A Longitudinal Characterization of Typical Laughter Development in Mother–Child Interaction from 12 to 36 Months: Formal Features and Reciprocal Responsiveness

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A Longitudinal Characterization of Typical Laughter Development in Mother–Child Interaction from 12 to 36 Months: Formal Features and Reciprocal Responsiveness

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Abstract
Laughter is a valuable means for communicating and engaging in interaction since the earliest months of life. Nevertheless, there is a dearth of work on how its use develops in early interactions—given its putative reflexive nature, it has often been disregarded from studies on pre-linguistic vocalizations. We provide a longitudinal characterization of laughter use analyzing interactions of 4 babies with their mothers at five time-points (12, 18, 24, 30, and 36 months). We show how child laughter is very distinct from mothers' (and adults' generally), in terms of frequency, duration, level of arousal displayed, overlap with speech, and responsiveness to others' laughter. Notably, contrary to what might be expected, we observed that children laugh significantly less than their mothers, especially at the first time-points analyzed. We indeed observe an increasing developmental trajectory in the production of laughter overall and in the contingent multimodal response to mothers' laughter, showing the child's increasing attunement to the social environment, interest in others' appraisals and mental states, and awareness of its communicative value. We also show how mothers' contingent responses to child laughter change over time, going from high-frequency mimicry, to a lower rate of diversified multimodal responses, in line with the child's neuro-psychological development. Our data support a dynamic view of dialogue where interactants influence each other bidirectionally and emphasizes the crucial communicative value of laughter. When language is not fully developed, laughter might be an early means, in its already fully available expressiveness, to hold the conversational turn and enable meaningful vocal contribution in interaction at the same level of the interlocutor. Our study aims to provide a benchmark for typical laughter development, since we believe it can be an early means, along with other commonly analyzed behaviors (e.g., smiling, gazing, pointing, etc.), to gain insight into early child neuro-psychological development.

Keywords Laughter · Mother–child interaction · Pragmatic development · Mimicry · Multi-modal maternal responsiveness

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Introduction

Laughter is one of the earliest means a child has to engage in conversation, emerging around 3-months of age (Nwokah et al., 1994), long before gesture, language, or walking, and slowly developing to reach adult pragmatically sophisticated competence (Mazzocconi et al., 2020). Rather than being a reflex behavior, laughter, both in production and perception, can tell us a lot about the neuro-cognitive development of babies and their attunement to the social and cultural environment (Mireault & Reddy, 2016). From very early on, laughter is a valuable means for participating in conversation, disclosing and understanding mental states (Hoicka & Gattis, 2008), and conveying meaning (Ginzburg et al., 2020). But while much is known about the early development of other vocalizations in mother-child interaction (especially speech-like vocalizations), both in terms of phonetics, timing, and functions (e.g., Bloom et al., 1993; Goldstein et al., 2003, 2009; Leonardi et al., 2016; Rączaszek-Leonardi et al., 2013), laughter has often been disregarded given its putative reflex-like nature (e.g.,Hsu & Fogel, 2001; Leonardi et al., 2016). Indeed very little is known about its development during the first years of life (but see Fogel et al., 1997; Hsu et al., 1998; Nwokah et al., 1994).

In order to fill this gap, we conducted a longitudinal corpus study analyzing laughter use in natural mother-child interaction from 12 to 36 months. As far as analyzing laughter goes, building on previous work, we consider laughter to be a much more complex behavior than a reflex and a valuable means to allow early participation and exchange both to children and parents (Fogel et al., 1997; Mireault & Reddy, 2016). Moreover, we take as a basic starting point the view that laughter in interaction has propositional content (Ginzburg et al., 2020). In the current work, we focus exclusively on formal aspects of laughter production over time (occurrences, duration, positioning in relation to speech and arousal) and on the responsiveness to the partner's laughter (laughter mimicry and other multi-modal behavioral responses to laughter). Given this, the semantic and pragmatic aspects of laughter in early interactions will not be our focus (these will be discussed in detail in a forthcoming paper). Nonetheless, as will become clear, the assumption that laughter has propositional content will be crucial for the interpretation of the data and discussion. Above all, because it implies that by laughing, children are contributing such content to the conversation.

The paper is structured as follows: we start with a literature review that motivates our interest in investigating the use of laughter in development, grounded in developmental literature, in the "Background" section. We present the longitudinal corpus study we conducted stating explicitly our research questions in the section titled "The Current Study". We explain the methodology applied ("Method" section), report our results ("Results" section), and discuss them in relation to the literature available ("Discussion" section). We conclude the paper with a discussion of how the changes observed over time in child laughter can be informative about the neuro-psychological development of children. Conversely, we also consider how the changes in mothers' responsiveness to child laughter over time highlight the important communicative and meaningful role that laughter has in conversation since the earliest interactions. Finally, we discuss the limitations of the current study and suggest ways of extending the current research ("Conclusion and Future Work" section).

Background: Why Laughter in Development?

Laughter as a Means for Early Participation in Interactions

Laughter emerges around the third month of life (Nwokah et al., 1994; Sroufe & Wunsch, 1972), enabling some of the first vocal nonverbal engaging and rewarding social interactions (Reddy, 2001, 2008). According to Ekman and Friesen (1975), laughter emerges as an unconscious vocalization reflex to a positive inner-state and, through the modeling and influence of the environment (Argyle, 1988; Malatesta & Haviland, 1982), it becomes an important and varied form of nonverbal communication, one that is, crucially, social in its nature (Kenderdine, 1931; Kohler, 2008; Nelson, 2012), showing important audience effects both in adults (Fridlund, 1991; Young & Frye, 1966) and children (Addyman et al., 2018; Chapman, 1973). Infants, contrary to their use of other nonverbal vocalizations, such as crying, laugh only when the caregiver is present (Bowlby, 1969; Nelson, 2012).

Like other vocalizations produced in the first months of life, it is a means to practice with turn-taking (Hilbrink et al., 2015; Stevenson et al., 1986) and engage in the first reciprocal communicative exchanges. What is particularly special about laughter is that it is a vocalization typically involving positive affect, which induces the same effect in the partner (Bachorowski & Owren, 2001; Owren & Bachorowski, 2003; Patterson, 1976, 1985). Voiced sounds like laughter are important transmitters of changes in affective status that have a crucial role in the elicitation and maintenance of social play interactions (Fogel, 1982, 1990), signaling recognition and positive appreciation of the caregiver's behavior. From this perspective, laughter emergence in children is also an important signal for the adult, who will begin to feel notably more engaged and prone to engage in interaction, and to maintain it (Reddy, 2008; Wilkie & Saxton, 2010).

Laughter, emerging around the third month of life, is therefore one of the first means available to children to attract attention, contribute to the conversation, respond, express meaning, and create a frame in the interaction that assures the partner of recognition of their behaviors (Apte, 1985; Collis, 1985). This allows children to have their first exchange with adults on a more or less equal footing. It could therefore constitute one of the earliest means of setting off the dynamic circle of meaning construction and social coordination as described in Fusaroli and Tylén (2012) (see Ginzburg et al., 2020, for a detailed account of how laughter contributes propositional content to dialogical moves in a manner akin to speech).

Laughter and Children's Neuro-psychological Development

Laughter can give us deep insights into the neuro-psychological development of babies, and at the same time, it is a special means to support and foster it under several perspectives. Studying in which contexts and in relation to which objects baby laughter is produced can tell us about their cognitive development (Martin, 2010; McGhee, 1979; Piaget, 1945), as well as about their social and cultural attunement to the environment (Mireault & Reddy, 2016). Laughter is most often related to the appraisal of an incongruity, either conceptual or related to sociocultural conventions and intentions, which require cognitive learning and attunement to the environment to be grasped (Reddy, 2001). Moreover, laughter can be used by children very early on as an attentional attractor (Stevenson et al., 1986), first towards the self, and subsequently towards external targets (similarly to

pointing, Tomasello et al., 1994). Many researchers have argued that the ability to direct others' attention in order to establish shared attention is the first stage for the development of Theory of Mind abilities, implying early awareness of others' mental states (Baron-Cohen, 1989, 1997; Camaioni, 1992; Charman et al., 2000; Tomasello et al., 1995), which has been found to correlate with later language abilities (Carpenter, Nagell, et al., 1998; Mundy et al., 1990). Laughter might therefore be an early valuable means, emerging already around the third month of life, to discover that others' attentional states can be influenced and to support the establishment of the first episodes of shared attention.

