, the article was selected and screened based on the aforementioned inclusion and exclusion criteria.

Two reviewers (JS and IS) independently conducted the selection process and disagreements were resolved during face-to-face discussions. When consensus was not reached a third review author was involved (AP).

2.4. Data extraction

We extracted three types of data from the included publications: (1) characteristics of studies (i.e., type of article, publication year, country); (2) characteristics of the observational instruments (e.g., constructs measured by the instrument, availability) and their psychometric properties (reliability and validity); (3) information about the use of the extracted instruments in the included publications (e.g., target population, location of the observation, type of task). The strategy of data extraction was created based on Bai et al. (2018), Lotzin et al. (2015), and Weiss and Niemann (2011)'s reviews (the form including this information can be obtained from the authors on request). The first (JS) and the second author (IS) separately performed the data extraction achieving a 93.18% interrater agreement, whereupon the two reviewers consulted the full text again to correct any observed inconsistencies.

3. Results

3.1. Review process

Fig. 1 summarizes the flow of information in this study as required by PRISMA guidelines. The search queries returned 3042 potentially eligible publications, including 2995 records from the selected databases, and 47 from other sources (Google Scholar and articles reference sections). Duplicates were subsequently removed, resulting in 1928 publications. After screening the titles and abstracts, a total of 149 publications were retrieved for full-text review. 45 publications that included microanalytic observational instruments for measuring the caregiver's touch behavior were retrieved. From these, 12 instruments were extracted.

3.2. Characteristics of the included publications

Publication dates for the records ranged from 1990 to 2021 with the majority (60%) published between 2010 and 2022 – see Fig. 2. Peer-reviewed journal articles comprised 82% of the included publications. The publications included samples from 10 countries distributed on four continents. The majority of the studies were conducted with North American samples (51% from the USA and 22% from Canada) followed by samples from Europe (20%), Asia (4%), Africa (2%), and South America (2%). Table 1 provides more thorough information on the characteristics of the publications included in the review.

3.3. Characteristics of the observational instruments

Table 2 and Table 3 summarize the characteristics of each instrument included, and how they have been used in the literature, regarding target population and experimental settings. From the 45 publications included, we extracted 12 observational instruments. Three different approaches to assessing the touch phenomenon were identified: (1) strictly behavioral measures; (2) functional measures; (3) mixed measures. We found three strictly behavioral measures: Caregiver Infant Touch Scale (CITS; Stack et al., 1996; Stack et al., 2001), Caregiver-Infant Touch Scale - Adapted (CITS-Adapted; Mercuri et al., 2019), and Face-to-face Touch Coding System (FFTCS; Koester, 2000); six functional instruments: Quality of Parent-to-Infant Touch Protocol (QPTP; Moreno et al., 2006), Functions of Touch Scale (FTS; Jean et al., 2005; Jean et al., 2007; Jean and Stack, 2009), Caregiver Touch Coding System (CTCS; Koester and Paradis, 2010; Paradis and Koester, 2015), The Functions of Mother-Infant Mutual Touch Scale (FMTS; Mantis et al., 2013; Mantis and Stack, 2018), The Mother-Infant Touch Scale (TMITS; Crucianelli et al., 2019) and Maternal Touch Coding System (MTCS; Provenzi et al., 2020). Finally, the three remaining instruments included both observable and functional constructs in their coding systems: Tactile Interaction Index (TII; Weiss, 1992; Weiss, 2000), Touch-Scoring Instrument (TSI; Polan and Ward, 1994), and Maternal Touch Scale (MTS; Stepakoff, 1999; Beebe et al., 2010). Regarding the dimensions of touch codes, the majority of the tools considered the functional role (75%) and the frequency of touch (92%). Other dimensions such as action (25%), duration (67%), location (25%), and intensity (25%) of touch were also coded. All the extracted instruments included reliability studies, however only one of them reported validity studies: the Tactile Interaction Index (Weiss, 1992; Weiss, 2000). Eight of the extracted instruments are available in published articles and book chapters (67%); the remaining are available on request from the authors of the unpublished manual. Most of the extracted publications included at least one clinical population (60%), while the remaining 40% only included non-clinical populations. This review included research with infants whose ages ranged from 0 to 24 months old, with a sample of infants aged 0–6 months of age in 84% of the included studies. We also examined the contexts where the instruments were used, of the 12 instruments: 42% were used in more than one context; 25% only in a

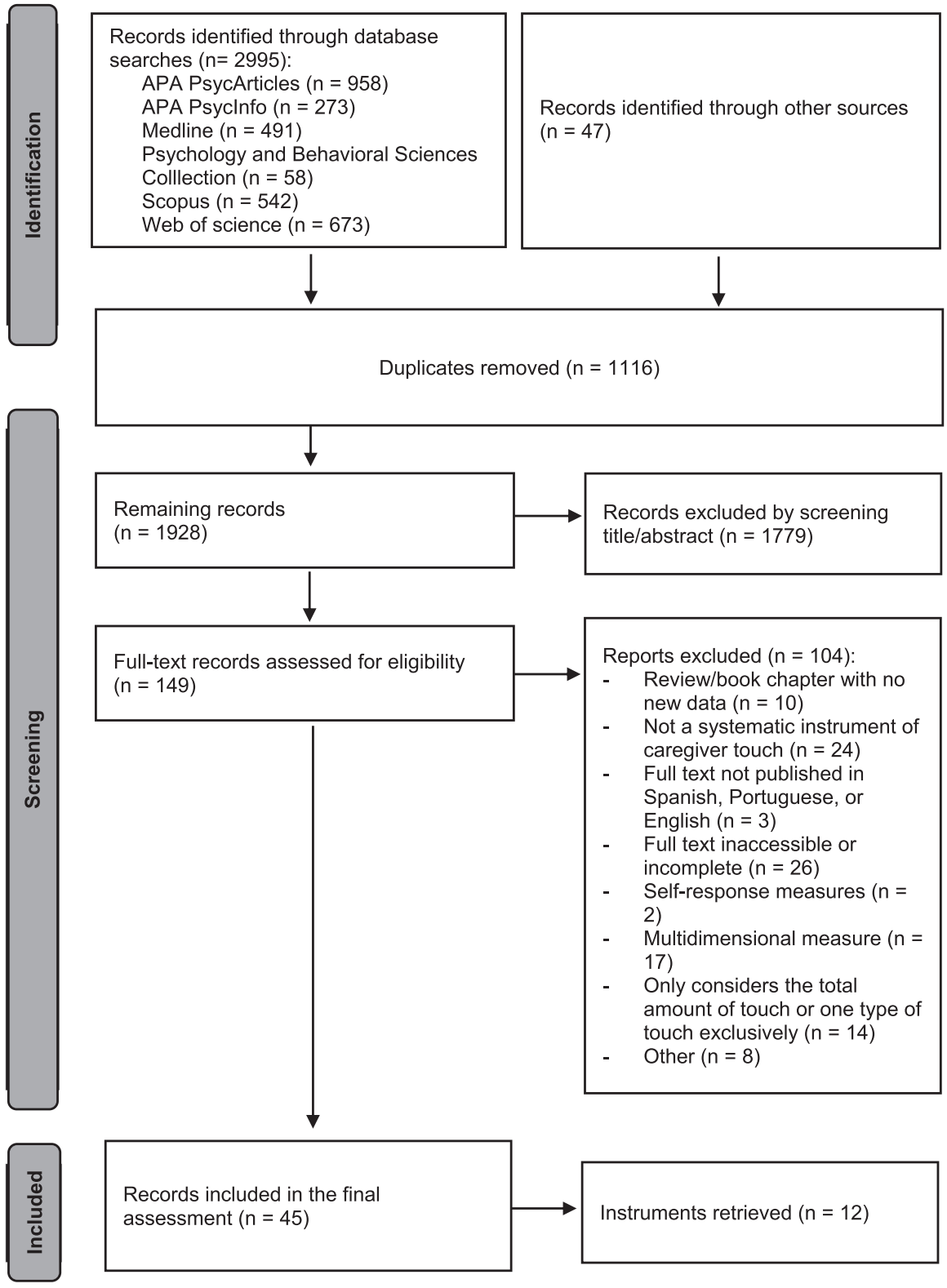

Fig. 1. PRISMA Systematic Review Flow Diagram.

laboratory context; 25% in a home context, and 17% were utilized in hospital settings. However, when we analyzed the 45 included publications, we found that 53% of the studies had occurred in a laboratory context, followed by a home context (31%), while the remaining 16% were conducted in a hospital or more than one context in the same study (or it was unspecified). The two most frequent tasks used in the studies were face-to-face interaction and the still-face procedure. Typically, the interaction duration ranged from 2.5 to 12 min. Except for one study which was conducted on newborns following delivery and lasted 45 min. Considering the frequency of use (in our sample of publications), the most commonly used was MTS (27%) followed by the CITS (18%), and then FTS and TII (13%).

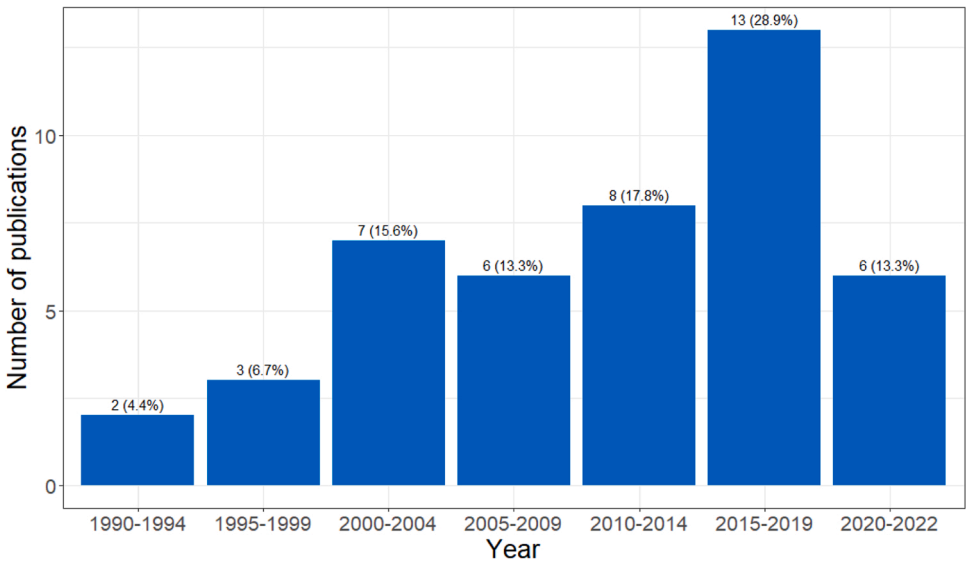

Fig. 2. Number of Publications Distributed Over Time.

Table 1
Characteristics of the 45 Publications Including Observational Instruments for Measuring Caregiver's Touch Behavior in Parent-Infant Interactions.

Characteristics		n	%
Type of article	Peer-reviewed article	37	82.2
	Dissertations and conference abstracts	8	17.8
Continent (Country[a])	America:		
	Canada	10	22.2
	USA	23	51.1
	Ecuador	1	2.2
	Europe:		
	Denmark	2	4.4
	Italy	4	8.9
	Germany	1	2.2
	Portugal	1	2.2
	UK	1	2.2
	Africa:		
	South Africa	1	2.2
	Asia:		
	Israel	2	4.4

[a] Total percentage is over 100 because 2 studies included a population of more than one country.

3.4. Description of included instruments

This section describes the 12 observational instruments for measuring social touch that resulted from our review. Instruments are presented in chronological order. The information presented here was based on the methods section of the publications reporting the instruments and in supplementary information materials (when made available by the authors) — see Table 2 for a summary of the constructs measured by each tool, and Table 3 for information on how the instrument was used in the included publications. Next, we summarize, for each observational instrument: the research contexts where it was used, the constructs measured, the control variables typically used (i.e., the measures used to control the quality and standardization of the touch measures, such as blind coding or percentage of double coded videotapes for reliability), psychometric metrics (when available), and a summary of how the tools were used in the selected studies.

3.4.1. Tactile Interaction Index (TII; Weiss, 1992; Weiss, 2000)

The Tactile Interaction Index (TII) was designed to objectively describe the features of touch in dyadic interactions and applies to a range of age groups and relationships (Weiss and Niemann, 2011), including parent-infant interactions. It has been used in a diversity of contexts, such as infant feeding, structured play with children, health care procedures in the intensive care unit, and interactions at home or in a laboratory setting (Weiss et al., 2000, 2001, 2004; Weiss and Niemann, 2011). Touch patterns measured by TII were also used to analyze the association between parental touch in secure attachment (Weiss et al., 2000), social adaptation and emotional/behavior problems (Weiss et al., 2001), the neurodevelopmental level in low-birth-weight infants (Weiss et al., 2004), and the relationship between parental touch of preterm infants and their parent's state of mind regarding touch (Weiss and Goebel, 2003).

TII was specifically conceived for the microanalysis of parent-infant videotaped interactions (Weiss et al., 2001) and measures five indexes of touch (that Weiss and colleagues labeled as qualities of touch): intensity, location, action, frequency, and duration of touch events (Weiss, 1992). In the intensity index, touch is coded as deep, strong, moderate, or light, depending on the level of pressure on the skin. The location index considers nineteen areas of the body that can be touched. The action index identifies twenty-eight gestures or movements that can be used in touch behavior: contact, grab, hit, hold, hug, kiss, lift, massage, pat, pick, pinch, poke, press, pull, push, rub, scratch, shake, slap, squeeze, stroke, bite, kick, lick, suck, tap, tickle, and vibrate. The duration index measures the total time of touch throughout an observation period, while the frequency index considers the number of touches (Weiss, 1992). These five qualities of touch can also be aggregated into two different modalities of tactile behavior: types of touch and patterns of touch (Weiss, 1992; Weiss and Niemann, 2011). Weiss and Niemann (2011) described the eight types of touch assessed by TII; two of these types of touch are determined by the location index: (1) frequency of "highly innervated body areas" (p. 254) touched by the social partner, such as face and hands; (2) extent of the contact (i.e., the quantity of body' locations touched by a social partner, from the previous nineteen coded locations). The remaining six types of touch are calculated from the action index: (3) nurturing or comforting touch (e.g., kiss, stroke); (4) harsh or painful touch (e.g., slap, pinch, pull); (5) cutaneous touch (e.g., contact); (6) proprioceptive touch (e.g., rub, hug); (7) vestibular touch (e.g., lifting); (8) diverse or varied touch, i.e., how many different actions the caregiver carried out among the 28 actions tracked by the scale (Weiss and Niemann, 2011).

Finally, the qualities and types of touch can also be combined into four patterns of touch: (1) stimulating touch, which refers to touch in

Table 2
Characteristics of Observational Instruments for Measuring Caregiver's Touch Behavior in Parent-Infant Interactions Extracted from Literature Review.

Instrument name (reference)	Strictly behavioral or functional measures?	Properties of touch[a]	Touch constructs measured	Availability	Reliability studies	Validity studies
Tactile Interaction Index (TII; Weiss, 1992;Weiss, 2000)	Mixed	Intensity Location Action Frequency Duration Functional role	5 Qualities of touch: Location, Action, Intensity, Frequency, Duration 8 Types of touch: Touch high innervated body areas; Extent of the contact; Nurturing touch, Harsh touch; Cutaneous touch; Proprioceptive touch; Vestibular touch; Diverse 4 Patterns of touch: Stimulating touch; Complexity of touch; Affective nature of touch; The overall amount of touch	Published article Unpublished manual	Inter-observer and retest reliability	Construct, Content and concurrent validity
Touch-Scoring Instrument (TSI;Polan and Ward, 1994)	Mixed	Action Frequency Functional role	3 Physical characteristics: Firm touch; Proprioceptive stimulation; Vestibular stimulation. 3 Affective communicative qualities: Light active touch; Holding; Awkward touch; Rough touch. 2 Non-specific touch: Matter-of-fact; Passive or accidental touch.	Published article	Inter-observer	Not available
Caregiver Infant Touch Scale (CITS;Stack et al., 1996; Stack et al., 2001)	Strictly behavioral	Action Frequency Duration	8 Types of touch: Static touch; Stroke/rub/ caress/massage, Pat/tap, Grab/squeeze/pinch; Tickle/finger-walk/prod/poke/ push; Shake/ wiggle; Pull/lift/flexion/ clap; Other types of touch	Published conference abstract Unpublished manuscript Published book section	Inter-observer	Not available
Caregiver-Infant Touch Scale - Adapted (CITS-Adapted;Mercuri et al., 2019)	Strictly behavioral	Action Frequency Duration	9 Categories of touch: Static touch; Stroke/ caress; Massage/rub; Holding; Palmar grasp reflex; Rocking; Utilitarian/instrumental; Other; Kissing.	Published article	Inter-observer	Not available
Maternal touch scale (MTS; Beebe et al., 2010; Stepakoff, 1999)	Mixed	Intensity, location, Action, Frequency, Duration. Functional role	21 Types of touch (e.g., tap, pat, rub/massage, kiss/nuzzle, tickle) 11 Categories of touch: Affectionate Touch, Static Touch, Playful touch, No touch, Centripetal Touch, Rough Touch, and High-Intensity Touch.	Published article Published thesis	Inter-observer	Not available
Face-to-face Touch Coding (FFTCS;Koester, 2000)	Strictly behavioral	Active vs passive actions Intensity Location Frequency Duration	4 Types of contact: Passive; Active/moving; Active/passive; Moving; 2 Intensities: Low-moderate or Moderate-high; 4 Locations: Head/face; Torso; Arms/hands; Feet/legs 3 Durations: Low, Medium, or High	Published article	Inter-observer	Discriminant validity
Quality of Parent-to-infant Touch Protocol (QPTP; Goldyn and Moreno, 2002;Moreno et al., 2006)	Functional	Functional role Frequency	5 Categories: Affectionate touch; Stimulating touch; Instrumental touch; No touch; Cannot code	Unpublished manuscript	Inter-observer	Not available
Functions of Touch Scale (FTS;Jean et al., 2005; Jean et al., 2007;Jean andand Stack, 2009)	Functional	Frequency, Duration. Functional role	9 Functions of touch: Passive accompaniment; Active accompaniment; Nurturing; Playful; Attention-getting; Accidental; Utilitarian; Harsh or negative; Unspecified function.	Unpublished manuscript	Inter-observer	Not available
Caregiver Touch Coding System (CTCS;Koester and Paradis, 2010; Paradis and Koester, 2015)	Functional	Frequency Functional role	7 Categories: Affection; Play-directed; Attentional; Instructive; Prohibitive; Reposition; Incidental	Unpublished manuscript	Not available	Not available
The functions of mother-infant mutual touch scale (FMTS;Mantis et al., 2013; Mantis and Stack, 2018)	Functional	Duration Functional role	6 Functions of touch: Playful; Regulatory; Passive; Attention-centered; Guided; Unbalanced.	Unpublished document	Inter-observer	Not available
The mother-Infant touch scale (TMITS;Crucianelli et al., 2019)	Functional	Functional role Frequency Duration	Incidental touch 3 Categories of intentional touch: Instrumental touch; Static; Affectionate touch (Contingent-Excitatory or Non-Contingent-Down-regulatory).	Published article	Inter-observer	Not available
Maternal Touch Coding System (MTCS;Provenzi et al., 2020)	Functional	Frequency Functional role	5 Touch types: Affectionate touch; Playful touch; Facilitating touch; Holding touch; Harsh touch;	Published article	Inter-observer	Not available

[a] We set the dimensions of touch-based on Hertenstein, 2002, Hertenstein, Verkamp et al. (2006); as cited in Burgoon et al. (1996) and Hertenstein (2002, as cited in Weiss and Campos, 1999)

Table 3
Use of extracted instruments in included publications.

Instrument name (reference)	Target population	Age of the infant/ child (months)	Location of observation	Type of task	Interaction duration (minutes)	Relevant publications	%[a, b] (n = 45)
Tactile Interaction Index (TII; Weiss, 1992;Weiss, 2000)	Parents of LBW/preterm infants	3	Home	Feeding	5	Weiss (1992) Weiss et al. (2000) Weiss et al. (2001) Weiss and Goebel (2003) Weiss (et al. (2004)	13.3 (n = 6)
Touch-Scoring Instrument (TSI; Polan and Ward, 1994)	Mothers of failure thrive infants, Mothers of typically developed infants Mothers with maternity blues/ depressive symptomology	2 days – 19	Lab Home Hospital	Feeding Free play with toys Caregiving session	5 or 10	Polan and Ward (1994) Ferber (2004) Ferber et al. (2008) Hardin et al. (2021)	8.9 (n = 4)
Caregiver Infant Touch Scale (CITS;Stack et al., 1996;Stack et al., 2001)	Caregivers of typically developed infants Mothers with high vs. low depressive symptoms Mothers of preterm infants	1–13	Home Lab Hospital	Still face procedure (original and adapted) Free play without toys	2 per task (SF procedure), 5 or 10	Stack et al. (1996) Jean et al. (2009) Mantis et al. (2019) Mercuri et al. (2019)	17.8 (n = 8)
Caregiver-Infant Touch Scale - Adapted (CITS-Adapted; Mercuri et al., 2019)	Parents of typically developed infants	0	Hospital	Free flow triadic interaction	45	Mercuri et al. (2019)	2.2 (n = 1)
Maternal touch scale (MTS; Stepakoff, 1999;Beebe et al., 2010)	Mothers with PPD Mothers with high vs. low depressive symptoms Mothers with high vs. low anxiety symptoms Preterm infant's mothers Caregivers of typically developed infants	4 – 12	Lab	Face-to-face interaction Structured play session	2.5, 3, 5, 10 or 12	Beebe et al. (2008) Beebe et al., (2010, 2016) Beebe et al. (2011) Beebe et al. (2018) Cordes et al. (2017) Egmose et al. (2018); Serra et al. (2020) Stefana and Lavelli (2017)	26.7 (n = 12)
Face-to-face Touch Coding (FFTCS; Koester, 2000)	Hearing and deaf mothers of hearing or deaf infants Mothers of typically developed infants	6/8 weeks – 9 months	Lab Hospital	Still-face procedure Face-to-face interaction	2 min per task	(Koester, 2000) Potgieter and Adams (2019)	4.4 (n = 2)
Quality of Parent-to-infant Touch Protocol (QPTP; Goldyn and Moreno, 2002; Moreno et al., 2006)	Mothers of typically developed infants	3.5	Lab	Face-to-face interaction	3	Moreno et al. (2006)	2.2 (n = 1)
Functions of Touch Scale (FTS; Jean et al., 2005;Jean et al., 2007;Jean and Stack, 2009)	Mothers of typically developed infants Mothers of VLBW preterm infants	4–5.5	Lab Home	Still-face procedure Modified SF with touch	2 min per task	Jean and Stack (2009, 2012) Jean et al. (2014) Lowe et al. (2016)	13.3 (n = 6)
Caregiver Touch Coding System (CTCS;Koester and Paradis, 2010;Paradis and Koester, 2015)	Hearing and deaf mothers of hearing or deaf infants	6–18	Lab	Free play with toys	10	Paradis and Koester (2015) Silvia (2011)	4.4 (n = 2)
The functions of mother-infant mutual touch scale (FMTS; Mantis et al., 2013;Mantis and Stack, 2018)	Mothers of VLBW preterm infants Mothers of full-term infants	5.5	Home	Still-face procedure	2 min per task	Mantis and Stack, (2018)	2.2 (n = 1)
The mother-Infant touch scale (TMITS;Crucianelli et al., 2019)	Mothers of typically developed infants	12	Home	Book sharing activity	10	Crucianelli et al., (2019)	2.2 (n = 1)
Maternal Touch Coding System (MTCS;Provenzi et al., 2020)	Mothers of infants with neurodevelopmental disability Mothers of VLBW preterm	3–24	Lab home	Free play with toys Face-to-Face Still-face paradigm	5 2 min per task	Provenzi et al. (2020) Mariani Wigley et al. (2021)	4.4 (n = 2)

(*continued on next page*)

Table 3 (*continued*)

Instrument name (reference)	Target population	Age of the infant/ child (months)	Location of observation	Type of task	Interaction duration (minutes)	Relevant publications	%[a, b] (n = 45)
	infants Mothers of typically developed infants						

Note. In this systematic review, we only considered studies including at least one sample of infants up to 24 months of age. For more detailed information about these measures see the following section: "Description of included instruments".
LBW = Low birth weight. VLBW = Very low birth weight. PPD = Post-partum depression.
[a] Percentage of the included studies that used each instrument.
[b] Total percentage is superior to 100 because 2 studies used more than one instrument.

very innervated body areas, high-intensity tactile stimulus, and proprioceptive touch; (2) complexity of touch, which considers the extent of body locations touched and the diversity of actions used in touching; (3) affective touch refers to the ratio between nurturing/comforting sensations and harsh or intrusive actions; (4) the overall amount of touch can be measured in terms of frequency or duration, these scores were obtained directly from the corresponding aforementioned indexes (Weiss and Niemann, 2011).

The interaction videos were examined twice or four times by a trained research assistant for each index: the control variable most frequently employed in the studies included (Weiss et al., 2000, 2001; Weiss and Goebel, 2003). Regarding inter-rater reliability, Weiss (1992) reported the Cronbach alpha coefficients by: location (0.33 for the breast and the remaining values ranged from 0.70 for the torso and 0.98 for the head); action (0.32 for grab, with remaining values ranging from 0.51 for tickle to 0.96 for kiss); intensity (ranging from 0.76 to 0.92) and duration (ranging from 0.84 to 0.99). Concurrent validity values between the coding observers and those who had been observed using touch were reported by Weiss (1992) as follows: location (r = 0.18–0.99), intensity (0.51–0.89), action (r = 0.11–0.88), and duration (r = 0.78–0.93). Studies were also conducted to determine the construct validity between the TII and a self-report questionnaire on touch experiences in daily life (r = 0.46–0.66), as well as the validity of content – 100% agreement across five experts in defining the four qualities of touch (Weiss, 1992). The use of the TII requires training, which includes the use of videotape examples of different touch qualities as well as a coding manual (Weiss and Niemann, 2011). Furthermore, in the context of this review, we found that TII has been primarily used to encode parental touch in brief 5-minute feeding interactions with 3 months-old infants at home.

3.4.2. *Touch-Scoring Instrument (TSI; Polan and Ward, 1994)*

The Touch-Scoring Instrument (TSI) was designed to capture and systematically classify the richness and diversity of the caregiver's touch repertoire. It was first created to measure the role of maternal touch behavior when interacting with typical and failure-to-thrive infants (Polan and Ward, 1994). However, more recently, TSI has been used to measure touch patterns in both clinical and normative samples and a diversity of contexts and tasks. For instance, Ferber (2004) analyzed the association between tactile stimulation, parity (number of pregnancies), and maternity blues in newborns. This instrument was also applied to capture the developmental trajectories of maternal touch behavior when interacting with their typically developed infants (Ferber et al., 2008).

TSI considers nine categories of touch, that were typically micro-coded into 30-second frames: three categories defined by their physical characteristics, four by their affective nature, and two general touch categories to describe other events that did not suit the previous categories. The three physical touch categories include:

(1) firm touch, defined as firm patting, stroking, or massaging with the whole hand; (2) proprioceptive stimulation, defined as flexion-extension of the child's limbs by the mother …; and (3) vestibular stimulation, defined as movements that change the infant's body orientation in space. (Polan and Ward, 1994, p.1100).

The four categories of touch's affective nature comprise:

(4) light touch, defined as affectionate kissing, or caressing, stroking, or tickling with the fingertips: (5) holding, defined as affectionately or comfortingly holding, leaning against, or hugging, in ventral-ventral, ventral-dorsal, or other positions; (6) awkward holding, defined as holding the child in an uncomfortable or precarious manner with an uninterested or neglectful quality; (7) rough handling, defined as exercising forceful or abrupt restraint or physical control of the child with an angry or punitive quality. (Polan and Ward, 1994, p.1100).

Lastly, the authors included two general touch categories:

(8) matter-of-fact touch, defined as purposeful utilitarian contacts such as wiping the child's mouth, guiding the child's hand to a toy, etc.; and (9) unintentional touch, defined as brushing, bumping, or other types of fortuitous physical contact. (Polan and Ward, 1994, p.1100).

Recently, Hardin et al. (2021)developed a modified version of the Touch Scoring-Instrument to examine the effects of maternal depression and breastfeeding on mother-infant affectionate touch. This adapted version includes seven touch categories: (1) rough handling; (2) awkward holding; (3) no touch; (4) not affectionate/passive/reactive, i.e., any maternal touch that does not fit into the affectionate, passive, or reactive touch categories; (5) passive touch; (6) light active; and (7) firm touch.