Furthermore, Hoicka and Gattis (2008) showed that laughter is used by babies as a cue of non-literal intention, namely humourous ones, already by 25 months: later than distinguishing intentional actions from mistakes (14–18 months, Carpenter, Akhtar, et al., 1998), but earlier than discriminating intentions to pretend from sincere intentions (36 months, Rakoczy et al., 2004), and intentions to lie (over 5-years, Sullivan et al., 1995). Based on Hoicka and Gattis (2008)'s results, it seems that understanding humorous intentions may be the first step in understanding that one can aim to do the wrong thing, which is, in turn. the basis for bootstrapping the successive abilities to understand pretence (Reddy, 1991, 2001). Humor, of course, is not the only situation for which special attunement to others' mental states and rich pragmatic reasoning is needed. What is special about humor is its early emergence and, in its first forms, its relative simplicity and rewarding accessibility (Bekinschtein et al., 2011; Hoicka et al., 2008).

Laughter therefore plays an important role in helping children discriminate between intentions. It discloses explicitly mental states that are most commonly left implicit in our interactions (Papafragou et al., 2007; Steglich-Petersen & Michael, 2015), and, when produced in relation to different kinds of incongruities, it informs us that the underlying conceptual or sociocultural scripts have been grasped. Looking at laughter production and at the response to another person's laughter can therefore tell us a lot about the neuropsychological development of babies from a pragmatic and social-cognition perspective, hence our particular interest in characterizing its development and use in interaction since the earliest years.

Laughter in Mother–child Interaction: Occurrence, Duration, Arousal, and Speech-laughter

While laughter has received attention from a wide range of researchers—it is present, for instance, in many of Piaget's observations (Piaget, 1945)—systematic studies on laughter development are sparse. There have been studies on laughter phonetics and acoustics in infants (Kret et al., 2021; Sauter et al., 2018) and studies looking at the relationship between child smile and laughter production and several mother characteristics such as personality traits, parenting, and attachment styles (e.g., Bridgett et al., 2013; Malatesta et al., 1989; Washburn et al., 1972). All these studies yield important insights into laughter evolution and the crucial role that laughter has for the development of a baby. Nevertheless, little work has been carried out about laughter development longitudinally, looking at laughter use in interaction over time. One of the few exceptions we are aware of is the study conducted by Nwokah et al. (1994). They observed laughter in mother-infant interaction during the first and second year of life (from 1 to 24 months of age), analyzing frequency, duration, onset and offset timing, and the correlation of children's parameters with those of the mothers. Their study was conducted in a laboratory setting, with children coming to a playroom and mothers asked to interact naturally with them: in a first session holding

the baby on the lap to encourage face to face interaction with no prompts (5 min), and in a second session playing on a carpet with pre-selected age-appropriate toys (around 8 min). Nwokah et al. (1994) observed that mothers laugh significantly more frequently than their children at all time points. They found relatively constant timing parameters in mothers, but clear changes in children during the first year, and observed a correlation in the rate of laughter between mother and child from the second year. In a second study (Nwokah et al., 1999), they then focused on the production of speech-laughter in child-directed speech, and they observed that on average 50% of the laughs produced by mothers were speech-laughter (laughter overlapping with speech from the laugher herself), though this exhibits a very high level of variability (from 5 to 50% of laughter occurrences). In the current work, we focus on some of the same variables considered by Nwokah et al., (1994, 1999), i.e., number of occurrences, duration, positioning in relation to speech (speech-laughter), adding also the level of arousal perceived. The aim is to explore whether similar patterns are observed in natural ecological contexts (as compared to lab settings) and how things evolve during the third year of life, therefore shifting the window of observation from 1–24 months (in Nwokah et al., 1994) to 12–36 months (in the current work).

Laughter Mimicry and Multimodal Responsiveness in Mother–Child Interaction

Mother and child reciprocal mimicry[1] and alignment more generally have been the object of in-depth study for facial expressions, nonverbal vocalizations, phonological, lexical, and syntactic structures (e.g.,Dale & Spivey, 2006; Fernández & Grimm, 2014; Misiek et al., 2020; Yurovsky et al., 2016). Mother responsiveness more generally, being not only related to pure mimicry, has also been the object of scrutiny. The role of contingent responsiveness to child behavior is recognized as very important for the neuro-psychological development of the babies, useful for the establishment of meaningful interaction and meaning construction, and predictive of successive child positive outcomes (Bornstein & Manian, 2013; Bornstein et al., 2008; Denby & Yurovsky, 2019; Nomikou et al., 2013).

Despite the fact that laughter is a vocalization that emerges very early on, and hence is crucial since the first interactions (see previous subsections), very little work is available on the mimicry and responsiveness to laughter during the first years of life. Laughter has been often disregarded—viewed as a non–speech-like vocalization and deemed to be a reflex-like behavior (e.g., Hsu & Fogel, 2001; Leonardi et al., 2016). In the Encyclopedia of Infant and Early Childhood Development (Pedroso, 2008) a "reflex is defined as an involuntary motor response, secretory or vascular, elicited shortly after a stimulus, which may be conscious or not. The response to the stimulus is unalterable, it cannot be changed or adapted according to needs or circumstances. It can be concluded, thus, that the response is stereotyped and has a fixed reflex arc, whose response is also fixed." Laughter does not satisfy these criteria: it is in fact, a behavior that undergoes development, being highly influenced by contextual factors (e.g., audience effect, Addyman et al., 2018; Young & Frye, 1966).

There are only two studies we are aware of focusing on laughter mimicry and overall behavioral responsiveness in children: Nwokah et al. (1994) and Reddy et al. (2002).

[1] In the current paper, by the term *mimicry* we mean the production of a behavior shortly after the partner that is type identical in certain dimensions, as used in Mayo and Gordon (2020) and El Haddad et al. (2019), and reviewed in Chartrand and Lakin (2013).

Nwokah et al. (1994) observe the production of laughter in response to a partner's laughter (*reciprocal*: with no overlap with the partner's laughter) or concomitant (*coactive*: with overlap with the partner's laughter). They observe that, contrary to what they expected, most of the laughs are actually neither reciprocal nor coactive (therefore produced in isolation, at least 4 seconds apart from a previous laughter) both in children and mothers. They observed changes both in the first and in the second year, with mothers most commonly laughing before the child during the first year, but, by contrast, most commonly laughing after the child during the second year. Notably, different temporal sequences in relation to other's laughter can convey different meanings or at least trigger different interpretations in the interactants. Nwokah et al. (1994) proposed some effective "translations" of different kinds of laughter: an isolated laughter (*non-dyadic*) could mean "This is fun!" while a shared laughter, produced in response to another (*antiphonal* or *dyadic*; Nwokah et al., 1994; Smoski & Bachorowski, 2003) says "If you find it funny so do I". In teasing, moreover, the child actually "plays" with his/her meta-representations of others' mental states, and a laugh in this context (*contrary affective situation*) can mean: "I love when you look shocked as long as you are not really angry" (Nwokah et al., 1994).

Reddy et al. (2002) conducted a study comparing laughter behavior in children affected by Down's Syndrome (mean age 3.4 ± 12 months) and autistic children (mean age y/o ± 9 months). There was no significant difference in the frequency of laughter in daily life, but autistic children showed significantly lower interest in and response to others' laughter (look, smile, laugh). Atypicalities in laughter use, multi-modal responsiveness, and orientation to laughter have been found in autistic children. Hence, we thought it would be useful to include this variable in our study that targets younger neuro-typically developing children in order to set a benchmark as to what would be the early typical development of responsiveness to caregivers' laughter.

The Current Study

With the current study, we aim to provide a characterization of laughter use in typical development from 12 to 36 months in what concerns some formal characteristics of laughter (frequency, duration, arousal, positioning in relation to speech) and responsiveness to others' laughter in ecological mother-child interactions in a familiar environment. The seminal paper by Nwokah et al. (1994) is based on a corpus collected in laboratory setting up to the age of 24 months, while the data from Reddy et al. (2002) analyzing responses to the partner's laughter (around 4 years of age) are related to clinical populations and do not track responsiveness longitudinally. We aim, therefore, to study laughter with the same level of detail and attention that has been devoted to other speech-like vocalizations. We provide, what is to our knowledge, the first longitudinal description of development of typical laughter use and response to partner's laughter in an ecological and familiar context from 12 to 36 months, grounded in and extending the current literature.

Research Questions

1. How does laughter production develop between 12 and 36 months in terms of frequency, duration, arousal, position in relation to speech? How does it differ from adult laughter production?

2. How do mothers use laughter in interaction with their children? Do mothers promote laughter production by systematically replying and aligning to it? Is the response modality specific? Does it change over time?
3. How do children react to the mother's laughter between 12 and 36 months? What does this tell us in terms of child neuro-psychological development?