The control variables most frequently used in the included studies are the following: blind coding for the study groups (Ferber, 2004; Ferber et al., 2008; Polan and Ward, 1994) and selecting a percentage of videos to be coded by two or more coders for reliability (Ferber, 2004; Ferber et al., 2008; Hardin et al., 2021; Polan and Ward, 1994). Regarding the interrater reliability of TSI, Polan and Ward (1994) reported the following intraclass correlation coefficients: 0.87 for light touch, 0.57 for firm touch, 0.79 for proprioceptive touch, 0.96 for vestibular touch, 0.94 for unintentional touch, 0.96 for the matter of fact, and 0.91 holding. Cohen kappa scores for the reliability of the TSI adapted version ranged from 0.85 to 0.95 (Hardin et al., 2021). In addition, to our knowledge, no validity studies were performed. The included studies reported that the observers were trained to use the coding system, but we were not able to find further details about that training process. In the context of this review, we also found that TSI was used to capture caregiver's touch when interacting with their infants (aged 2 days to 19-month-old) during a diversity of tasks (e.g., feeding, free play with toys, caregiving moments) and experimental contexts (home, hospital, and lab).

3.4.3. *Caregiver Infant Touch Scale (CITS; Stack et al., 1996; Stack et al., 2001) and Caregiver Infant Touch Scale – adapted (CITS – adapted; Mercuri et al., 2019)*

The Caregiver Infant Touch Scale (CITS) was developed to identify in detail the different caregiver touch types from videotapes of caregiver-infant interactions. This scale has been applied with 1- to 13-month-old infants in both clinical, e.g., mothers with depressive symptomatology, and non-clinical contexts and populations, and across different interactional contexts, e.g. home, hospital, and lab, and tasks, e.g. still-face procedure and free-play (e.g., Jean et al., 2009; Mantis et al., 2019; Mercuri et al., 2019; Stack et al., 1996).

This instrument considers eight different types of touch assessed on a second-by-second basis: (1) *static touch*; (2) *stroke/rub/caress/massage*; (3) *pat/tap*; (4) *grab/squeeze/pinch*; (5) *tickle/finger-walk/prod/poke/push*; (6) *shake/wiggle*; (7) *pull/lift/flexion/ clap*; and (8) *other types of touch*, such as, adjusting clothing, rocking or bouncing. Any physical contact between the mother's hands and the infant that lasts more than 0.5 s is coded. Later on, some studies aggregated these touch types into more general touch categories, such as: *nurturing/affectionate touch* (i.e., static, stroke, and pat types of touch) and *playful/stimulating* (i.e., pull, squeeze, shake, and tickle types of touch) (e.g., Mantis et al., 2019). This aggregation of categories was conducted not only with CITS but also with CITS-adapted (Mercuri et al., 2019). Thus, the CITS has an adapted version, the Caregiver Infant Touch Scale - Adapted (CITS-Adapted).

The CITS-Adapted was created to measure caregiver's touch behavior specifically when interacting with their newborn (i.e., during the immediate postpartum period). To our knowledge, this instrument was only used by Mercuri et al. (2019) to study how mothers and fathers use touch to interact with their newborn infant during their first naturalistic interaction.

The CITS-adapted includes nine categories of touch that were measured on a second-by-second basis: (1) *static touch*; (2) *stroke/caress*; (3) *massage/rub*; (4) *holding*; (5) *palmar grasp reflex*; (6) *rocking*; (7) *utilitarian/instrumental*; (8) *other*; and (9) *kissing*. When compared with the original scale, the CITS-adapted excludes the following touch behaviors: pat/tap, squeeze/pinch/grasp, tickle/finger-walk/prod/poke/push, shake/wiggle, and pull/lift/extension/clap. The authors justified the removal of these touch behaviors by citing the low likelihood of them occurring immediately after birth. Instead, more typically touch patterns for this period were added to the scale: *holding*, *rocking* (i.e., cradling), and *utilitarian/instrumental* behaviors (Mercuri et al., 2019).

For both CITS and CITS-Adapted, the following control variables were most frequently employed in the included studies: the coders were blind to the study's hypotheses, a percentage of a random position of the video recordings were double coded, and percentage durations were used to control for duration of time across interactions (Jean et al., 2009; Mantis et al., 2019; Mercuri et al., 2019). Inter-rater reliability was frequently observed in the included studies using Cohen's Kappa, with the overall touch ranged from 0.88 (Jean et al., 2009) to 0.90 (Mantis et al., 2019) for CITS. To our knowledge, no validity studies were performed for both CITS and CITS-Adapted. The majority of studies included reported that the observers were trained to use the coding system, but we were unable to find further details regarding that training process. Mercuri et al. (2019) reported, as an exception, that the training procedure included identifying discrepancies between the coders, evaluating the corresponding portion of the video second-by-second, then discussing and finally choosing what type of touch should be coded in that segment.

3.4.4. Maternal Touch Scale (MTS; Stepakoff, 1999; Stepakoff, 1999; Beebe et al., 2010)

The Maternal Touch Scale (MTS) was designed to examine parental touch behavior in the context of mother-infant interactions. MTS has mainly been used by Beebe and colleagues to study self- and interactive contingency during early mother-infant interactions at 4 months, in both clinical and non-clinical populations, and laboratory settings (Beebe et al., 2007, 2008, 2010, 2011, 2016, 2018; Beebe and Lachmann, 2017). MTS has also been used to examine the effect of the infant's gender, and the mother's ethnicity and depressive symptomatology on her touch behavior (Stepakoff, 1999). More recent studies applied MTS to understand the association between maternal touch behavior, post-partum depression, sensitive and overriding caregiving behavior (Cordes et al., 2017), and infant's affect (Egmose et al., 2018). Finally, this scale was adopted to study the effect of object vs. non-object-oriented play tasks on maternal touch behavior (Serra et al., 2020).

This instrument is very complete as it considers not only different touch types (e.g., stroking, kissing, tapping) but also a variety of meanings and implications that touch can bring to the social exchanges (e.g., affectionate touch, caregiving touch). MTS is coded with second by second windows and in each second interval a code for one of the 21 touch types included in the scale is assigned: no touch, hold, provide hand or fingers, stroke/caress, jiggle/large movements with arms or legs, caregiving, tap, pat, rub/massage, kiss/nuzzle, tickle, pull/push, pinch, poke, scratch, object-mediated touch, self-directed oral touch, infant-directed oral touch, other, un-codable. The location where the touch is applied (face, body, head/neck, hands/arms, feet/legs) and the intensity of the touch type (mild/moderate, high intense, n.a.) are also coded. All these 21 types of touch can also be aggregated into 11 categories, ordinalized from more affectionate to more intrusive: affectionate touch, static touch, playful touch, no touch, caregiving touch, jiggle/bounce touch, oral touch, object-mediated touch, centripetal touch, rough touch and high-intensity touch (Beebe et al., 2010; Stepakoff, 1999).

Studies using MTS most frequently used the following control variables: coding carried out by observers who were blind to the study's group status, along with double coding of a random percentage of the dyads (e.g., Beebe et al., 2008, 2010, 2011) or/and a randomly selected position of the video recordings for reliability (Cordes et al., 2017; Egmose et al., 2018; Serra et al., 2020). Cohen's Kappa score was used in the included studies to assess inter-rater reliability, with the overall touch ranging from 0.60 (Cordes et al., 2017) to 0.90 (Beebe et al., 2018). To our knowledge, no validity studies were performed for MTS. Most of studies included reported that the observers were trained to use the coding system, but we were unable to find further details about that training process - see Stepakoff, 1999 for one exception. In the context of this review, we found that MTS has primarily been used in studies conducted in a laboratory setting with infants from 4 to 12 months.

3.4.5. Face-to-Face Touch Coding System (FFTCS; Koester et al., 2000)

The Face-to-Face Touch Coding System (FFTCS) was designed to assess touch behavior performed by hearing vs. deaf mothers when engaged in the still-face procedure with their hearing or deaf infants. Touch was measured during the normal and reunion periods (Koester, 2000). However, FFTCS was also used in non-clinical contexts: Potgieter and Adams (2019) examined the effect of early skin-to-skin contact on maternal touch behavior at 7–8 weeks postpartum.

The four types of tactile contact considered in FFTCS were coded using the event-sampling approach: (1) passive, touch without movement, e.g., resting the hand on the infant's leg; (2) active, touch that implies movement, e.g., tapping or stroking; (3) active and passive touch combined, e.g., one hand rests on the leg while the other strokes the infant's head; (4) movement of the infant's body or limbs. The location, intensity and duration of the touch behavior are also coded. In this sense, four locations (arms/hands, feet/legs, torso, head/face, or any combination of these), and two intensities ("gentle/mild," or "vigorous/strong") are considered (Koester, 2000).

A random percentage of the video recordings double coded for reliability were utilized as a control variable in studies using FFTCS (Koester, 2000; Potgieter and Adams, 2019). Inter-rater reliability of this scale is 84.7% for the type of contact, 97.8% for location, and 77% for the intensity of touch (Koester, 2000). Weiss and Niemann (2011) found evidence of discriminant validity on the constructs assessed by this instrument. The included studies sugested that the observers were trained to use the coding system, but we were unable to find additional details regarding the training process. We found that FFTCS has been used in studies conducted in hospital and laboratory settings with infants from 6 to 8 weeks post-partum to 9 months.

3.4.6. Quality of Parent-to-infant Touch Protocol (QPTP; Goldyn and Moreno, 2002; Moreno et al., 2006)

The Quality of Parent-to-infant Touch Protocol (QPTP) was developed for measuring individual differences both in the quality and type of

parental touch. This instrument has been applied to typically developing populations in mother-infant face-to-face interactions, e.g to 3.5-month-old infants to analyze the effect of touch on mother-infant coregulation (Moreno et al., 2006).

The QPTP consists of 5 mutually exclusive categories, measured in 5-second segments: (1) affectionate touch; (2) stimulating touch; (3) instrumental touch; (4) no touch; and (5) cannot code. The level of affection and stimulation conveyed through touch is rated on a 4-point scale. In the case of two types of touch occurring simultaneously only the most salient one is coded. The mother's actual actions with her hands and fingers, the infant's reaction, and the duration of the contact are all considered by coders to determine the salience of one touch type over another in a 5-second segment (Moreno et al., 2006).

Control variables in QPTP research included coding performed by observers who were unaware of the study's hypothesis and double coding of a random percentage of the video recordings. Regarding the inter-rater reliability of this scale, Moreno et al. (2006) reported the following intraclass correlation coefficients per touch category: 0.81 for affectionate touch, and 0.79 for stimulating touch. To our knowledge, no validity studies are available. QPTP requires training to be used, including the use of a coding manual and the achievement of a satisfactory degree of inter-rater reliability between coders, i.e., higher than.80 on 10 dyads (Moreno et al., 2006).

3.4.7. *Functions of Touch Scale (FTS; Jean et al., 2005; Jean et al., 2007; Jean and Stack, 2009)*

The Functions of Touch Scale (FTS) is a systematic observational instrument designed to assess the functions of touch used by mothers to interact with their infants. This coding system measures the qualitative and quantitative aspects of maternal touch as well as contextual information such as verbal and non-verbal modalities of communication, maternal affect, verbalizations, or the infant's affect and attention (Jean and Stack, 2009).

In this scale, for each second of the interaction, one of nine functions of touch are coded: (1) passive accompaniment, i.e., touch that does not imply movement (e.g., a resting hand on the infant's leg) and complements other communication modalities, such as speaking; here, touch is not the primary means of communication in the interaction; (2) active accompaniment, that is, touch with movement without playful goals (e.g., lifting and moving the infant) that accompanies another communication modality; again, touch is not the primary means of communication in the interaction; (3) nurturing touch, affectionate touch behaviors aimed to transmit affection or regulate infant's affect (e.g., kissing, stroking); (4) playful touch, active touch usually to make the infant smile and laugh (e.g., tickle, extend, or flex the infant's limbs); (5) attention-getting touch (e.g., patting or squeezing the infant); (6) accidental touch; (7) utilitarian touch that is used to perform instrumental tasks (e.g., fixing the infant's clothes); (8) harsh or negative touch, which typically involves controlling the infant's behavior by touching in an intrusive and negative way; and (9) unspecified function, i.e., touch without an apparent function (Jean et al., 2007; Jean et al., 2005; Jean and Stack, 2009).

The following control variables are the most frequently employed in the included studies: the coders were blind to the study's hypotheses; a percentage of a random position of the video recordings were double coded; and percentage durations were used to control for duration of time across interactions (Jean et al., 2014; Jean and Stack, 2009, 2012). The included studies evaluated inter-rater reliability using the Cohen's Kappa score, with an overall range of 0.86 (Lowe et al., 2016) to 0.90 (Jean et al., 2014). All the included studies reported that the observers were trained to use the coding system, but we were not able to find further details about that training process. No formal validity testing has been described for this instrument (Weiss and Niemann, 2011). In the context of this study, we found that FTS has been applied mainly with infants (5.5-month-old), both normative and clinical populations, during the still-face procedure.

3.4.8. *Caregiver Touch Coding System (CTCS; Koester and Paradis, 2010; Paradis and Koester, 2015)*

The Caregiver Touch Coding System (CTCS) was created to capture the functional role of maternal touch behaviors. Similarly to the Face-to-face Touch Coding System (FFTCS), CTCS has been used in longitudinal projects studying the impact of early deafness on an infant's cognitive, social, and communicative development (Paradis and Koester, 2015; Silvia, 2011).

CTCS measures the frequency of touch and categorizes each type of touch considering its function. Thus, this instrument considers even mutually exclusive categories: (1) affection touch, tactile behavior is gentle and/or has nurturing nature; although it can include more abrupt movements as in the case of playfulness or tickling (2) play-directed touch, touching the infant in a playing interaction, without the intention of helping the infant interact with the toy; (3) attentional touch (e.g., tapping on the infant's hand to get his attention); (4) instructive touch, guiding the infant interaction with a toy; (5) prohibitive touch, applied to control or redirect infant behavior; and (6) incidental: touch without an apparent purpose; (7) reposition touch, applied to adjust the infant's position in space. Each touch behavior initiated by the mother is counted, resulting in frequencies for each category (Paradis and Koester, 2015).