Method

Laughter behaviors were measured by analyzing video recordings of interaction between mother and child in familiar contexts, and applying the annotation framework proposed in Mazzocconi et al., (2020) tested on adult dialogue, which clearly distinguishes different levels of laughter analysis: form, positioning, semantics, and pragmatics of laughter.

The Corpus

Laughter is a nonverbal vocalization, which affects our facial expressions, our body movements and posture (Urbain et al., 2013). The availability of multimodal data is not only important for conducting pragmatic analysis of laughter (not the focus of the current paper), allowing for a holistic interpretation of the contextual cues, but also for its detection: audio alone allows for less precise annotation both in terms of laughter onset and offset time, but also for detection itself, considering that laughter can also be silent (Cosentino et al., 2016; Griffin et al., 2013). For this reason, we chose to use a corpus for which video data was available: the Providence Corpus (Demuth et al., 2006). This allows us to note also the presence of other nonverbal behaviors in response to laughter (namely smile and gaze).

The Providence Corpus was compiled during 2002–2005, collecting data from participants in southern New England. It contains longitudinal audio/video recordings of 6 monolingual English-speaking mothers and their children from approximately 1-year to 3-years of age during spontaneous interactions at home: 3 boys (Alex, Ethan, William) and 3 girls (Lily, Naima, Violet). Each child was recorded for approximately 1 hour every two weeks. Recording began around the age of one year or once the parent reported that the child was producing approximately four words. Digital audio/video recordings took place in each child's home while engaged in their daily unscripted activities (e.g., playing on the floor, reading books, eating, etc.). All the interactions have been orthographically transcribed using CHAT conventions (cf. MacWhinney, 2000). All transcriptions of the mothers' and children's speech, as well as audio/video files, are publicly available as part of the CHILDES database (https://phon.talkbank.org/access/Eng–NA/Providence.html).

Our Data

Our corpus study focuses on a subset of the Providence Corpus (Demuth et al., 2006), looking at laughter behavior development in 4 children: Alex, Lily, Naima, and William.[2] We analyzed 30 min of spontaneous interaction with the mother at intervals of 6 months

[2] We excluded Ethan from our study because he was later diagnosed with Asperger's syndrome and no videos were available for annotation; Violet was excluded arbitrarily, without having looked at her data, simply because we were aiming at a gender-balanced corpus (two female subjects and two male subjects).

from the age of 12 to 36 months,[3] for a total of five time points per child (see Table 6 in Appendix A for more precise information), and ultimately annotating 287 laughs. In order to avoid selective bias, the 30 min of annotation for each video started from the very beginning of the recording session. Parts of the video with no interaction (e.g., child and mother in different rooms) or in the presence of third persons were excluded from further analysis, and subtracted from the total duration of the video, in order to focus exclusively on mother-child interaction patterns. Impressionistic observations indicate, indeed, that the presence of a third person (especially when adult) particularly influences the mothers' laughter behavior, who immediately produce laughter more often than when interacting with the child alone.[4]

Our Annotation

All our annotations have been carried out using the software ELAN (Brugman & Russel, 2004). The coding was carried out by the first author herself watching and listening to a video until a laugh occurred. The coder then stopped the videotape, went back in the recording in order to mark the onset and offset of the laugh, and coded the form, the temporal sequence, in relation to speech and others' laughs, the context of laughter occurrence, the laughable it was related to, the partner's response, and the pragmatic function following the framework proposed in Mazzocconi et al. (2020) for laughter annotation in adult dialogue. In the current paper, we focus only on some of these features: the occurrence of laughter (frequency), duration, arousal, position in relation to speech, and the response to the partner's laughter.[5] Definitions and description of the variables object of the current study are presented in Table 1 and the protocol provided to annotators available in Appendix B. Our criteria for laughter identification, arousal, and overlap with speech annotation are in line with previous work (e.g., El Haddad et al., 2019), while the annotation relative to the response to partner's laugher is based on Reddy et al. (2002). The same procedure for laughter annotation was applied both for children and mothers.[6]

NOTE: When reporting extracts of conversations, for laughter transcriptions we will use the annotation guidelines used in the DUEL corpus (Hough et al., 2016). Especially relevant will be these two conventions: <laughter/> to tag standalone laughter not overlapping with speech (e.g., "that's cool <laughter/>"), and <laughter> </laughter> to tag speech-laughter (e.g., "<laughter> yeah </laughter>"). Throughout the paper, whenever an extract of the interaction is reported, this is provided with a hyperlink to a video-clip of the original recording.

[3] Choosing to use the Providence Corpus entails that we miss the earliest laughter episodes, which occur between the 3rd and 4th month of life (; Sroufe & Wunsch, 1972; Nwokah et al., 1994).

[4] For these two reasons we were forced on two occasions (Lily and Naima at time-point 5: 36 months) to integrate the analysis of the originally selected video with the temporally closest other video available, and sum the duration of minutes and laughs analysed (see Table 6). We selected the videos closest to our age of interest, but an important exception was made for Alex: the first video, which we analyze as related to the first time-point (12 months), was actually recorded at 16 months of age (the time when his parents reported he had a vocabulary of about 4 words).

[5] A detailed analysis of the annotations related to the objects of laughter and its pragmatic functions will be reported in a forthcoming work.

[6] Annotations and data are available at https://osf.io/48fmd/?view_only=a3bcf69ab71f43fdac820b1e46c6e5de.

Results

In what follows we present the results from the variables observed. We will discuss the results in relation to our research questions previously stated ("The Current Study" section), comparing patterns observed in mothers and children, overall and over time, as well as commenting on mother laughter behavior in interaction with the child, in comparison to adult-adult behavior. All the statistical analyses reported in the following sections have been conducted using the statistical software R (Team, 2016).[7,8] In order to be able to perform meaningful statistical analyses, different statistical tests and procedures will be used, accommodating for the sample sizes available and the type of variable to be analysed. Justifications for each choice will be presented either in the main text or in footnotes.

Inter-annotator Agreement

The corpus has been annotated completely by the first author. Inter-annotator reliability was assessed by having 18% of the corpus (52 laughs)[9] annotated by two native English speakers: one post-graduate student and an undergraduate student, both naïve to the framework used for the analysis and to the hypotheses of the study. The second and third annotator proceeded to the annotation after a detailed explanation of the framework (Mazzocconi et al., 2020), following a tutorial where examples of each feature were presented, and with the support of a structured annotation protocol (see Appendix B). We assessed the agreement on laughter identification and segmentation (start-time and end-time boundaries) using the Staccato algorithm implemented in ELAN (Lücking et al., 2011). We ran the analysis with 1000 Monte Carlo Simulations, a granularity for annotation length of 10, and $a = 0.05$. The average degree of organization between three annotators is 0.70. It is worth noting that this value is higher for children than for mothers in all the comparisons between annotators. The results in terms of percentage agreement and Krippendorff's a (Krippendorff, 2012) are given in Table 2 for each variable annotated.[10] It is also interesting to remark that arousal is the feature for which the degree of agreement is lower (found to be low also in other studies, e.g., El Haddad et al., 2019, possibly indicating the extreme importance of subjectivity in arousal perception). After discussion the three annotators came to agreement on both laughter identification and on the annotation values of the individual features. The analysis we will present in the rest of the paper is based on such final agreement.

[7] In the current work we consider children and mothers as two groups, leaving to a future work scrutiny over individual variabilities.

[8] The R scripts used raw annotations and data are available at https://osf.io/48fmd/?view_only=a3bcf69ab71f43fdac820b1e46c6e5de.

[9] The overall count of laughs in the corpus is based on the number of laughs identified by the first annotator.

[10] In Krippendorff (2012, p. 241) cut-off values of acceptability are proposed to guide a value interpretation, as rules of thumb: $a \geq 0.8$ is considered as a reliable degree of agreement, while $a \geq 0.66$ is considered as an acceptable value for tentative conclusions.

Table 1 Laughter annotation scheme for interactions with children (see Appendix B for further details)

Occurrences	Raw count of laughs
Duration	End-Time–Start-Time
L. in relation to speech	*Stand-alone laughter*: laugh not overlapping with speech from the laugher him/herself
	Speech-laughter: laugh overlapping with speech from the laugher him/herself
L. in relation to others' laughter	*Isolated*: laugh not shortly following (1 s) a laughter from the partner
	Dyadic: laugh starting shortly after a laugh from the partner and within 1 second after its offset (with or without overlap), or having the same onset
Arousal	Low, Medium, High (annotators' qualitative perception)
Partner's Response (Reddy et al., 2002)	*Explicit*: Laugh; Smile; Look; Exclamation; Clarification Request
	Implicit: Repeat or continuing same activity
	None: no orienting attention behavior can be observed, neither continuation of activity
	Not visible: subject face/body not visible from video recording

Frequency of Laughter

In Fig. 1 we report the means of laughter occurrences observed in mothers and children at each time point. We ran a logistic regression,[11] using the *glm* function from the *lme4* package (Bates et al., 2015), in order to explore whether *age* had an effect on the number of laughs produced by children and mothers, treating laughter occurrence as a dichotomous dependent variable for each second of the video analyzed (laughter present/laughter not present).[12] [13] We applied the Helmert contrast, which allows us to compare each time point to the average of the previous ones. The formula is reported in (1), while coefficients are reported in Table 3.

(1) (glm(Laughter ~ Age * Participant, data = data, family = binomial))

We observed a significant difference in the amount of laughter produced by children and mothers overall ($p = .001$), in that mothers are more likely to laugh than their children

[11] A mixed-effect logistic model was not a viable option given the limited amount of data available.

[12] Only two laughs had a duration lower than 0.5 s, and they were not from the same video. There is, therefore, no possibility that two laughs occurred in the same window.

[13] The operationalization chosen is aimed at maximizing the informativity of our data, given the limited sample size.

Table 2 Inter-coder annotation agreement

Feature	Providence Overall		Children		Mothers	
	% agreem 3 coders	Krip *a*	% agreem 3 coders	Krip *a*	% agreem 3 coders	Krip *a*
L-SL	98.72	0.97	97.98	0.95	100	1
Dyadic	98.71	0.96	97.98	0.94	100	1
Arousal	75.64	0.57	81.82	0.66	64.91	0.42
Response	96.15	0.94	97.98	0.96	92.98	0.89
Overall	92.30	0.86	93.94	0.87	89.47	0.82

independently of *age*; we also see that laughter production undergoes a significant development and when comparing the last time-point (36 months) to the average of the previous ones (36 vs. (12+18+24+30)/4) we observe a significant difference ($p < .001$). We also observe a significant interaction of *age* and *participant* in the contrasts (2) and (4) (Fig. 2a, b), with respective *p*-value of: < .05 and < .005 (Table 3).

Laughter Arousal

With the term arousal we refer to the state of activation or wakefulness as intended for example in the dimensional approach to emotion literature (e.g., Russell, 1980, or in Fontaine et al., 2007) in as much as signaled by the laughter itself. In some previous work, it has been referred to as 'laughter intensity' (e.g., Curran et al., 2017; El Haddad et al., 2018; McKeown & Curran, 2015), but in the current work, we prefer to refer to it as 'arousal' since we believe it is informative about the change in the laugher's mood as a result of appraising the laughable (Ku et al., 2017; Reisenzein et al., 2019), and because it avoids confusion with acoustic intensity. Laughter can in fact be silent (Cosentino et al., 2016; Griffin et al., 2013) and nonetheless signal a very high arousal state.

The stacked barplot in Fig. 3 shows the arousal level displayed in laughter over all time-points by children and mothers (as perceived and agreed upon by annotators[14]). Children produced significantly more high arousal laughter than their mothers [McNemar's χ^2 [15] $= 72.864$, $df = 1$, $p < .0001$], while mothers produced significantly more low arousal laughter [McNemar's $\chi^2 = 23.141$, $df = 1$, $p < .0001$].

It is interesting to observe that the percentage of high arousal laughter produced by the mothers (11%) is not very different to that reported in ecological adult interactions (Mazzocconi et al., 2020) (BNC: 13.15%), even though low arousal laughter is more frequent in adult-adult (BNC: 47.06%) conversations than in mother-child (34%)

[14] We acknowledge that the arousal annotation had a rather low degree of inter-annotator agreement and that our current analysis is based on the annotation agreed upon after discussion between annotators. Our results on this score, therefore, need to be viewed with caution.

[15] We decided to perform a McNemar's Chi-squared test since it is a good non-parametric alternative to the Pearson's Chi-squared test, and is a better fit for small paired nominal data samples (2×2 contingency table) compared to the Fisher's Exact Test.

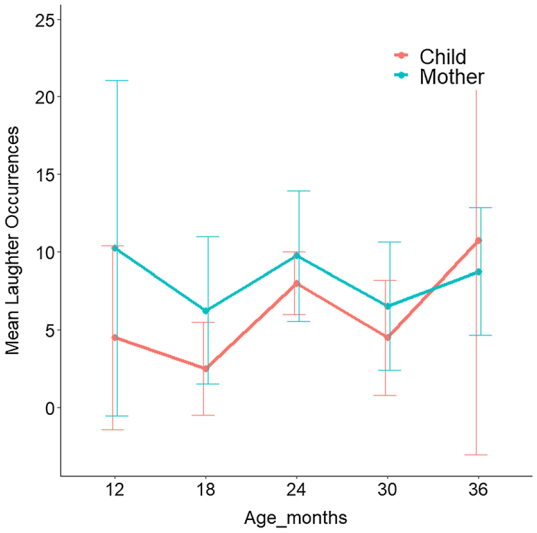


Fig. 1 Count of laughter occurrences in children and mothers over time: Means and standard deviations

Table 3 Results of the Logistic Regression with Helmert contrast—in the first part of the table we report the coefficients relative to each factor and contrast singularly, while in the second part we report the interactions between each of the contrasts and participant (Mother vs Child)

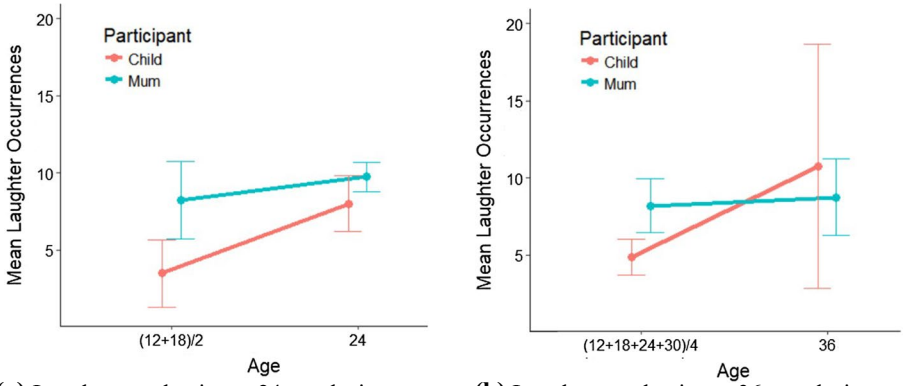
Contrast	Estimate	Std. Error	*z* value	Pr(>|z|)
(1) 18 vs.12	−0.27146	0.11739	−2.312	0.020758*
(2) 24 vs. (12 + 18)/2	0.17832	0.05585	3.193	0.001409**
(3) 30 vs.(12 + 18 + 24)/3	−0.03391	0.04422	−0.767	0.443141
(4) 36 vs. (12 + 18 + 24 + 30)/4	0.09693	0.02745	3.531	0.000414***
Mum vs.Child	0.42109	0.13024	3.233	0.001224**
(1) Mum vs.Child	0.04599	0.23479	0.196	0.844720
(2) Mum vs.Child	−0.22453	0.11170	−2.010	0.044422*
(3) Mum vs.Child	−0.06976	0.08844	−0.789	0.430269
(4) Mum vs. Child	−0.15702	0.05490	−2.860	0.004237**

interactions. On the other hand, high arousal laughter is much more frequent in children (25%) both compared to mothers (11%) and to adults in general (13.15%).

Laughter Duration

We observed a mean laughter duration of 2,31s (*SD* = 1,62) in children and of 1,65 (*SD* = 1,01) in mothers. In Table 4, we report means and standard deviation for mothers and children at each time-point analyzed. We performed a two-way ANOVA[16] to investigate

[16] For the analysis of duration, given the availability of sufficiently many data points (287 laughs), we chose to use ANOVA since it is a robust test for comparing a continuous variable such as duration among two groups and three conditions and testing their interaction.

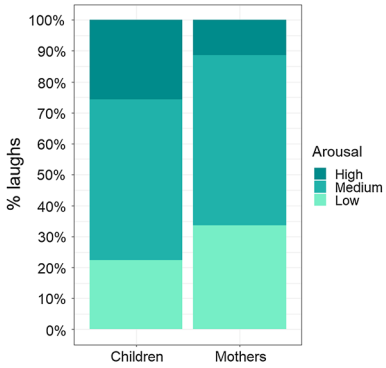


(a) Laughter production at 24months in contrast toearlier time points - (Contrast 2).

(b) Laughter production at 36 months in contrast toearlier time points - (Contrast 4).