The CTCS requires training before it can be used, which involves instruction on a set of "master recordings" that have been coded by the system's creators and reaching a satisfactory level of inter-rater agreement of at least 80% on all categories of touch prior to coding the actual study tapes (Paradis and Koester, 2015; Silvia, 2011). Apart from the training information, no details about interrater reliability between coders or validity metrics was provided, in the studies that were included. In the context of this review, we found that CTCS has been applied to mothers interacting with their 6- to 18-month-old infants, generally in face-to-face or free play with toy interactions.

3.5. *The Functions of Mother-infant Mutual Touch Scale (FMTS; Mantis et al., 2013; Mantis and Stack, 2018)*

The Functions of Mother-Infant Mutual Touch Scale (FMTS) was designed to analyze the functions of mutual touch within early mother-infant social interactions. Functions of mutual touch are defined as a continuous and dynamic tactile exchange between the elements of a dyad (Mantis and Stack, 2018). This instrument was based on two previous coding systems, the Functions of Touch Scale (FTS, and the Functions of Infant Touch Scale (FITS; Moszkowski et al., 2009). Specifically, the coding method and the mutual touch definitions in this scale were based on a previously unpublished scale (Mantis et al., 2013).

FMTS includes six categories of mutual touch coded on a second by second basis: (1) playful touch, mutual touch transmitting enthusiasm to the dyad; (2) regulatory touch, mutual touch that conveys calmness to the dyad with the potential aim of regulating emotions; (3) passive touch, when both elements of a dyad hold their resting hands; (4) attention-centered touch, when one element of the dyad gets the other's attention, for instance, by tapping the other; (5) guided touch, that occurs when one element of the dyad helps the exploratory touch of the other; (6) unbalanced touch, occurring when there is not enough synchrony between the elements of the dyad to engage in mutual touch (Mantis et al., 2013; Mantis and Stack, 2018).

Research using FMTS presents the following control variables: percentage durations were used to control for duration of time across interactions, Cohen's kappa was corrected for chance, and a percentage of the videos were randomly selected to be coded by two coders for reliability (Mantis and Stack, 2018). Inter-rater reliability in FMTS for the total amount of mutual touch was $\kappa = 0.87$, while reliability coefficients by function were: $\kappa = 0.89$ for playful mutual touch; $\kappa = 1.00$ for regulatory mutual touch; and $\kappa = 0.78$ for passive, guided, and attention-centered mutual touch (Mantis and Stack, 2018). No information about validity metrics was mentioned. The authors reported that

the observers were trained to use the coding system, but we were unable to find additional details considering that training process. In the course of this review, we found that FMTS has been utilized to code maternal touch interaction with full-term or very low birth weight infants who were 5.5 months old during still-face procedures.

3.5.1. The Mother-infant Touch Scale (TMITS; Crucianelli et al., 2019)

The Mother-Infant Touch Scale (TMITS) is based on previous observational tools (Ferber et al., 2008; Polan and Ward, 1994; Reece et al., 2016; Stack et al., 1996; Stack et al., 2001) and was developed to code both maternal and infant touch, considering the contingency, valence, functionality, and purpose of touch behaviors. This scale, to our knowledge, was used once to examine whether the contingency of maternal mind-mindedness (i.e., a mother's social cognitive ability to understand their infant's mental state, needs and desires) was related to the maternal touch behavior when they read a book to their 12-month--old (Crucianelli et al., 2019).

In this scale, maternal touch is classified as incidental, when touch is directed at an object instead of the child, or intentional, when touch is directed at the child (Reece et al., 2016). Intentional touch is then coded second by second in one of three touch categories: instrumental, static, or affectionate touch. Affectionate touch can be divided into two subtypes, considering the touch valence: (1) contingent-excitatory when touch provides positive affect and is congruent with the infant's experience, e.g., gentle, tickling, kissing; (2) non-contingent-down-regulatory, when touch is not congruent with the infant's experience, e.g., restrictive firm touch and rough tickling. The decision as to which sub-type best describes the touch depends on the infant's mental state before and after the maternal touch, considering the infant's facial expression, e.g., happy vs. sad, sounds/calls/utterances, e.g., laugh vs. cry, and the infant's body movement, e.g., rapid vs. slow, approaching, retreating (Crucianelli et al., 2019).

The study using TMITS presents the following control variables: coders were blind to any demographic information of the infant and mother; a percentage of the videos were randomly selected to be coded by two coders for reliability and each touch category's total touch occurrences (measured as frequencies) were weighted according to the precise length of each videorecording to account for differences in duration (Crucianelli et al., 2019). An inter-observer agreement in this instrument was computed for all touch categories using Cohen's kappa of 0.56, 95% CI 0.30–0.82 (Crucianelli et al., 2019). No information about validity metrics was mentioned. TMITS requires training to be used, which entails two observers coding six tapes randomly selected from the study database for reliability, with parallel discussions about their agreements and disagreements, until a level of agreement equal to 80% of all tactile behaviors is reached (Crucianelli et al., 2019).

3.5.2. Maternal Touch Coding System (MTCS; Provenzi et al., 2020)

The Maternal Touch Coding System (MTCS) results from the merging and adaptation of previous coding systems (Crucianelli et al., 2019; Jean and Stack, 2009; Polan and Ward, 1994; Reece et al., 2016). This instrument was developed to measure and compare the functions of maternal touch in play interactions of 12- to 24- month-old toddlers with neurodevelopmental disabilities and toddlers with typical development (Provenzi et al., 2020).

MTCS is focused on the functional role of touch behavior and it includes seven touch categories measured on a 2 s basis: (1) affectionate touch (e.g., slow pace/ gentle stroking, caressing, or massaging); (2) playful touch (e.g., tickle, shake or lift); (3) facilitating touch, divided into two subcategories: (3.1) instrumental touch (e.g., fixing child's position or facilitating infant's physical equilibrium by holding) and (3.2) attention-getting (helping the infant to pay attention to the mother by tapping or patting the infant's arm, for instance); (4) holding touch, including two subcategories: (4.1) containment (i.e., touch that may regulate the infant's negative emotional state, aimed at controlling infant's posture and movements); (4.2) static (e.g., when the mother is resting her hand on the infant's leg); (5) harsh touch (e.g., intrusive, awkward or overwhelming touch behavior); (6) no touch; and (7) unspecified touch. For every two-second segment, coders have to select only one type of touch. If two types of touch occur simultaneously, the authors prioritize the one with greater duration during the segment.

The studies using MTCS present the following control variables: coders were blind to the study's aims and hypothesis; a percentage of the videos were randomly selected to be coded by two coders for reliability and percentage of time in touch were used to control for duration of time across interactions (Mariani Wigley et al., 2021; Provenzi et al., 2020). The included studies evaluated inter-rater reliability using Cohen's Kappa score, for the overall touch range of 0.80 (Mariani Wigley et al., 2021) to 0.81 (Provenzi et al., 2020). No information about validity metrics was mentioned. MTCS requires training to be used, which entails identifying discrepancies between the coders, evaluating the corresponding portion of the video, then discussing and finally choosing what type of touch should be coded in that segment. For the purposes of this study, we found that MTCS was used to measure and compare the functions of maternal touch on full-term, very low birth weight infants and infants with neurodevelopmental disability aged 3–24 months old in play interactions and still-face procedures.

4. Discussion

Touch is a foundational part of the infant's early experience of the world, marked by proximity with social partners who use touch in multiple forms and for multiple purposes (Hertenstein, 2002; Jean and Stack, 2009; Stack, 2001), from the practicalities of caregiving to the regulation of physiology or emotion, or for play. The complexity of social touch is more frequently studied using observational methods where touch events are segmented from video recordings of social interactions and categorized according to a well-defined instrument (Brzozowska et al., 2021; Weiss and Niemann, 2011).

We conducted a systematic review of the literature on observational instruments designed specifically to measure the caregiver's touch behavior in parent-infant interactions. This approach offers several advantages when compared with other alternatives, based, for example, on parental retrospective evaluation or self-report (Brzozowska et al., 2021), and we conjecture that these benefits have motivated renewed interest in observational methods for touch research. As such, our main goals were to identify available instruments, describe their main features, and summarize how these instruments were used in the literature. We also propose categorizing the different tools into three groups based on how they measure the touch phenomenon, discussing the core strengths and limitations of each group of instruments, and providing guidelines for the design of future observational instruments.

From the 45 publications that met the inclusion criteria, we extracted 12 observational tools for measuring caregiver touch behavior. Ten different countries produced these studies, with the USA producing the majority. The number of observational studies of caregiver touching patterns has grown considerably over the past decade, with 60% of the included papers published between 2010 and 2022. Our analysis found different instruments designed to capture distinct perspectives of the touch phenomenon (strictly behavioral, functional, or mixed). Although some observational tools were developed using previous tools, and thus share similar features or organizational structures, there is, nonetheless, a great conceptual and operational variability, as well as a lack of consistency across observational measures of touch. Half of the instruments in question measure the functional role of the caregiver's touch behavior. In addition to this, publications that include observational instruments are mostly concerned with the first 6 months of life, measuring touch in two laboratory tasks: (1) structured social interaction (e.g., face-to-face interactions); and (2) the still-face procedure. MTS (Mother Touch Scale) is the most widely employed instrument included in the selected publications.

4.1. Characteristics of the observational instruments

We organized the 12 selected observational instruments using three main categories: strictly behavioral, functional, and mixed (i.e., tools that include both strictly behavioral and functional constructs). This classification system was developed to help structure the information in the article and was based on conceptual frameworks for touch already used in the literature (Burgoon et al., 1996 cited in Hertenstein et al., 2006; Brzozowska et al., 2021; Hertenstein, 2002), as well as on the major similarities that we identified between the instruments in our post-hoc analysis (after extraction).

Half of the instruments included in this review were focused on the functional role of touch, i.e., the particular function that each touch event has in the flow of the caregiver-infant interaction, for example, if a mother squeezes the infant's arm to get his/her attention. Our study also revealed that 75% of the included instruments provided a measure of the functional role of touch. Furthermore, all the functional tools included in this review have been developed over the last 20 years. We advance two possible explanations to account for this rise in levels of research into the functional character of touch. Firstly, there is growing evidence that certain types of touch elicit specific responses in the infant (Stack and Arnold, 1998; Stack and LePage, 1996), suggesting that different touches play distinct functional roles in caregiver-infant interactions. Secondly, studies in this area have also found that specific touch patterns are associated with positive developmental outcomes in the infant. For instance, nurturing/affectionate touch can relax and soothe the infant after a distressing event (Jean and Stack, 2009; Moreno et al., 2006; Peláez-Nogueras et al., 1996). When compared with highly vulnerable preterm infants, higher levels of nurturing touch promote more secure attachment in less vulnerable preterm infants (Weiss et al., 2000).

Furthermore, infants that receive more nurturing/affectionate touch at 3 months old exhibit fewer behavioral and emotional problems at the age of 2 years (Weiss et al., 2001, 2004). Another example is caregiving touch: this type of touch can help lower the infant's negative affect (Egmose et al., 2018) and is associated with a higher level of maternal sensitivity (Cordes et al., 2017). The growing corpus of studies indicating that the different types of touch serve various functions in social interactions and have an impact on the infant's development and behavior may have also served as a catalyst for the creation of new methods to evaluate touch constructs.

Our findings also show that most instruments are accessible, and can be used and consulted in published articles, theses, and book sections (67%). Despite this, we argue that the practical replication of the coding systems included in these observational tools is demanding. The descriptions of the methods available are often vague and poorly detailed, making it difficult to accurately replicate the coding systems in new studies. Additionally, proper training of coders involves several hours of supervised coding, followed by a highly time-consuming coding process. Besides that, it is crucial to create and publish more specific guidelines per instrument (with examples on how to apply and score the caregiver's touch behavior) and/or to develop open-access training programs for the coding systems. This would support the overall research community in applying these instruments/coding systems and would make them more replicable.

The availability of studies on the psychometric proprieties of the instruments is another salient point to consider. In general, reliability studies are included but formal validity studies of the instruments are practically non-existent — see Weiss (1992) for an important exception. As a result, more thorough psychometric studies, which include validity comparisons of various observational touch instruments paired with self-response measures, are crucial for improving the accuracy and reliability of the observational tools available for measuring touch.

Detailed information on the use of the instruments in research was also provided in this review. We systematically reviewed the observational instruments used to measure the caregiver's touch behavior on infants between the ages of 0–24 months old and found that most studies focused on infants younger than 6 months. Observational tools were used to assess both non-clinical and clinical populations (e.g., failure to thrive, preterm or deaf infant's caregivers, and mothers with postpartum depression) and were primarily used in the context of two tasks, face-to-face interactions, and the still-face procedure. Finally, the majority of the instruments were applied in three settings: hospital, family home, or laboratory, with most of the studies occurring in the laboratory context. The higher frequency of the laboratory setting can be explained by the fact that MTS is commonly applied in that context (Beebe et al., 2010; Stepakoff, 1999).

4.2. Measuring caregiver touch behavior: strictly behavioral vs functional instruments

Before discussing the advantages and disadvantages of utilizing the instruments included in each category of observational touch measure (strictly behavioral, functional, and mixed), we will first look at some similarities and differences between them. Some instruments were designed to capture specific behavioral traits, such as the parent's touch action (stroke, pat, tap), the touch's intensity, and whether or not the hand was moving – we referred to them as strictly behavior instruments, because they were focused on the surface-level observable aspects of touch behavior. Other methods, in turn, were more focused on assessing what parents meant to convey to their infants through these specific behavioral features – we called them functional (Hertenstein et al., 2006, as cited in Burgoon et al., 1996) because the emphasis is not on the touch behavior per se but on the role it has in the interaction. Then, we identified that some instruments measured specific behavioral features and then aggregated them in functional categories – because these instruments measured both construct types alluded to in the two previous categories, we referred to them as mixed instruments. Despite these operationalization differences among the categories, there are also some overlapping similarities. These similarities appear to be mostly accounted for by the fact that some recent observational measures were based on earlier observational measures and as such, they measured similar or slightly modified constructs. For instance, when comparing the functional tools, FTS and FMTS, we found that FTS presents more constructs (e.g., active accompaniment, accidental, harsh, and negative) than FMTS; however, the common constructs between the two tools either have the same name (playful) or have a different name but measure very similar behaviors (e.g., attention-getting vs attention-centered). Attributing different designations to the same touch behaviors is a common occurrence in observational measures of touch, a point that will be covered in more detail later in this review. Another commonality can be found between the strictly behavioral and mixed instruments categories since they both measured directly observable characteristics of the touch behavior. However, while in mixed instruments the directly observable touch behavior is aggregated based on the function touch has on the interaction (e.g., kiss and stroke transmit affection to the infant, thus, these actions are included in the affectionate category in MTS), strictly behavioral tools code these observable touch patterns per se (e.g., kiss, tap, tickle, hold) and are not focused on their function. Although we did not focus on similarities between categories in the following sections, it is crucial to bear in mind that they do exist and could be helpful when comparing the findings of research that employs different observational measurements. The benefits and drawbacks of using the instruments contained in each category of observational touch measure will be discussed in the sections that follow.

4.2.1. Strictly behavioral instruments

Strictly behavioral instruments (e.g., CITS and FFTCS) allow researchers to capture and describe touch in a great level of detail. They provide information about how specific touch types and their dimensions vary across time, contexts, caregiver/infant's health, and even between caregivers. For instance, Jean et al. (2009) used CITS to

examine the mother's touch behavior when interacting with their infants at 1, 3, and 5.5 months of age, in two interactional contexts (lap and floor). They found that mothers touch their infants more at 1 month of age than at 3 months, but also used different types of touch depending on the infant's age and context. Specifically, while in the lap, mothers used more patting and tapping touch when their infants were one month of age compared with when they were 5.5 months old; mothers stroked their infants more often at 1 month than at 3 months and applied more tickling at 5.5 months than at 1 month. In the floor context, mothers used lifting touch more often at 1 month than when interacting with their older infants. The auditory status of mothers also impacts the use of touch: hearing mothers use touch with longer duration and are more active compared with deaf mothers (Koester, 2000). These findings underscore the importance of touch in its most basic observable behavioral element. They also suggest that parents adapt the use of touch to a diversity of circumstances, such as infant age, interactional context, and touch is altered in clinical dyads. The description of touch behavior at this level of detail could be beneficial for several practical reasons. For example, for the development of parenting intervention programs that stimulate certain touch types considering specific interactional contexts and clinical conditions, or for early detection of clinical indicators that may impact an infant's healthy development.

However, it is important to note that some of these studies, particularly the more recent ones, grouped specific touch patterns into more functional categories (e.g., nurturing, stimulating, and instrumental categories), after collecting them using a strictly behavioral instrument – for example see Mantis et al. (2019) and Mercuri et al. (2019). Parental touching exchanges go beyond their simple actions and have different roles and communicate different messages within the interaction, a fact which is ignored by methodologies that only focus on the observable touch behavior. However, the grouping of specific touching behaviors into more functional ones may reflect to some extent the research field's recognition of this. This assertion is further supported by the fact that over the past 20 years, researchers have focused on developing more functional tools.

4.2.2. *Functional instruments*

Functional instruments code for the functional purpose of a touch behavior in the context of the interaction (not necessarily the same as the exact type of touch). According to our systematic review, there has been an increased interest in this component of touch, as evidenced by the rise in studies using functional tools available in the recent literature - 75% of the tools presented in this review included a measure of the functional role of touch. Functional measures (such as FTS, FMTS, and TMITS) consider the function that each touch event plays in the interaction flow. For example, a mother's kissing and slow stroking in response to the infant's fussiness may be coded as nurturing touch, according to the FTS. Indeed, such tools have been essential for deepening our understanding of the functional significance of parental touch behavior in early parent-infant interactions as well as the relationship between these touch behaviors and the infant's emotional, social, and physical development (e.g., Crucianelli et al., 2019; Jean and Stack, 2009; Moreno et al., 2006). However, there is a lot of variation in how the functional role of touch has been operationalized across instruments. Some tools are more detailed than others, with a range of 3–9 functions of touch (e.g., QPPTP vs FTS). There are different research teams categorizing comparable touch functions using different terms (in the following section, this specific point is covered in more detail). Additionally, distinct instruments operationalize similar functional constructs of touch differently. A caregiver's gentle and slow touch behavior intended to soothe, relax, and calm the infant, for instance, is assessed differently depending on the tool employed. The CTCS characterized this action as affection touch and this category includes both touch with a gentle and nurturing quality but also playful movements such as patting and tickling. TMITS categorizes this type of touch as contingent-excitatory affectionate touch, and in addition to considering the gentle quality of touch (much like CTCS), it also assesses whether touch is contingent on the baby's emotional state. Playful and nurturing touch behaviors fall under separate categories in FTS and FMTS, while gentle contact is designated as nurturing touch and regulatory touch in each scale, respectively.

Moreover, the behavioral variables that different instruments take into account can vary. For example, some instruments (such as FTS, CTCS, and QPPTP) only assess the caregiver's tactile behavior, while others (such as FTS) consider other interaction modalities when coding, such as vocalizations; others still evaluate the infant response to the caregiver when operationalizing the functional role of parent's touch behavior (e.g., TMITS and FMTS). Overall, this variability in how the functions of touch were evaluated via the lens of various observational metrics makes systematic comparisons between studies and instruments difficult at best.

Another limitation associated with functional instruments is that they only measure the purpose of a specific touch behavior in a given situation, and do not account for the observable behaviors associated with each function (i.e., the opposite problem of when the same touch behavior is used for multiple functions). For instance, when various touch actions (e.g., caress, stroke, tap) are classified as affectionate touch category, we lose access to information about how many caresses the mother provides to their infant at a given context or age; instead, we only have access to the composite that included it, affectionate touch in this particular example. In fact, some studies have shown that there is an association between the developmental trajectory of different touch types and infant development (e.g., Stack and Jean, 2011; Jean et al., 2009; Mantis et al., 2019). Do parents use the same touch behaviors to communicate the same message? How do these changes relate to the infant's well-being, behavior, and developmental level? Responding to these questions in future studies may help researchers to explore the relation between certain socio-emotional and cognitive skills, and specific touch types provided by the caregiver.

Despite these limitations, when compared with strictly behavioral tools, functional instruments go beyond the mere description of tactile behavior since they collect information on the purpose of tactile stimulation in each moment of the interaction flow, for instance, if a mother is slowly caressing her infant on the head, she probably aims to relax, show affection, or regulate her baby's affect.

4.2.3. *Mixed instruments*

We found three instruments measuring both the strictly observable touch behavior and the functional role of touch: TII, MTS, and TSI. These instruments, in a first step, code for the type of touch and their additional dimensions (e.g., intensity and location). In a second step, this detailed information is aggregated into more general categories/patterns of touch, reflecting the functional role of the touch in the interaction. When compared with functional tools, mixed measures provide a more accurate description of the precise relationship between the type of touch and the dimensions that underlie each function of touch. This is particularly important because different touch types may have different functions in the interaction depending on factors such as the location of the body touched or the intensity of the touch. For instance, in the MTS instrument, the "tap" type of touch can be used to play with the infant when caregivers touch their infant's hands, arms, feet, or legs with moderate intensity. Yet, if the same "tap" behavior was applied to the face, body, head, or neck, it may be regarded as more stimulating (i.e., centripetal touch), or as intrusive, if applied with great intensity. Thus, these instruments can describe in detail how parents use touch at different levels of abstraction. However, important information could be missed when using mixed measures, since the functional role is not coded from the interaction but rather comes from the combination of other elements (e.g., types of touch, intensity). For example, pulling the baby by the arm with moderate intensity may reflect two different functions if we consider what is happening in the interaction: it may be intrusive to restrict the infant's access to the desired toy (rough touch) or

a protective behavior from the parent to protect the baby from approaching danger, for example, an electrical plug (caregiving touch). This disadvantage can be mitigated by simultaneously encoding the observable behavior (e.g., actions, intensity, location of the touch behavior) and the function associated with it.

4.3. Towards more uniform and consistent social touch constructs

Touch researchers have noted that designing an observational instrument that accurately measures the complexity of caregiver's touch exchanges in parent-infant interactions is a challenging task (Hertenstein, 2002; Hertenstein et al., 2006). This stems from the caregiver's use of diverse touch behaviors, and how these behaviors vary in several important dimensions (e.g., action, location, velocity, intensity, frequency, and duration). The combination of these dimensions defines the purpose or function of each specific touch behavior performed by a caregiver. In addition, parents and infants have their unique social context and bring particular characteristics to everyday interactions that naturally affect the quality and quantity of touch exchanges. As such, designing a measure that captures the phenomenon of touch to its fullest extent is a difficult task for researchers (Hertenstein, 2002; Hertenstein et al., 2006), which may have contributed (in part) to the diversity of instruments found in this review. Thus, there is considerable heterogeneity in the way each instrument is organized, both in the dimensions of touch that are used, and in which constructs of touch are included for measurement. This is evident when comparing terminology associated with the same or very similar touch behavioral cues. At the strictly behavioral level, which includes the different behaviors that parents use to interact with their infants through touch (e.g., hold, tap, stroke, tickle), we observe several terminological variations. For instance, in TII these behaviors are called actions, in MTS and CITS they are named touch-types, while in TSI they are designed as categories of touch. This terminological inconsistency also applies to the higher-level touch dimensions. The functional role of touch in interpersonal interaction has, in touch research, been labelled touch categories (e.g., QPPTP, CTCS, and TMITS), functions of touch (e.g., FTS and FMTS), or types of touch (e.g., MTCS). Distinct scales also use different categorizations for the same touch, for example, purposeful/utilitarian contacts, such as wiping an infant's nose are categorized as matter-of-fact touch in the TSI, as utilitarian touch in FTS, as instrumental touch in QPPTP or as caregiving touch in MTS. The opposite is also true: similar functions have different definitions per instrument. For instance, considering affectionate/-nurturing/affection touch: CTCS included playful movements such as tickling in the affectionate construct; FTS considered other interaction modalities, such as vocalizations, in their measurement of nurturing touch; in TMITS, the contingency of parental touch to the infant experience is considered as part of the affectionate touch definition. A greater effort to clarify, standardize and seek a more uniform use of terms and definitions in the literature is an important next step.

In summary, the great variety of measurement strategies and the lack of consistency in definition and operationalization hinder direct comparisons between similar concepts measured by different instruments. We argue for an increase in uniformity and consistency of the assessed constructs, with the future goal of supporting more standardized measures of tactile behavior, and for the importance of including both the observable and functional features of caregiver's touch behavior in the design of new observational measures.

4.3.1. Strengths and limitations of this review

To the best of our knowledge, this is the first systematic review of observational tools to measure parental touching behavior during infancy; a previous review was done in 2011 but was not systematic in the methodology (Weiss and Niemann, 2011). A broad search with no year limitations in several relevant datasets was conducted. We included a detailed description of the constructs, the main characteristics of the instruments, and how they are used in the literature. The information collected in this review can assist researchers in the process of selecting an instrument for designing an observational study. However, in our review, we have only included structured observational instruments specifically oriented to measuring the quality and quantity of the parent's touch behavior in interaction with their infants up to 24 months, and multimodal instruments were not included – these code for several modalities in the interaction and include touch, but do not propose a separate instrument for touch. In addition, we only added observational measures, although recent work indicates that self-report and observational measures should be used together to enhance the understanding of touch behavior in parent-child interactions (Brzozowska et al., 2021).

Finally, only a limited number of gray literature publications, including conference papers and dissertations, were considered in our analysis (we only included conference papers and dissertations that were published on the commercial platforms that we had access to or were available in Google Scholar); recent evidence has shown the importance of considering more gray literature in systematic reviews (see Paez, 2017). A broader review of all the available measures, including self-report measures and other methods of evaluating touch behavior described in the literature, such as neurophysiological measures, should be addressed in further research.

4.3.2. Future directions

We will now address some potential directions that might be taken in further research. Although some more recent tools (e.g., TMITS, FMTS) measure the role of parental touch in the interaction by considering both the parent's intention when touching, and whether it is congruent or not with the infant's experience in a particular moment, the majority of these tools were designed to capture only the caregiver's behavior (and primarily the mother's), independently of the infant's response to it.[3] However, we know that caregivers and infants interact in a bidirectional manner, and, in the flow of the interaction, infants will actively respond to their parent's touch, or initiate touching by touching their parents or by touching themselves. There also moments of discoordination, in which the intention of the parent when initiating the touch will not be adequate. All these moments are an important part of parent-infant natural interactions, however, save for some exceptions, infant and caregiver touch is measured separately – see Beebe et al., (2010, 2016, 2018); Crucianelli et al. (2019) and Mantis and Stack (2018) for studies that measure both. Future research should therefore consider the development of instruments that more extensively and consistently account for both infant touch behavior and how it ties in to adult touch behavior. More attention should also be paid to how the contact is initiated, i.e., if parental touch behavior is congruent with the infant's experience, and how these aspects affect the infant's development, behavior, and emotional state.

The validity of observational touch measures is another crucial factor that needs to be evaluated in subsequent studies. Although some of the instruments included in this review mentioned validity studies (e.g., TII), this is not the rule. The fact that many observational measures were developed to evaluate touch for a single study or a few related research projects, rather than creating standardized touch assessment tools appears to account in part for the lack of these investigations. As a result, further empirical studies on an instrument's validity are required to increase the level of confidence in the findings and conclusions of observational studies of touch. To uniformly describe and clarify the variability that has been utilized to assess and touch on observational instruments, studies on the content and construct validity would be greatly beneficial. This is of particular importance for functional tools because of conceptual discrepancies. There has already been some research on evaluating the criterion validity of an observational

[3] For more information on instruments to measure infant's touch behavior see Moszkowski, Stack, and Chiarella (2009); Moszkowski, Stack, Girouard, et al., 2009 and Moszkowski & Stack, 2007

instrument in comparison to a self-report measure (Brzozowska et al., 2021). To our knowledge, however, the criteria validity between two or more distinct observational tools has not yet been carried out, even though it would be important in order to comprehend the degree of correlation that exists between the instruments used to measure related constructs. Finally, cross-cultural validity studies on tactile contact are essential for identifying cultural similarities and differences, as well as for determining how well the existing instruments can accurately measure touch in different cultural contexts.