Fig. 2 Number of laughter occurrences in mothers and children over time: Each time point illustrated on the right of the x-axis is compared to to the average of all the preceding time-points analyzed

Fig. 3 Perceived laughter arousal level in children and mothers



whether the difference observed could be attributed to the fact that children produce more high arousal laughter, generally longer in duration (Mazzocconi et al., 2016). We observe main effects of both arousal [$F(2, 28) = 82.10$, $p < .001$] and participant (child or mother) [$F(1, 28) = 7.81$, $p = .005$] on laughter duration, while the interaction between the two factors is not significant. Laughs tend therefore to be longer when the level of arousal increases, and children tend to produce longer laughs than mothers regardless of the level of arousal. We then performed another two-way ANOVA to investigate whether the age of the child had an effect on laughter duration in children, but that was found not to be significant.

Laughter Positioning in Relation to Speech

We observe a significant difference in the amount of speech-laughter produced by children (11; 9%) and mothers (58; 35%) [McNemar's χ^2 [17] = 77.44, $df = 1$, $p < .0001$]. In Table 5, we report the actual occurrences observed over time.

While all mothers frequently produce speech-laughter at all time points, we observe its use only in two children: in Naima from the age of 30 months and in Alex from the age of 36 months. While in children we obviously see a significant change over time [Fisher's Exact Test (2×5)[18]: $p < .01$], we do not observe any significant change in the production of speech-laughter over time in mothers [Fisher's Exact Test: $p = 0.24$].

In line with Nwokah et al. (1994), we found speech-laughter to occur both on content and function words. In (2) we report an example of speech-laughter from the mother, while in (3) one of the first examples of speech-laughter produced by a child.

(2) Example from the Providence Corpus—William 010412—Mother speech-laughter
Mum: who's hiding in the honeycomb?
Mum: huh, what's that?
Child: a zee.
Mum: <laughter> bee! </laughter>, that's right!
Mum: zzzzz a bee. <laughter/>
Mum: <laughter> (a)n(d) who is hiding among the flowers? <laughter/>

(3) Example from Providence Corpus—Alex 020606—Child speech-laughter
Child: <laughter> Upside </laughter>
Mum: What's that?
Child: That's ...
Mum: An apple!
Child: <laughter> Apple </laughter>
Mum: An apple
Child: <laughter> An apple </laughter>
Mum: How about...

Responsiveness to Others' Laughter

We studied the response to other's laughter annotating for two variables: dyadic laughter/laughter mimicry (laughter shortly following a laugh from the partner, see Table 1) and explicit response to other's laughter (including laugh, smile, exclamation, orienting look, and clarification requests).

[17] See footnote 15 for a justification of our choice.

[18] We performed a Fisher's exact test, since it is a good alternative to Chi-square tests when dealing with small sample size. We could not perform a McNemar's test, even though it would have been a more suitable option for paired data, since it can be applied only for 2×2 contingency tables (therefore viable for the 2×2 comparison between mothers and children overall, but not for the 2×5 comparison of speech laughter production over time for each participant).

Table 4 Laughter duration in children and mothers over time: means and standard deviations

Participant	12m		18m		24m		30m		36m		Overall	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Mothers	1.76	0.84	1.46	0.62	1.79	1.08	1.73	1.64	1.40	0.65	1.65	1.01
Children	2.10	1.05	1.60	1.12	3.04	2.19	2.02	1.44	2.15	1.32	2.31	1.62

Table 5 Laughter and Speech-laughter Over Time in Children and Mothers

Children	12 m	18 m	24 m	30 m	36 m	Total
Laughter	18	10	32	16	34	110
Speech-laughter				2	9	11
Mothers	12 m	18 m	24 m	30 m	36 m	Total
Laughter	25	12	29	17	25	108
Speech-laughter	16	13	10	9	10	58

Dyadic Laughter and Mimicry

With the term 'dyadic laughter' we refer to every laughter starting shortly after a laugh from the partner, and within 1 second after its offset, (i.e., antiphonal laughter, Smoski & Bachorowski, 2003) or having the same onset.[19] We decided to consider them as a unique comprehensive category since we had only three instances of laughs with the same onset. Laughs produced with the same onset time were found to be rare also in Nwokah et al. (1994).

The first observation to be made is that, contrary to what might be expected, isolated laughter is much more likely than dyadic laughter both in children and mothers. A result which is found also in younger children (Nwokah et al., 1994) and adults (Mazzocconi et al., 2020). We observe an overall significant difference in the production of dyadic laughter in mothers (31 dyadic laughs over a total of 166 laughs, 19%) and children (14 dyadic laughs over a total of 121 laughs, 12%) [McNemar's $\chi^2 = 40.76$, $df = 1$, $p < 0.001$]. In (4), (5), (6), and (13) we report examples of antiphonal laughter (laughter mimicry) from the mother. In the example (6) there is an interesting particularly posed laughter production from the mother in response to her child 's laughter. While in (7), (8) and (14) we report three occasions of dyadic laughter (laughter mimicry) from the child.

(4) Example from Providence Corpus—Naima 010014 (43–48)—Mother laughter mimicry
Mum: I'm gonna lie down here. Is that okay with you?
Child: yyy
Mum: ah, lying down
Child: down
Child: <laughter/>

[19] In the class antiphonal laughter, we include both laughter with no overlap (reciprocal in Nwokah et al., 1994) and those resulting in overlap (coactive in Nwokah et al., 1994).

Mum: <laughter/>

(5) Example from Providence Corpus—William 020012 (586–594)—Mother laughter mimicry
Child: We go up and down!
Mum: We go up and down?
Child: Yeah
Mum: Yeah
Child: Up...
Mum: and down
Child: Down
Mum: Up and down
Child: <laughter/>
Mum: <laughter/>

(6) Example from Providence Corpus—William 010605 (604–606)—Mother laughter mimicry
Mum: now everybody was beautiful
Child: <laughter/>
Mum: <laughter/> isn't that good?

(7) Example from Providence Corpus—Alex 030103 (406–409)—Child laughter mimicry
Mum: What is that?
Child: Happy!
Mum: <laughter> No, it isn't! </laughter>
Child: <laughter/>

(8) Example from Providence Corpus—Lily 030010 (1356–1363)—Child laughter mimicry
Child: Oh
Mum: Oh
Child: Oh
Mum: oh <laughter/>
Child: yyy sit on me!
Mum: Sorry!
Child: <laughter/>
Mum: <laughter/>

Given that at some time-points children laughed much less than mothers, we decided to measure the probability of dyadic laughter production taking in account the number of laughs produced by the partner. Following a procedure similar to the one used in El Haddad et al. (2019) to quantify mimicry, we calculate the probability of dyadic laughter occurring from one participant over the total of laughs produced by her/his partner (i.e., the amount of dyadic laughter of child X over the total of laughter produced by X's

mother – and vice-versa, as in (9)). We will refer to this measure as Transitional Probability (TP), since it gives us indication about the likelihood of one participant moving from a "non-laughing" state to a "laughing state" given the laughter production from the partner.

$$(9)\quad \text{Trans. prob. of dyadic laughter by child} = \frac{\text{tot. sum \#dyadic laughter by child}}{\text{tot. sum \#laughs by mother}}$$

This is overall higher in mothers (41%) than in children (9%) [McNemar's $\chi^2 = 17.9$, $df = 1$, $p < 0.001$]—Fig. 4a. Given our relatively small sample size, in order to explore whether a developmental trend in dyadic laughter could be observed, both in children and mothers, we divided our *Age* time-points (12, 18, 24, 30, 36 months) into 3 periods[20]: one relative to the second year (12 and 18 months), one relative to the third year (24 and 30 months), and one relative to the beginning of the fourth year (36 months) of child development. We conducted a Wilcoxon test[21] at each time-window comparing mothers' and children's TP of laughing in response to the partner's laugh. Results show a significant difference in the window relative to the second year [$W = 3$, $p = 0.004$], which disappears in the third [$W = 16$, $p = 0.2$] and the fourth year [$W = 4.5$, $p = 1$]. This is visible in Fig. 4a, where at 36 months of *age,* children and mothers come to similar values, respectively 13.2% and 10.9%. While in children we do not observe a significant difference in the production of dyadic laughter over time, we see a marked decrease in dyadic laughter productions from mothers, even though the statistical analysis did not show a significant difference when comparing the second year and the beginning of the fourth [$W = 19$, $p = 0.059$].

For mothers, the overall TP of producing laughter in response to the child's laugh is not so different from that observed in very cooperative adult corpora: e.g., DUEL French 42.18% (SD = 15.07) and DUEL Chinese 42.13% (SD = 17.47) (Mazzocconi et al., 2020). By contrast, when looking exclusively at the percentage of dyadic laughter over the total, we observe much lower rates in mothers (18.67%), compared to adults generally (Duel Fr: 39%, Duel Ch: 37%, BNC: 26%). It is important to note that raw percentages are affected by the fact that children, especially in certain videos used, laugh far less than adults, offering therefore fewer opportunities for the mothers to laugh antiphonally.

Explicit Multimodal Response to Others' Laughter

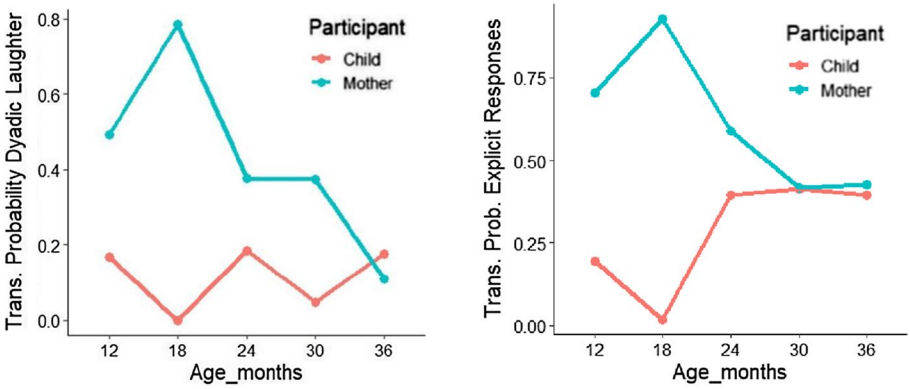
Following Reddy et al. (2002), we then observed the reactions to other's laughter productions, not only when they were constituted by laughter, but also when constituted by other positive expressions (smiles, exclamations) or by a clear orienting reaction (looks, clarification requests).

As for the analysis of dyadic laughter and mimicry, we calculate the TP of *explicit response* to laughs over the total number of laughs produced by the partner following the same method used for the calculation of the TP of dyadic laughter, both for children and mothers:

$$(10)\quad \text{TP explicit response by child} = \frac{\text{tot. sum \# explicit child responses}}{\text{tot. sum \# laughs by mother} - \text{\# child response not visible}}$$

[20] The choice to collapse points of observation was motivated by the fact that having a relatively small sample size considering each time-point independently would have resulted in a weak statistical reliability.

[21] This test was used here since it is a viable non-parametric alternative (appropriate for our data) to the paired Student's t-test.



(a) Dyadic Laughter / Laughter mimicry

(b) Explicit multimodal response to partner's laughter

Fig. 4 Responses to each other's laughter: Children and mothers. Transitional Probabilities (TP)

For this variable, the total amount of laughs produced by the partner was computed by subtracting the occurrences in which the response from the interactant was not visible (41 mother laughs and 11 child laughs excluded from the total count). The other categories are *implicit response* (the partner repeated her/his behavior or simply continued her activity), *no response* (see Table 1 and Appendix B). In Fig. 4b we see children's and mothers' responses to each other's laughter to be very different at 12 months (mothers much higher than children); values get closer around the age of 24 months, and then come to almost identical values at 30 and 36 months (Mother: 30 months 41.6% and 36 months 42.8%; Child: 30 months 41.5% and 36 months 39.5%). In order to conduct statistical tests, given our small sample size (4 dyads), similarly to the previous analysis, we divided *age* into 3 windows: second, third, and beginning of the fourth year of children's development. We conducted a Wilcoxon test to compare child and mother explicit responses to the partner's laughter within each window.

We observe a significant difference between mother and child during the second year (12 and 18 months) [$W=57.5$, $p=0.007$], which then disappears during the third [$W=30.5$, $p=0.9$] and the beginning of the fourth year [$W=8$, $p=1$]. In mothers, we see a significant change between the second and the third year [$W=9$, $p=0.01$], which is absent between the third and the beginning of the fourth [$W=15$, $p=0.9$]; when comparing the first window (12–18 months) with the last one (36 months) the change in TP of explicit responses to the child's laughter is significant [$W=3$, $p=0.03$]. In children, on the other hand, the comparison between the second and third year is not significant; we see a significant change in the TP of explicit response to the mothers' laughter only when comparing the second year to the beginning of the fourth [$W=28$, $p=0.04$].

Discussion

We conducted a longitudinal observation of four American English-speaking children interacting in their home environment with their mother from 12 until 36 months, analyzing 30 min of interaction at intervals of 6 months. We analyzed the laughter behavior

of children and mothers in terms of occurrences, duration, arousal, position in relation to speech, and contingent mimicry and multimodal response to the partner's laughter. We observe the children's behavior to be significantly different from the mothers' (and adults more generally) in all the features analyzed, and we observe interesting developing trajectories in the number of laughter produced over time in children, as well as in the contingent responses to the partner's laughter both in children and mothers, mirroring the neuro-psychological development of the baby and the mothers' attunement to it.

Frequency

Our analysis shows that in the age range and contexts considered, children laugh significantly less than their mothers, highlighting an increase in child laughter production over time, becoming as frequent as their mothers around the last time-point (36 months) (Table 3 and Fig. 2). Our data are, therefore, complementary to the ones reported by Nwokah et al. (1994), who tracked laughter rate development from one month until 2-years of age. Although comparing the raw counts would not be meaningful given the extremely different contexts of interaction, the relation between child and mother laughter production is still comparable and informative on a very generic level of the overall behavioral alignment between child and caregiver. Nwokah et al. (1994) also found that children produce significantly fewer laughs than their mothers, with an increase in laughter production over time. This, despite the fact that in the window they analyzed the frequency of laughter produced by babies, never reached the same rate of the caregiver. Our data suggest that around 36 months of age, laughter starts to be produced as frequently as by caregivers. On the other hand, mothers' laughter production remains rather stable across time.

We need to stress though, that we observe a wide variability especially at the last time point for children (e.g., one child, William, did not produce any laughter at all). The variability observed should be attributed to at least two factors, individual temperament and personality of the children involved, and the fact that the activities children were engaged with in the videos analyzed were not pre-scripted (an inevitable drawback of a fully naturalistic study in a familiar environment).

Interestingly, we observe that the frequency of laughs produced by the mother in interaction with her child over 10 min ($M = 2.13$, $SD = 2.01$) is much lower than the one observed in adult-adult interaction: friendly conversations 5.8 ($SD = 2.5$)/10 min (Vettin & Todt, 2004); speed-dating 21($SD = 9.28$)/5 min (Fuchs & Rathcke, 2018); friendly loosely-controlled conversation DUEL French 45/10 min, DUEL Chinese 26/10 min; fully ecological and diverse contexts BNC 5/10 min (Mazzocconi et al., 2020). Our data, considered specifically in relation to the age range and context analyzed, therefore go against the commonly reported finding that children laugh more than adults (see, for example Young, 1937; Kret et al., 2021, even though the latter was not focused on studying laughter frequency) and show how laughter is increasingly exploited as a communicative resource over time. Laughter, expressing a positive appraisal of an event or stimulus (Ginzburg et al., 2020; Mazzocconi et al., 2020), can be used to show appreciation and enjoyment, thereby implicitly being used to ask for repetition and to show closeness (Nelson, 2012).

Laughter Arousal

The discrepancy observed in the production of high arousal laughter[22] between mothers and children (Fig. 3) can be probably explained as a consequence of the activities they are involved with. For the children, these activities are clearly calibrated for their age and their level of cognitive development. Therefore, they trigger more enthusiasm in them compared to the adult they are playing with. While it is incontrovertible that laughter is also produced in response to stimuli that are not humorous, we know from humor appreciation studies, that stimuli are more successful in eliciting laughter when carefully calibrated in terms of cognitive complexity for the subject. Laughter is more easily elicited by stimuli that are neither too difficult based on the current acquired knowledge about the world, nor too easy nor too complex, requiring an optimal amount of effort to be grasped (McGhee, 1977, 1979; Zigler et al., 1966, see Martin, 2010 for a review). For the future, it would be interesting to explore whether it is the higher percentage of *high arousal laughter* from the babies that influences the higher percentage of *medium arousal laughter* observed in mothers as compared to adults. Mothers might align with the child's expression but on a lower level of intensity, similarly to what has been observed in El Haddad et al. (2019) where listeners mirrored the same expressions produced by speakers (smiles and laughs) but on a lower level of intensity.

Laughter Duration

We found that children produce significantly longer laughs than their mothers, regardless of the level of arousal ("Laughter Duration" section). This piece of data is interesting when considered along with data about laughter production in aphasic patients. Norris and Drummond (1998) found that patients produce significantly longer laughs compared to their healthy controls. The authors suggested, therefore, that when language is impaired, laughter might be a means for patients to prolong their role as speakers in the conversation and contribute meaningfully to the interaction. We can speculate that the same might apply to children. When language is not fully developed, laughter might be an early means, in its already fully available expressiveness, to hold the conversational turn and enable meaningful vocal contribution in interaction at the same level of the interlocutor. Whether the latter speculation or rather more basic psycho-psychological factors (e.g., emotional regulation and inhibition) are the main explanatory factors is still an open question.