While the relation between the caregiver's touch behavior and the infant́s social and emotional development has been widely explored (e.g., Ferber et al., 2008; Weiss, 2000; Weiss et al., 2001, 2004; Beebe et al., 2010; Cordes et al., 2017; Mantis et al., 2014; Mercuri et al., 2019; Polan and Ward, 1994), comparatively less is known about how parental touch, which is a permanent presence in the infant's everyday routines, impacts the infant's early cognitive development, particularly object exploration. Social touch and the development of object exploration in infancy have been studied separately in the literature: social touch studies typically study the dyad in non-object interactions, while studies of object exploration, in mother-infant play interactions with objects, are typically more interested in understanding how object manipulation and exploration is associated with developmental outcomes, especially high-order social cognition abilities, such as sustained attention and joint attention skills (de Barbaro et al., 2016; Yu and Smith, 2013; Suarez-Rivera et al., 2019; Schatz et al., 2020). The object-oriented behaviors may or may not include contact, such as the difference between a mother who holds the infant's hand with a mother that rings the bell for the infant. There are a few studies that suggest that parents adapt their tactile behavior to the infant's developmental needs and interests, in different play contexts (Leiba, 2000; Serra et al., 2020) and that parent's physical contact is associated with infant's object exploration (Tanaka et al., 2021). As such, the possible association between the caregiver's touch and the infant́s cognitive development raises some important questions: does parental touch affect the infant's cognitive development? If it does, is this effect direct (i.e., the parent's touch behavior scaffolds the infant when exploring objects)? or indirect (i.e., the parent's touch behavior touch behavior provides suitable circumstances that favor the exploration of an object)? Or is it a result of both direct and indirect pathways? To answer the aforementioned questions, and expand our understanding of the association between social touch and the development of the infant's ability to explore objects, it is necessary to develop instruments that combine the knowledge of these two research fields, i.e., including in future research not only the measurement of the quality of touch in the interactional context but also the detailed description of parental touch behaviors geared towards facilitating the infant's manipulation and exploration of objects.

Another relevant issue is the implicit assumption of intentionality. In functional instruments, the category for each touch type can be interpreted as stating some level of parental intentionality: a mother's gentle caress in a baby's arm can be categorized as affectionate touch, but this also suggests that she is acting with the intention of showing affection. Unless the method is explicit, there is an implicit assumption here that parental touch behavior always entails a communicative intention towards the infant (Hertenstein, 2002; Hertenstein et al., 2006). However, and across instruments, the strategy for coding of the functional role of a touch event is heterogeneous and any intentionality is inferred. While some instruments code the functional role of touch in the interaction by only considering parental touch behavior (e.g., CTCS and QPTP), others also include contextual variables, such as the infant's response to parental touch or the presence of other modalities (e.g., FTS and FMTS). As a result, we argue that more work can be done in future research to clarify the construct of the functional role and whether the assumption of intentionality is required.

Finally, future research should also make efforts to organize and summarize the terms used to define the touch construct, in order to clarify them, and move toward greater conceptual uniformity and consistency, with the goal of creating more standardized measures. There is also a lack of studies measuring the caregiver's touch behaviors when engaging with infants over 6 months of age, particularly in more naturalistic tasks and contexts. In addition, although measuring touch behavior is important, there is a critical need to measure its association with other sensory modalities and how it impacts infant global development.

5. Conclusion

Our systematic review provides a detailed description and synthesis of the available observational instruments to assess a parent's touch behavior in the context of caregiver-infant interactions. We identified three categories of observational measures, examined the strengths and limitations of each category for assessing touch behaviors in parent-infant interactions, and proposed possible future directions for research. Twelve instruments were identified from 45 publications. Our review collected a set of instruments designed to capture distinct perspectives of the touch phenomenon. We found a lack of conceptual and operational uniformity and consistency among them, and most of these instruments assess the functional role of caregiver touch behavior. In addition, most of the studies included in this review are with infants below six months of age, measuring touch in face-to-face interactions and the still-face procedure in a laboratory setting.

The current work provides an updated review of the available observational instruments for measuring caregiving touch behaviors, taking into account how they have been used in the literature, which can serve as a guide for future researchers to select the more suitable measurement for their future studies. Furthermore, we reviewed the primary strengths and limits of each of the three identified categories of instruments, as well as the conceptual challenges that the field of touch is facing, particularly when it comes to measurement. Such observations may help to increase the quality of future developed observational instruments of caregiver touch behavior, taking another step toward standardizing touch measurements. Finally, we summarize some of the key challenges in the field of touch and explore potential approaches to addressing them in future research.

Data Availability

Data will be made available on request.

Acknowledgments

This study was conducted at the Psychology Research Centre (PSI/01662), School of Psychology, the University of Minho, supported by the Foundation for Science and Technology (FCT) through the Portuguese State Budget (UID/PSI/01662/2020). This research was funded (in part) by the Portuguese FCT program, Center of Technology and Systems (CTS) UIDB/00066/2020. This research was also supported by FCT projects IF/00217/2013, PTDC/MHC/PCN/1530/2014, PTDC/PSI-GER/2463/2021, awarded to AFP, and FCT doctoral fellowship PD/BD/142819/2018 awarded to JS. We thank the anonymous reviewers for their insightful comments and recommendations, which has assisted us in improving the quality and presentation of this article.

References

Ackerley, R., Wasling, H.B., Liljencrantz, J., Olausson, H., Johnson, R.D., Wessberg, J., 2014. Human C-tactile afferents are tuned to the temperature of a skin-stroking caress. J. Neurosci. 34 (8), 2879–2883. https://doi.org/10.1523/jneurosci.2847-13.2014.

Álvarez, M.J., Fernández, D., Gómez-Salgado, J., Rodríguez-González, D., Rosón, M., Lapeña, S., 2017. The effects of massage therapy in hospitalized preterm neonates: A systematic review. International Journal of Nursing Studies 69, 119–136. https://doi.org/10.1016/j.ijnurstu.2017.02.009.

Andersen, P.A., 2011. Tactile traditions: Cultural differences and similarities in haptic communication. Handb. Touch.: Neurosci., Behav., Health Perspect. 351–369.

Ardiel, E.L., Rankin, C.H., 2010. The importance of touch in development. Paediatr. Child Health 15 (3), 153–156. https://doi.org/10.1093/pch/15.3.153.

Bai, J., Swanson, K.M., Santacroce, S.J., 2018. Observational coding systems of parent–child interactions during painful procedures: a systematic review. Pain. Pract. 18 (1), 130–145. https://doi.org/10.1111/papr.12588.

de Barbaro, K., Johnson, C.M., Forster, D., Deák, G.O., 2016. Sensorimotor decoupling contributes to triadic attention: a longitudinal investigation of mother-infant-object interactions. Child Dev. 87 (2), 494–512. https://doi.org/10.1111/cdev.12464.

Barnett, W., Hansen, C.L., Bailes, L.G., Humphreys, K.L., 2022. Caregiver-child proximity as a dimension of early experience. Dev. Psychopathol. 34 (2), 647–665. https://doi.org/10.1017/S0954579421001644.

Barr, R.G., Kramer, M.S., Boisjoly, C., McVey-White, L., Pless, I.B., 1988. Parental diary of infant cry and fuss behaviour. Arch. Dis. Child. 63 (4), 380–387. https://doi.org/10.1136/adc.63.4.380.

Beebe, B., 2006. Co-constructing mother–infant distress in face-to-face interactions: contributions of microanalysis. Infant Obs. 9 (2), 151–164. https://doi.org/10.1080/13698030600810409.

Beebe, B., 2017. My journey in infant research and psychoanalysis: microanalysis, a social microscope. Psychoanal. Psychol. 31 (1), 4–25. https://doi.org/10.1037/a0035575.

Beebe, B., Lachmann, F., 2017. Maternal self-critical and dependent personality styles and mother-infant communication. J. Am. Psychoanal. Assoc. 65 (3), 491–508. https://doi.org/10.1177/0003065117709004.

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Blatt, S., Kaminer, T., Feldstein, S., Andrews, H., 2007. Six-week postpartum maternal self-criticism and dependency and 4-month mother-infant self- and interactive contingencies. Dev. Psychol. 43 (6), 1360–1376. https://doi.org/10.1037/0012-1649.43.6.1360.

Beebe, B., Jaffe, J., Buck, K., Chen, H., Cohen, P., Feldstein, S., Andrews, H., 2008. Six-week postpartum maternal depressive symptoms and 4-month mother – infant self- and interactive contingency. Infant Ment. Health J.: Off. Publ. World Assoc. Infant Ment. Health 29 (5), 442–471. https://doi.org/10.1002/imhj.

Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., Bahrick, L., Andrews, H., Feldstein, S., 2010. The origins of 12-month attachment: a microanalysis of 4-month mother-infant interaction. Attach. Hum. Dev. 12 (1–2), 3–141. https://doi.org/10.1080/14616730903338985.

Beebe, B., Steele, M., Jaffe, J., Buck, K.A., Chen, H., Cohen, P., Kaitz, M., Markese, S., Andrews, H., Margolis, A., Feldstein, S., 2011. Maternal anxiety symptoms and mother-infant self- and interactive contingency. Infant Ment. Health J. 32 (2), 174–206. https://doi.org/10.1002/imhj.20274.

Beebe, B., Messinger, D., Bahrick, L.E., Margolis, A., Buck, K.A., Chen, H., 2016. A systems view of mother-infant face-to-face communication. Dev. Psychol. 52 (4), 556–571. https://doi.org/10.1037/a0040085.

Beebe, B., Myers, M.M., Lee, S.H., Lange, A., Ewing, J., Rubinchik, N., Andrews, H., Austin, J., Hane, A., Margolis, A.E., Hofer, M., Ludwig, R.J., Welch, M.G., 2018. Family nurture intervention for preterm infants facilitates positive mother-infant face-to-face engagement at 4 months. Dev. Psychol. 54 (11), 2016–2031. https://doi.org/10.1037/dev0000557.

Botero, M., 2016. Tactless scientists: ignoring touch in the study of joint attention. Philos. Psychol. 29 (8), 1200–1214. https://doi.org/10.1080/09515089.2016.1225293.

Botero, M., 2018. Bringing touch back to the study of emotions in human and non-human primates: a theoretical exploration. Int. J. Comp. Psychol. 31, 1–17. https://doi.org/10.46867/IJCP.2018.31.02.05.

Botero, M., Langley, H.A., & Venta, A. (2020). The untenable omission of touch in maternal sensitivity and attachment research. September 2018, 1–24. https://doi.org/10.1002/icd.2159.

Brown, C., Filion, D.L., Weiss, S.J., 2011. Measurement of tactile response and tactile perception. Handb. Touch.: Neurosci., Behav., Health Perspect. 219–244 http://ovidsp.ovid.com/ovidweb.cgi?T=JS&reference&D=psyc8&NEWS=N&AN=2011-14742-009.

Brzozowska, A., Longo, M.R., Mareschal, D., Wiesemann, F., Gliga, T., 2021. Capturing touch in parent–infant interaction: a comparison of methods. Infancy 26 (3), 494–514. https://doi.org/10.1111/infa.12394.

Burgoon, J.K., Buller, D.B., & Woodall, W.G. (1996). *Nonverbal communication: the unspoken dialogue*.

Campbell-Yeo, M.L., Disher, T.C., Benoit, B.L., Johnston, C.C., 2015. Understanding kangaroo care and its benefits to preterm infants. Pediatr. Health, Med. Ther. 6, 15–32. https://doi.org/10.2147/PHMT.S51869.

Cascio, C.J., Moore, D., McGlone, F., 2019. Social touch and human development. Dev. Cogn. Neurosci. 35, 5–11. https://doi.org/10.1016/j.dcn.2018.04.009.

Charpak, N., Ruiz, J.G., Zupan, J., Cattaneo, A., Figueroa, Z., Tessier, R., Cristo, M., Anderson, G., Ludington, S., Mendoza, S., Mokhachane, M., Worku, B., 2005. Kangaroo Mother Care: 25 Years after. Acta Paediatr., Int. J. Paediatr. 94 (5), 514–522. https://doi.org/10.1080/08035250510027381.

Chen, S.C., Yu, J., Yuen, S.C.S., Lam, J.C.S., Suen, L.K.P., Yeung, W.F., 2021. Massage therapy in infants and children under 5 years of age: protocol for an overview of systematic reviews. Systematic Reviews 10 (1), 1–9. https://doi.org/10.1186/s13643-021-01681-x.

Conde-Agudelo, A., Díaz-Rossello, J.L., 2016. Kangaroo mother care to reduce morbidity and mortality in low birthweight infants. Cochrane Database Syst. Rev. 2016 (8) https://doi.org/10.1002/14651858.CD002771.pub4.

Cordes, K., Egmose, I., Smith-Nielsen, J., Køppe, S., Væver, M.S., 2017. Maternal touch in caregiving behavior of mothers with and without postpartum depression. Infant Behav. Dev. 49, 182–191. https://doi.org/10.1016/j.infbeh.2017.09.006.

Crucianelli, L., Wheatley, L., Filippetti, M.L., Jenkinson, P.M., Kirk, E., Fotopoulou, A., 2019. The mindedness of maternal touch: An investigation of maternal mind-mindedness and mother-infant touch interactions. Dev. Cogn. Neurosci. 35, 47–56. https://doi.org/10.1016/j.dcn.2018.01.010.

Dunbar, R.I.M., 2010. The social role of touch in humans and primates: behavioural function and neurobiological mechanisms. Neurosci. Biobehav. Rev. 34 (2), 260–268. https://doi.org/10.1016/j.neubiorev.2008.07.001.

Egmose, I., Cordes, K., Smith-Nielsen, J., Væver, M.S., Køppe, S., 2018. Mutual regulation between infant facial affect and maternal touch in depressed and nondepressed dyads. Infant Behav. Dev. 50, 274–283. https://doi.org/10.1016/j.infbeh.2017.05.007.

Ellsworth, C.P., Muir, D.W., Hains, S.M.J., 1993. Social competence and person-object differentiation: an analysis of the still-face effect. Dev. Psychol. 29 (1), 63–73. https://doi.org/10.1037/0012-1649.29.1.63.

Erica, S., Carol, M., 2018. Infant Handling Among Primates. Int. J. Comp. Psychol. *31*.

Esfahani, M.S., Sheykhi, S., Abdeyazdan, Z., Jodakee, M., & Boroumandfar, K. (2013). A comparative study on vaccination pain in the methods of massage therapy and mothers' breast feeding during injection of infants referring to Navabsafavi Health Care Center in Isfahan. 18(6), 494–498.

Fairhurst, M.T., McGlone, F., Croy, I., 2022. Affective touch: a communication channel for social exchange. Curr. Opin. Behav. Sci. 43, 54–61. https://doi.org/10.1016/j.cobeha.2021.07.007.

Faust, K.M., Carouso-Peck, S., Elson, M.R., Goldstein, M.H., 2020. The origins of social knowledge in altricial species. Annu. Rev. Dev. Psychol. 2 (1), 225–246. https://doi.org/10.1146/annurev-devpsych-051820-121446.