In terms of child laughter duration, we found a higher mean compared with the results of Nwokah et al. (1994). This disparity might be due to the fact that in our corpus, the children were playing with their mothers in a very familiar environment (their home), where children probably feel more at ease, playful, and free to choose familiar and preferred activities, which are more likely to provoke excitement, compared to the environment in which Nwokah et al. (1994)'s data were collected (i.e., laboratory room, controlled situation, controlled selection of toys, unfamiliar environment and only a short time to get used to it—10 min).

[22] We need to acknowledge again that the arousal annotation had a rather low degree of inter-annotator agreement and that our current analysis is based on the annotation agreed upon after discussion between annotators.

Alternatively, it might just be a consequence of the different protocols used for laughter identification: in Nwokah et al. (1994) annotators were instructed to annotate laughter when both a vocalization and an accompanying facial expression based on the description of Apte (1985) and Ekman and Friesen (1975) were observed. In contrast, following also the approach of other researchers' (e.g., El Haddad et al., 2019), we did not want to give such strict criterion for laughter identification, since laughter can be silent or can be audible but not accompanied by the typical facial expression as described by Apte (1985) and Ekman and Friesen (1975) (cfr. Protocol in Appendix B).

We did not find any effect of child age on the duration of laughter in children, which is in line with results from Nwokah et al. (1994), observing an increase in duration only during the first year, stabilizing around the age of 12 months.

Speech-Laughter

We observe a rather invariable and frequent use of speech-laughter by all mothers at all time-points (35% of all laughs produced) (Table 5). In children, on the other hand, speech-laughter is much rarer: in our corpus, it is observed only in 2 children around 30–36 months. This is clearly influenced by the fact that children do produce a much smaller amount of speech compared to mothers, but it also suggests that for the production of speech-laughter, there is a need for quite advanced language abilities, as a matter either of vocal control and coordination, or of the development of laughter's pragmatic use to shape verbal contributions. Interestingly the percentage of speech-laughter in mothers (35%) is not that different from the one reported in naturalistic adult dyadic conversation (DUEL French: 31%, DUEL Chinese: 47%, BNC: 30%, Mazzocconi et al., 2020), while lower than that observed in other adult studies (e.g., Trouvain, 2001, 50%; O'Connell & Kowal, 2005, 60%; Devillers & Vidrascu, 2007, 58%). On the other hand, it is higher than the mean of speech-laughter observed in mothers as reported by Nwokah et al. (1999): 18.6%, even though they also report very high variability ranging from 5.1 to 50.2%.

Despite not being the focus of the current paper, and the few occurrences of speech-laughter observed in children, a notable finding worth mentioning is that from the initial emergence of speech-laughter, we observe in children similar distributions to those observed in adults: it occurs both on content and function words, it accompanies most frequently statements rather than questions or exclamations (as also reported in Nwokah et al., 1999), and it is more likely to occur (by comparison with isolated laughter) if the argument of the laughter is what according to the Mazzocconi et al. (2020)'s framework would be classified as a *social incongruity* (i.e., a potentially socially discomforting event/act: criticizing, providing a dispreferred answer, embarrassment, etc.) [McNemar's $\chi^2 = 16.488$, $df = 1$, $p < .0001$]. This piece of data supports the view that multimodal and verbal non-linguistic elements contribute to the construction of meaning and are tightly linked to the social action performed (Bavelas & Chovil, 2000; Mazzocconi et al., 2021; Trujillo & Holler, 2021) since the early stages of development.

Laughter Mimicry and Multimodal Responses to Other's Laughter

Mothers' Response to Child Laughter

We observe mothers aligning with their child's laughter production, especially at the initial time-points (12 and 18 months), while we observe a decrease at the following time-points (24, 30, and 36 months) (Fig. 4a). The percentage of contingent responses to child's laughter is even higher if we consider other explicit multimodal reactions (i.e., exclamations, smiles, orienting looks, clarification requests) (Fig. 4b). This is in line both with Nwokah et al. (1994) and Cohn and Tronick (1987) who observe that during the second year of life, it is more likely that children become positive before their mothers, while the mothers tend to attune to their children's emotional expressions. This could be explained by the fact that the child is the focus of the mother's attention, and she takes advantage of any occasion to engage positively with him/her, to react to their positive expressions, and to establish mutual engagement (Hoff, 2006).

While allowing the earliest exchanges on an equal footing, a systematic contingent response from the caregiver (either aligning with or providing a response in other modalities) teaches the child that his/her contribution is meaningful, communicatively relevant and helps them shape its use (Cuffari et al., 2015; De Jaegher & Di Paolo, 2007; Fusaroli et al., 2014). Similar patterns have been observed for other speech-like vocalizations (Bloom et al., 1993; Leonardi et al., 2016), where a positive correlation has also been found between maternal responsiveness to vocalizations and the timing of achievement of basic language milestones (Tamis-LeMonda et al., 2001). Of particular interest, then, are the cases when the contingent response to child laughter from the mother is a verbal reformulation of the non-verbal laughter vocalization asking for confirmation, as in (11) and (6), or a clarification request (12). In so doing, the mother makes explicit that laughter has a communicative value, propositional content (Mazzocconi et al., 2018) and shows availability to negotiate jointly its meaning and reference.

(11) Example from Providence Corpus—Naima 010604 (328–348)—Propositional reformulation of laughter
Mum: Did you help Daddy make the coffee?
Mum: Where did you make the coffee?
Child: Tea
Mum: Tea? there was no tea!
Mum: did you make the coffee in the bathroom?
Mum: no! Where did you make the coffee?
Mum: where did you make the coffee this morning?
Child: <smiling> upstairs
Mum: upstairs!?
Mum: That's a joke, right?
Child: <laughter/>
Mum: <laughter> yeah </laughter> you're making a joke!
Mum: you know that coffee +...
Mum: there's no kitchen upstairs!
Child: listen Mommy
Mum: what?
Child: nursie Daddy

Mum: nursie Daddy, that's another joke!
Mum: you're being funny now, oh, no, we do not draw on clothes

(12) Example from Providence Corpus—Naima 02004 (116–120)—Laughter clarification request from the mum
Mum: March eighteenth
Child: yyy
Mum: Can you say that?
Child:<laughter/>
Mum: Can you say March eighteenth?
Child: <laughter/>
Mum: <laughter> Is that funny? </laughter>
Child: <laughter/>

It is then interesting to observe the decrease in these mother's contingent mimicry (Fig. 4a) and multimodal responses (Fig. 4b) to child laughter over time. This can be explained by the fact that by the age of two, the child's language and social competences are much more developed and functional than before. Children have, therefore, new means to engage in mutual interaction, apart from laughter, and the mother, in turn, has many more opportunities to engage in mutual and balanced interaction with the child. Over time, mothers might therefore have a decrease in the urge to respond to every instance of laughter. Moreover, it is interesting to observe in more detail how the transitional probability of pure laughter mimicry is lower compared to the transitional probabilities of explicit multimodal responses at 36 months. This mirrors other results reported in the literature, showing that as the child grows older, mothers diversify the type of their responses, being, therefore, more variegated and less consistent, both in the form of response provided and in the timing (Fogel, 1977; Leonardi et al., 2016). The variation in laughter mimicry and contingent multimodal explicit responses over time in mothers might therefore be one of the features of caregivers' adaptation to the communicative development of their children, similarly to the well-known characteristics of child-directed speech (Saxton, 2009). Our data also matches results from other studies suggesting that when interacting with simpler systems, e.g., virtual agents or robots, human behavioral alignment is particularly marked (Branigan et al., 2010, 2011). The same seems to also apply to very young children, partly motivated by the will to be at the same level and partly (even unconsciously) aiming to reinforce behavior, offer explicit feedback, contingent response, and helping to scaffold functional communication development. The dynamic nature of mothers' responsiveness to laughter (similar to what has been observed in the context of play, exploration, and vocalization) (e.g., Bornstein et al., 2008), adapting to the neuro-psychological development of the child, supports a dynamic view of interaction. Such a view moves away from a perspective where interaction is only modeled in terms of a sender and a receiver, but where children themselves play an active role in eliciting caregivers' behavior. This becomes increasingly diverse and more complex over time, attuning to the relevance for the current developmental stage of the child (Cuffari et al., 2015; Fusaroli et al., 2014).