Feldman, R., Eidelman, A.I., 2003. Skin-to-skin contact (Kangaroo Care) accelerates autonomic and neurobehavioural maturation in preterm infants. Dev. Med. Child Neurol. 45 (4), 274–281. https://doi.org/10.1111/j.1469-8749.2003.tb00343.x.

Feldman, R., Rosenthal, Z., Eidelman, A.I., 2014. Maternal-preterm skin-to-skin contact enhances child physiologic organization and cognitive control across the first 10 years of life. Biol. Psychiatry 75 (1), 56–64. https://doi.org/10.1016/j.biopsych.2013.08.012.

Ferber, S.G., 2004. The nature of touch in mothers experiencing maternity blues: the contribution of parity. Early Hum. Dev. 79 (1), 65–75. https://doi.org/10.1016/j.earlhumdev.2004.04.011.

Ferber, S.G., Feldman, R., Makhoul, I.R., 2008. The development of maternal touch across the first year of life. Early Hum. Dev. 84 (6), 363–370. https://doi.org/10.1016/j.earlhumdev.2007.09.019.

Field, T., 2010. Touch for socioemotional and physical well-being: a review. Dev. Rev. 30 (4), 367–383. https://doi.org/10.1016/j.dr.2011.01.001.

Field, T., 2014. Massage therapy research review. Complement. Ther. Clin. Pract. 20 (4), 224–229. https://doi.org/10.1016/j.ctcp.2014.07.002.

Field, T., 2016. Massage therapy research review. Complement. Ther. Clin. Pract. 24, 19–31. https://doi.org/10.1016/j.ctcp.2016.04.005.

Field, T., 2018. Infant massage therapy research review. Clin. Res. Pediatr. 1 (2), 1–9.

Field, T., 2019. Social touch, CT touch and massage therapy: a narrative review. Dev. Rev. 51, 123–145. https://doi.org/10.1016/j.dr.2019.01.002.

Field, T., 2021. Massage therapy research review. Int. J. Psychol. Res. Rev. 4, 45–45.

Field, T., Vega-Lahr, N., Scafidi, F., Goldstein, S., 1986. Effects of maternal unavailability on mother-infant interactions. Infant Behav. Dev. 9 (4), 473–478. https://doi.org/10.1016/0163-6383(86)90019-6.

Field, T., Diego, M., Hernandez-Reif, M., 2010. Preterm infant massage therapy research: a review. Infant Behav. Dev. 33 (2), 115–124. https://doi.org/10.1016/j.infbeh.2009.12.004.

Furman, L., 2017. Kangaroo mother care 20 years later: connecting infants and families. Pediatrics 139 (1). https://doi.org/10.1542/peds.2016-3332.

Geldard, F.A., 1960. Some neglected possibilities of communication. Science 131 (3413), 1583–1588. https://doi.org/10.1126/science.131.3413.1583.

Gliga, T., Farroni, T., Cascio, C.J., 2018. Social touch: a new vista for developmental cognitive neuroscience? Dev. Cogn. Neurosci. 35, 5–11. https://doi.org/10.1016/j.dcn.2018.05.006.

Góis-Eanes, M., Gonçalves, Ó.F., Caldeira-da-Silva, P., Sampaio, A., 2012. Biological and physiological markers of tactile sensorial processing in healthy newborns. Infant Ment. Health J. 33 (5), 535–542. https://doi.org/10.1002/imhj.21328.

Goldyn, D.T., Moreno, A.J., 2002. *The quality of parent-to-infant touch protocol.* Unpublished measure. University of Colorado Health Sciences,, Denver.

Gusella, J.L., Muir, D., Tronick, E.Z., 1988. The effect of manipulating maternal behavior during an interaction on three- and six- month-olds' affect and attention. Child Dev. 59 (4), 1111–1124. https://doi.org/10.2307/1130278.

Hardin, J.S., Jones, N.A., Mize, K.D., Platt, M., 2021. Affectionate touch in the context of breastfeeding and maternal depression influences infant neurodevelopmental and temperamental substrates. Neuropsychobiology 80 (2), 158–175. https://doi.org/10.1159/000511604.

Harlow, H.F., Suomi, S.J., 1970. Nature of love—simplified. Am. Psychol. 25 (2), 161.

Henrich, J., Heine, S.J., Norenzayan, A., 2010. The weirdest people in the world? Behav. Brain Sci. 33 (2–3), 61–83. https://doi.org/10.1017/S0140525×0999152X.

Hepper, P.G., 2008. Haptic perception in the human foetus. In: Grunwald, M. (Ed.), *Human Haptic Perception: Basics* and *Applications*. Springer Science & Business Media, pp. 149–154 https://doi.org/10.1007/978-3-7643-7612-3_11.

Hepper, P.G., 2015. Behavior during the prenatal period: adaptive for development and survival. Child Dev. Perspect. 9 (1), 38–43. https://doi.org/10.1111/cdep.12104.

Herrera, E., Reissland, N., Shepherd, J., 2004. Maternal touch and maternal child-directed speech: Effects of depressed mood in the postnatal period. J. Affect. Disord. 81 (1), 29–39. https://doi.org/10.1016/j.jad.2003.07.001.

Herring, F.W., 1949. Touch: the neglected sense. J. Aesthet. Art. Crit. 7 (3), 199. https://doi.org/10.2307/426662.

Hertenstein, M.J., 2002. Touch: Its communicative functions in infancy. Hum. Dev. 45 (2), 70–94. https://doi.org/10.1159/000048154.

Hertenstein, M.J., Verkamp, J.M., Kerestes, A.M., Holmes, R.M., 2006. The communicative functions of touch in humans, nonhuman primates, and rats: a review and synthesis of the empirical research. Genet., Soc., Gen. Psychol. Monogr. 132 (1), 5–94. https://doi.org/10.3200/MONO.132.1.5-94.

Hertenstein, M.J., Keltner, D., App, B., Bulleit, B.A., Jaskolka, A.R., 2006. Touch communicates distinct emotions. Emotion 6 (3), 528–533. https://doi.org/10.1037/1528-3542.6.3.528.

Hooker, D., 1952. The Prenatal Origin of Behavior. Lawrence. https://doi.org/10.1176/appi.psychotherapy.1971.25.2.316a.

Humphrey, T., Hooker, D., 1959. Double simultaneous stimulation of human fetuses and the anatomical patterns underlying the reflexes elicited. J. Comp. Neurol. 112 (1), 75–102. https://doi.org/10.1002/cne.901120110.

Jablonski, N.G., 2021. Social and affective touch in primates and its role in the evolution of social cohesion. Neuroscience 464, 117–125. https://doi.org/10.1016/j.neuroscience.2020.11.024.

Jean, A.D.L., Stack, D.M., 2009. Functions of maternal touch and infants' affect during face-to-face interactions: new directions for the still-face. Infant Behav. Dev. 32 (1), 123–128. https://doi.org/10.1016/j.infbeh.2008.09.008.

Jean, A.D.L., Stack, D.M., 2012. Full-term and very-low-birth-weight preterm infants' self-regulating behaviors during a Still-Face interaction: Influences of maternal touch. Infant Behav. Dev. 35 (4), 779–791. https://doi.org/10.1016/j.infbeh.2012.07.023.

Jean, A.D.L., Girouard, N., & Stack, D.M. (2005). The functions of touch scale. *Unpublished Manuscript*.

Jean, A.D.L., Girouard, N., Stack, D.M., 2007. The qualitative properties of maternal touch and their relationship to infant distress during a still-face procedure. Poster Presente Bienn. Meet. Soc. Res. Child Dev.

Jean, A.D.L., Stack, D.M., Fogel, A., 2009. A longitudinal investigation of maternal touching across the first 6 months of life: age and context effects. Infant Behav. Dev. 32 (3), 344–349. https://doi.org/10.1016/j.infbeh.2009.04.005.

Jean, A.D.L., Stack, D.M., Arnold, S., 2014. Investigating maternal touch and infants' self-regulatory behaviours during a modified face-to-face Still-Face with Touch procedure. Infant Child Dev. 23 (6), 557–574. https://doi.org/10.1002/icd.

Johnston, C., Campbell-Yeo, M., Disher, T., Benoit, B., Fernandes, A., Streiner, D., Inglis, D., Zee, R., 2017. Skin-to-skin care for procedural pain in neonates. Cochrane Database Syst. Rev. 2017 (2) https://doi.org/10.1002/14651858.CD008435.pub3.

Kennell, J.H., Jerauld, R., Wolfe, H., Chester, D., Kreger, N.C., McAlpine, W., Steffa, M., Klaus, M.H., 1974. Maternal behavior one year after early and extended post-partum contact. Dev. Med. Child Neurol. 16 (2), 172–179. https://doi.org/10.1111/j.1469-8749.1974.tb02738.x.

Kennell, J.H., Trause, M.A., Klaus, M.H., 1975. Evidence for a sensitive period in the human mother. Ciba Found. Symp. . Issue 33 https://doi.org/10.1002/9780470720158.ch6.

Klaus, M.H., Kennell, J.H., 1976. Maternal-infant bonding: the impact of early separation or loss on family development. In: Journal of Nurse-Midwifery, Vol. 2. MO: CV Mosby Company, pp. 16–17.

Klaus, M.H., Jeraulds, R., Kreger, N.C., McAlpine, W., Steffa, M., Kennell, J.H., 1972. Importance of the first post-partum days. N. Engl. J. Med. 286 (9), 460–463.

Koester, L.S., 2000. Tactile contact by deaf and hearing mothers during face-to-face interactions with their infants. J. Deaf Stud. Deaf Educ. 5 (2), 127–139. https://doi.org/10.1093/deafed/5.2.127.

Koester, L.S., & Paradis, G. (2010). Caregiver touch coding system. Unpublished manuscript. University of Montana, Missoula.

Kostandy, R.R., Ludington-Hoe, S.M., 2019. The evolution of the science of kangaroo (mother) care (skin-to-skin contact). Birth Defects Res. 111 (15), 1032–1043 http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L2002486101%0Ahttps://doi.org/10.1002/bdr2.1565.

Koukounari, A., Pickles, A., Hill, J., Sharp, H., 2015. Psychometric properties of the parent-infant caregiving touch scale. Front. Psychol. *6*. https://doi.org/10.3389/fpsyg.2015.01887.

Lam, J., Barr, R.G., Catherine, N., Tsui, H., Hahnhaussen, C.L., Pauwels, J., Brant, R., 2010. Electronic and paper diary recording of infant and caregiver behaviors. J. Dev. Behav. Pediatr. 31 (9), 685–693. https://doi.org/10.1097/DBP.0b013e3181e416ae.

Lamb, M.E., Malkin, C.M., 1986. The development of social expectations in distress-relief sequences: a longitudinal study. Int. J. Behav. Dev. 9 (2), 235–249. https://doi.org/10.1177/016502548600900207.

Leiba, E. (2000). *Maternal nonverbal behaviours and infant gaze during triadic play with toys at 5 and 12 months*. [Doctoral dissertation, Concordia University]. ProQuest Dissertations and Theses.

Li-Chin, L., Shao-Huan, L., Yen-Ping, H., Long-Yau, L., Jong-Chen, C., Shou-Jen, L., 2020. Massage therapy for weight gain in preterm neonates: A systematic review and meta-analysis of randomized controlled trials. Complementary Therapies in Clinical Practice 39.

Lotzin, A., Lu, X., Kriston, L., Schiborr, J., Musal, T., Romer, G., Ramsauer, B., 2015. Observational tools for measuring parent–infant interaction: A systematic review. Clin. Child Fam. Psychol. Rev. 18 (2), 99–132. https://doi.org/10.1007/s10567-015-0180-z.

Lourenço, V., Coutinho, J., Pereira, A.F., 2021. Advances in microanalysis: Magnifying the social microscope on mother-infant interactions. Infant Behav. Dev. *64*. https://doi.org/10.1016/j.infbeh.2021.101571.

Lowe, J.R., Coulombe, P., Moss, N.C., Rieger, R.E., Aragón, C., MacLean, P.C., Caprihan, A., Phillips, J.P., Handal, A.J., 2016. Maternal touch and infant affect in the Still Face Paradigm: a cross-cultural examination. Infant Behav. Dev. 44, 110–120. https://doi.org/10.1016/j.infbeh.2016.06.009.

Mantis, I., Stack, D.M., 2018. The functions of mutual touch in full-term and very low-birthweight/preterm infant-mother dyads: associations with infant affect and emotional availability during face-to-face interactions. Int. J. Comp. Psychol. 31, 1–24. https://doi.org/10.46867/IJCP.2018.31.02.04.

Mantis, I., Burnside, K., & Stack, D.M. (2013). *Functions of mother-infant mutual touch scale*. Unpublished document, Concordia University, Montreal, Quebec, Canada.

Mantis, I., Stack, D.M., Ng, L., Serbin, L.A., Schwartzman, A.E., 2014. Mutual touch during mother-infant face-to-face still-face interactions: Influences of interaction period and infant birth status. Infant Behav. Dev. 37 (3), 258–267. https://doi.org/10.1016/j.infbeh.2014.04.005.

Mantis, I., Mercuri, M., Stack, D.M., Field, T.M., 2019. Depressed and non-depressed mothers' touching during social interactions with their infants. Dev. Cogn. Neurosci. 35, 57–65. https://doi.org/10.1016/j.dcn.2018.01.005.

Mariani Wigley, I.L.C., Mascheroni, E., Fontana, C., Giorda, R., Morandi, F., Bonichini, S., McGlone, F., Fumagalli, M., Montirosso, R., 2021. The role of maternal touch in the association between SLC6A4 methylation and stress response in very preterm infants. Dev. Psychobiol. 63 (S1) https://doi.org/10.1002/dev.22218.

Marx, V., Nagy, E., 2015. Fetal behavioural responses to maternal voice and touch. PLoS ONE 10 (6), 1–15. https://doi.org/10.1371/journal.pone.0129118.

Marx, V., Nagy, E., 2017. Fetal behavioral responses to the touch of the mother's abdomen: a frame-by-frame analysis. Infant Behav. Dev. 47, 83–91. https://doi.org/10.1016/j.infbeh.2017.03.005.

McGann, J.P., 2017. Poor human olfaction is a nineteenth century myth. Science 356 (6338), 1–17.

McGlone, F., Spence, C., 2010. The cutaneous senses: touch, temperature, pain/itch, and pleasure. Neurosci. Biobehav. Rev. 34 (2), 145–147. https://doi.org/10.1016/j.neubiorev.2009.08.008.

Mercuri, M., Stack, D.M., Trojan, S., Giusti, L., Morandi, F., Mantis, I., Montirosso, R., 2019. Mothers' and fathers' early tactile contact behaviors during triadic and dyadic parent-infant interactions immediately after birth and at 3-months postpartum: Implications for early care behaviors and intervention. Infant Behav. Dev. *57*. https://doi.org/10.1016/j.infbeh.2019.101347.

Mesman, J., van IJzendoorn, M.H., Bakermans-Kranenburg, M.J., 2009. The many faces of the Still-Face Paradigm: A review and meta-analysis. Developmental Review 29 (2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001.

Moberg, K.U., Handlin, L., Petersson, M., 2020. Neuroendocrine mechanisms involved in the physiological effects caused by skin-to-skin contact – with a particular focus on the oxytocinergic system. Infant Behav. Dev. 61 (July) https://doi.org/10.1016/j.infbeh.2020.101482.

Montagu, A., 1983. The Neglected Sense. Sciences 23 (4), 60–61. https://doi.org/10.1002/j.2326-1951.1983.tb02638.x.

Montagu, A., 1986. Touching: The human significance of the skin. Harper & Row.

Moore, E.R., Bergman, N., Anderson, G.C., Medley, N., 2016. Early skin-to-skin contact for mothers and their healthy newborn infants. Cochrane Database Syst. Rev. 2016 (11) https://doi.org/10.1002/14651858.CD003519.pub4.

Moreno, A.J., Posada, G.E., Goldyn, D.T., 2006. Presence and quality of touch influence coregulation in mother-infant dyads. Infancy 9 (1), 1–20. https://doi.org/10.1207/s15327078in0901_1.

Moszkowski, R.J., Stack, D.M., 2007. Infant touching behaviour during mother-infant face-to-face interactions. Infant and Child Development 16 (3), 307–319. https://doi.org/10.1002/icd.510.

Moszkowski, R.J., Stack, D.M., Chiarella, S.S., 2009. Infant touch with gaze and affective behaviors during mother-infant still-face interactions: co-occurrence and functions of touch. Infant Behav. Dev. 32 (4), 392–403. https://doi.org/10.1016/j.infbeh.2009.06.006.

Moszkowski, R.J., Stack, D.M., Girouard, N., Field, T.M., Hernandez-Reif, M., Diego, M., 2009. Touching behaviors of infants of depressed mothers during normal and perturbed interactions. Infant Behavior and Development 32 (2), 183–194. https://doi.org/10.1016/j.infbeh.2008.12.009.

Mrljak, R., Danielsson, A.A., Hedov, G., Garmy, P., 2022. Effects of infant massage: a systematic review. Int. J. Environ. Res. Public Health 19 (11). https://doi.org/10.3390/ijerph19116378.

Myers, B.J., 1984. Mother-infant bonding: rejoinder to Kennell and Klaus. Dev. Rev. 4 (3), 283–288. https://doi.org/10.1016/S0273-2297(84)80009-X.

Norholt, H., 2020. Revisiting the roots of attachment: a review of the biological and psychological effects of maternal skin-to-skin contact and carrying of full-term infants. Infant Behav. Dev. 60 (July 2019) https://doi.org/10.1016/j.infbeh.2020.101441.

Olausson, W., Cole, J., Mcglone, F., Elam, M., Rylander, K., Wessberg, J., & Bushnell, M. C. (2008). Neuroscience Letters Unmyelinated tactile afferents have opposite effects on insular and somatosensory cortical processing. 436, 128–132. https://doi.org/10.1016/j.neulet.2008.03.015.

Ouzzani, M., Hammady, H., Fedorowicz, Z., Elmagarmid, A., 2016. Rayyan-a web and mobile app for systematic reviews. Syst. Rev. 5 (1), 1–10. https://doi.org/10.1186/s13643-016-0384-4.

Pados, B.F., McGlothen-Bell, K., 2019. Benefits of infant massage for infants and parents in the NICU. Nurs. Women's Health 23 (3), 265–271.

Paez, A., 2017. Gray literature: an important resource in systematic reviews. J. Evid. -Based Med. 10 (3), 233–240. https://doi.org/10.1111/jebm.12266.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., Moher, D., 2021. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ *372*. https://doi.org/10.1136/bmj.n71.

Paradis, G., Koester, L.S., 2015. Emotional availability and touch in deaf and hearing dyads. Am. Ann. Deaf 160 (3), 303–315. https://doi.org/10.1353/aad.2015.0026.

Peláez-Nogueras, M., Gewirtz, J.L., Field, T., Cigales, M., Malphurs, J., Clasky, S., Sanchez, A., 1996. Infants' preference for touch stimulation in face-to-face interactions. J. Appl. Dev. Psychol. 17 (2), 199–213. https://doi.org/10.1016/S0193-3973(96)90025-8.

Peláez-Nogueras, M., Field, T., Gewirtz, J.L., Cigales, M., Gonzalez, A., Sanchez, A., Richardson, S.C., 1997. The effects of systematic stroking versus tickling and poking on infant behavior. J. Appl. Dev. Psychol. 18 (2), 169–178. https://doi.org/10.1016/S0193-3973(97)90034-4.

Polan, H.J., Ward, M.J., 1994. Role of the mother's touch in failure to thrive: a preliminary investigation. J. Am. Acad. Child Adolesc. Psychiatry 33 (8), 1098–1105. https://doi.org/10.1097/00004583-199410000-00005.

Potgieter, K.L., Adams, F., 2019. The influence of mother-infant skin-to-skin contact on bonding and touch. South Afr. J. Occup. Ther. 49 (2), 11–17. https://doi.org/10.17159/2310-3833/2019/vol49n2a3.

Provenzi, L., Rosa, E., Visintin, E., Mascheroni, E., Guida, E., Cavallini, A., Montirosso, R., 2020. Understanding the role and function of maternal touch in children with neurodevelopmental disabilities. Infant Behav. Dev. *58*. https://doi.org/10.1016/j.infbeh.2020.101420.

Rad, M.S., Martingano, A.J., Ginges, J., 2018. Toward a psychology of Homo sapiens: making psychological science more representative of the human population. Proc. Natl. Acad. Sci. USA 115 (45), 11401–11405. https://doi.org/10.1073/pnas.1721165115.

Reece, C., Ebstein, R., Cheng, X., Ng, T., Schirmer, A., 2016. Maternal touch predicts social orienting in young children. Cogn. Dev. 39, 128–140. https://doi.org/10.1016/j.cogdev.2016.05.001.

Saarinen, A., Harjunen, V., Jasinskaja-Lahti, I., Jääskeläinen, I.P., Ravaja, N., 2021. Social touch experience in different contexts: a review. Neurosci. Biobehav. Rev. 131, 360–372. https://doi.org/10.1016/j.neubiorev.2021.09.027.

Schatz, J., Suarez-Rivera, C., Kaplan, B., Linn, E., Tamis-LeMonda, C.S., 2020. Playing and learning together: Spontaneous joint engagement scaffolds infant play at home. Virtual International Congress of Infants Studies, pp. 117–118.

Serra, J., Miguel, H., Moura, A.A., Sampaio, A., Pereira, A.F., 2020. The effect of play task on maternal touch patterns when interacting with their 12 months-old infants: an exploratory study. Infant Behav. Dev. 59 (March), 101438 https://doi.org/10.1016/j.infbeh.2020.101438.

Sorokowska, A., Saluja, S., Sorokowski, P., Frąckowiak, T., Karwowski, M., Aavik, T., Akello, G., Alm, C., Amjad, N., Anjum, A., Asao, K., Atama, C.S., Atamtürk Duyar, D., Ayebare, R., Batres, C., Bendixen, M., Bensafia, A., Bizumic, B., Boussena, M., Croy, I., 2021. Affective interpersonal touch in close relationships: a cross-cultural perspective. Personal. Soc. Psychol. Bull. 47 (12), 1705–1721. https://doi.org/10.1177/0146167220988373.

Stack, D.M., 2001. The salience of touch and physical contact during infancy: Unraveling some of the mysteries of the somesthetic sense. In: Bremner, J.G., Fogel, A. (Eds.), Blackwell Handbook of Infant Development. Blackwell Publishing, pp. 351–378. https://doi.org/10.1002/9780470996348.ch13.

Stack, D.M., 2004. Touching during mother-infant interactions. In: Tiffany Field (Ed.), Touch and massage in Early Child Development. Johnson & Johnson Pediatric Institute, pp. 49–82 https://doi.org/Artn 84173l\rDoi 10.1117/12.976030.

Stack, D.M., Arnold, S.L., 1998. Changes in mothers' touch and hand gestures influence infant behavior during face-to-face interchanges. Infant Behav. Dev. 21 (3), 451–468. https://doi.org/10.1016/s0163-6383(98)90019-4.

Stack, D.M., Jean, A.D., 2011. Communicating through touch: touching during parent–infant interactions. Handb. Touch.: Neurosci., Behav., Health Perspect. 273–298.

Stack, D.M., LePage, D.E., 1996. Infants' sensitivity to manipulations of maternal touch during face-to-face interactions. Soc. Dev. 5 (1), 41–55. https://doi.org/10.1111/j.1467-9507.1996.tb00071.x.

Stack, D.M., Muir, D.W., 1990. Tactile stimulation as a component of social interchange: New interpretations for the still-face effect. Br. J. Dev. Psychol. 8 (2), 131–145. https://doi.org/10.1111/j.2044-835x.1990.tb00828.x.

Stack, D.M., Muir, D.W., 1992. Adult tactile stimulation during face-to-face interactions modulates five-month-olds' affect and attention. Child Dev. 63 (6), 1509–1525. https://doi.org/10.1111/j.1467-8624.1992.tb01711.x.

Stack, D.M., LePage, D.E., Hains, S., Muir, D.W., 1996. Qualitatitive changes in maternal touch as a function of instructional condition during face-to-face social interactions. Infant Behav. Dev. 19, 761. https://doi.org/10.1016/S0163-6383(96)90815-2.

Stefana, A., Lavelli, M., 2017. Parental engagement and early interactions with preterm infants during the stay in the neonatal intensive care unit: protocol of a mixed-method and longitudinal study. BMJ Open 7 (2). https://doi.org/10.1136/bmjopen-2016-013824.

Stepakoff, S.A., 1999. Mother-infant tactile communication at four months: Effects of infant gender, maternal ethnicity, and maternal depression. [Doctoral dissertation, St. John's University, New York, NY], Ovid.

Suarez-Rivera, C., Smith, L.B., Yu, C., 2019. Multimodal parent behaviors within joint attention support sustained attention in infants. Dev. Psychol. 55 (1), 96–109. https://doi.org/10.1037/dev0000628.

Tanaka, Y., Kanakogi, Y., Myowa, M., 2021. Social touch in mother–infant interaction affects infants' subsequent social engagement and object exploration. Humanit. Soc. Sci. Commun. 8 (1), 1–11. https://doi.org/10.1057/s41599-020-00642-4.

The EndNote Team. (2013). *EndNote 20* (p. 2503). Clarivate.

Tronick, E., Als, H., Adamson, L., Wise, S., Brazelton, T.B., 1978. The infant's response to entrapment between contradictory messages in face-to-face interaction. J. Am. Acad. Child Psychiatry 17 (1), 1–13. https://doi.org/10.1016/S0002-7138(09)62273-1.

Tronick, E.Z., 1995. Touch in early development. Touch Mother-Infant Interact. 53–65.

Trotter, P.D., McGlone, F., Reniers, R.L.E.P., Deakin, J.F.W., 2018. Construction and Validation of the Touch Experiences and Attitudes Questionnaire (TEAQ): A Self-report Measure to Determine Attitudes Toward and Experiences of Positive Touch. Journal of Nonverbal Behavior 42 (4), 379–416. https://doi.org/10.1007/s10919-018-0281-8.

Weiss, S.J., 1992. Measurement of the sensory qualities in tactile interaction. Nurs. Res. 41 (2), 82–86. https://doi.org/10.1097/00006199-199203000-00005.

Weiss, S.J., 2000. *Tactile Interaction Index: Manual and Coding Guidelines.* [Unpublished Manual]. University of California, San Francisco.

Weiss, S.J., Campos, R., 1999. Touch. Fundam. Contemp. Nurs. Pract. 941–962.

Weiss, S.J., Goebel, P.W., 2003. Parents' touch of their preterm infants and its relationship to their state of mind regarding touch. J. Prenat. Perinat. Psychol. Health 17 (3), 185–202.

Weiss, S.J., Niemann, S.K., 2011. Measurement of touch behavior. Handb. Touch.: Neurosci., Behav., Health Perspect. 245–270.

Weiss, S.J., Wilson, P., Hertenstein, M.J., Campos, R., 2000. The tactile context of a mother's caregiving: Implications for attachment of low birth weight infants. Infant Behav. Dev. 23 (1), 91–111. https://doi.org/10.1016/S0163-6383(00)00030-8.

Weiss, S.J., Wilson, P., Seed, M.S.J., Paul, S.M., 2001. Early tactile experience of low birth weight children: links to later mental health and social adaptation. Infant Child Dev. 10 (3), 93–115. https://doi.org/10.1002/icd.236.

Weiss, S.J., Wilson, P., Morrison, D., 2004. Maternal tactile stimulation and the neurodevelopment of low birth weight infants. Infancy 5 (1), 85–107. https://doi.org/10.1207/s15327078in0501_4.

Wilhelm, F.H., Kochar, A.S., Roth, W.T., Gross, J.J., 2001. Social anxiety and response to touch: Incongruence between self-evaluative and physiological reactions. Biol. Psychol. 58 (3), 181–202. https://doi.org/10.1016/S0301-0511(01)00113-2.

World Health Organization, 2022. WHO recommendations for care of the preterm or low-birth-weight infant. *World Health Organ.* 1–123. ⟨https://apps.who.int/iris/handle/10665/363697⟩.

Silvia, G. (2011). *Emotional availability and touch among deaf and hearing mother-infant dyads.* [Doctoral dissertation, University of Montana]. ProQuest Dissertations and Theses.

Stack, D.M., LePage, D.E., Hains, S.M.J., & Muir, D.W. (2001). *Differential touch as a function of instruction during mother-infant interactions: Application of the caregiver-infant touch scale (CITS)*. Unpublished manuscript, Concordia University.

Yu, C., & Smith, L.B. (2013). Joint Attention without Gaze Following: Human Infants and Their Parents Coordinate Visual Attention to Objects through Eye-Hand Coordination. 8(11). https://doi.org/10.1371/journal.pone.0079659.