Children's Response to Mothers' Laughter

We observe that children are much less responsive to their mothers' laughter, especially at 12 and 18 months of age, both when considering only laughter mimicry (Fig. 4a) and the multimodal explicit responses to their mothers' laughter (Fig. 4b). The fact that the child does not orient towards the mother's laughter around 12 months can also be explained on the basis of their still developing attentional capacities (Buckley, 2012).

When considering explicit multimodal responses we observe that mothers and children converge around the age of 24 months (Fig. 4b). The increase in explicit responses from the child is in line with the finding reported by Thompson (1991) of infants responding significantly more quickly to emotional elicitors with increasing age, and reflects an increasing interest in others' reactions and engagement in the interaction. On the other hand, the observed convergence is also due to the decrease in mothers' contingent response to laughter, which can be partly explained considering some interactional dynamics at play when the child reaches 24 months. At this age, it becomes more frequent for children to engage in provocative behavior and to tease their parents, who respond with a (real or pretended) serious attitude (Nwokah et al., 1994), whereas during the second year of life (12–18 months) the contrary is more frequent, i.e., the mother laughing while the child is in an incongruent mood (e.g., the baby is crying, has mispronounced something, or has made a clumsy movement, but does not join in the mother's response and remains self-absorbed, etc.).

Our results are consistent with comments reported in Nwokah et al. (1994) where laughter was observed to be particularly effective in the process of re-establishing attention from the child, particularly from the age of 24 months, and especially when visual attention was not possible, functioning as an attention-getting device (Stevenson et al., 1986). Similar increases in response to other's laughter have also been reported in non-human apes: during development, chimpanzees replicate laughter more often (Davila-Ross et al., 2011), and orangutang juveniles show more rapid facial mimicry of their playmates than infants (Davila Ross et al., 2007). At the last two time-points (30 and 36 months), we see much more balanced reactions to each others' laughter, both in terms of explicit multimodal responses and in terms of laughter mimicry, signaling the child's increasing awareness and interest in others' nonverbal emotional expressions and mental states, and the progressive establishment of more balanced dynamics in interaction.

Conclusions and Future Work

In the current work, we offer a characterization of typical laughter development, in terms of formal features, reciprocal mimicry, and multimodal responsiveness to the partner's laughter, in four American English-speaking children engaged in naturalistic interactions with their mums.

We summarize our results and the discussion, answering concisely our research questions stated just following the "Background" section. We then highlight what the practical and theoretical implications of our study are for the field of developmental and clinical neuro-psychology, linguistics, and interactional studies. Finally, we outline future work we believe the current study gives rise to.

RQ1. How Does Laughter Production Develop Between 12 and 36 Months in Terms of Frequency, Duration, Arousal, Position in Relation to Speech? How Does it Differ from Adult Laughter Production?

We observe that the laughter behavior of children is highly divergent from adult behavior, even at 36 months. In the age range and context investigated, we observe overall lower occurrences of laughter production in children compared to adults, refuting the commonly held belief that children laugh more than adults (as mentioned, for example, in Kret et al., 2021; Young, 1937). Nonetheless, there is an incremental trajectory in the frequency of laughter between 12 and 36 months, one which converges towards the caregivers' laughter frequencies. We observe that children produce, proportionately, high arousal laughter significantly more often than their caregivers, and generally produce longer laughs compared to their caregivers, regardless of the arousal perceived. In terms of laughter positioning in relation to speech we observe that speech-laughter, frequent both in adults and caregivers (constituting about 30–50% of laughter production in adults and 35% of laughter production from mothers in the current study), emerges with few occurrences in 2 of the children in our corpus from the age of 30 months. Whether this is linked to the fine physiological control needed over the vocal apparatus or to the development of more sophisticated social skills in order to modulate the linguistic dialogue act is an open question. It is of interest, however, to observe that the sporadic occurrence of speech-laughter in children is, when compared to stand-alone laughter, more likely to be related to a potentially socially discomforting event/act (e.g., criticizing, providing a dispreferred answer, embarrassment for a mistake, etc.). This is a generalization that has already been observed in adults. This suggests that multi-modal, verbal, and para-linguistic, elements contribute to the construction of meaning and are tightly linked to the social action performed (Bavelas & Chovil, 2000; Mazzocconi et al., 2021; Trujillo & Holler, 2021) since the very early stages of development.

RQ2. How Do Mothers Use Laughter in Interaction with Their Children? Do Mothers Promote Laughter Production by Systematically Responding Contingently to it? Is the Response modality Specific? Does it Change over Time?

As far as mothers' laughter behavior goes, we observe interesting similarities (duration, arousal, speech-laughter use) and differences (lower frequency overall and higher laughter mimicry during the child's second year) in comparison with data from adult-adult interaction. We observe that mothers align with the child's laughter production with a significantly higher transitional probability to that observed in adult-adult conversation. This tends to decrease over time, partly substituted by more varied multimodal responses. We note, therefore, that laughter is treated similarly to other speech-like vocalizations (e.g., Bloom et al., 1993; Leonardi et al., 2016), eliciting contingent mimicry or other multimodal contingent responses in mothers. The contingent responses from mothers help children to learn the effect and meaning that laughter has on the interaction, reinforcing its production, offering propositional reformulations, and exemplifying its use. In this way, the communicative relevance of laughter in dialogue gets reinforced. The progressive change in mothers' contingent responses to child laughter over time suggests that this might constitute one of the adaptations instinctively used by adults in child-directed speech, attuning to the neuro-psychological development of children (Bornstein et al., 2008).

RQ3. How Do Children React to the Mother's Laughter Between 12 and 36 Months? What Does this Tell us in Terms of the Child's Neuro-psychological Development?

In terms of laughter mimicry, we observe significantly lower transitional probabilities by comparison to the caregivers, and adults more generally, at all time points. We observe, nonetheless, a clear increasing developmental trajectory for what concerns responsiveness to the caregivers' laughter when considering other explicit multi-modal responses (i.e., not only laughter per se, but also smiling, orienting looks, exclamations, clarification requests), with the most important shift happening between the child's second and third year. Explicit multi-modal responses to the partner's laughter reach similar values in children and mothers when the child is around 30 months. We believe that this patterns reflect the neuro-psychological development of the child at several levels: attentional capacities, pragmatic abilities, interest in others' emotional expressions, appraisals and mental states, and therefore attunement to the cultural and social environment.

Laughter as Tracking Neuro-psychological Development

Our study complements and extends the current literature on laughter in interaction and early years ("Background" section), giving new insights on how even just considering low level features (such as frequency, duration, positioning, and responsiveness), we can obtain much valuable information about children's neuro-psychological development. Our data show how children over time learn to use laughter more frequently in their interaction both in production and as a meaningful cue from the partner, orienting towards it and responding increasingly over time, showing their increasing attunement to the social environment, interest in others' appraisals and mental states, and awareness of its communicative value. We also know from studies in clinical populations that atypicalities in laughter perception and production are observed when pragmatic abilities are impaired (Polimeni & Reiss, 2006; Reddy et al., 2002; Samson, 2013).

This furthermore supports the hypothesis, which is the central motivation of the current study, that laughter production and responsiveness to laughter trajectories can be a valuable means to study the social-communicative development of babies, as it can be informative about social and pragmatic competences early on.

Laughter Meaning in Interaction, Dynamical Approaches to the Study of Dialogue, and Mimicry

The pattern of mothers' responsiveness to child laughter over time give us multi-fold insights: on the crucial role of laughter in interaction since the earliest years of life, on the diversification of mother responsiveness as the child grows older, and about the need to take a dynamical approach for the study of dialogue.

Mothers seem to be careful to respond contingently to any laughter production aligning with it, especially between 12 and 24 months. Subsequently, their systematic responses decrease and diversify, leading to a wider range of feedback, including other modalities. The diversification of maternal responses over time also speaks in favor of a view of interaction where mimicry, when intended as the repetition of a behavior from one of the interactants shortly after its production from the partner (Chartrand & Lakin, 2013),

does not necessarily reflect better social coordination. On the other hand, depending on the social context and the developmental stage, more or less interpersonal synchrony might be desired, and synchronous and asynchronous behavior alternate flexibly (Mayo & Gordon, 2020).

The mothers' change in laughter responsiveness is also in line with a view of communication as a dynamical process where participants, namely children and mothers, influence each other bidirectionally (Chapman, 2000; Sameroff, 2010), generating and transforming meaning together (Asada, 2016; De Jaegher & Di Paolo, 2007; Fusaroli et al., 2014). Our study, therefore, complements results obtained about caregivers' responsiveness in relation to speech-like vocalizations ("Background" section), stressing how nonverbal behavior and para-linguistic elements, often overlooked in the study of dialogue, deserve deeper attention as they are highly meaning–bearing from the earliest interactions.

Additionally, the study of laughter mimicry between mothers and babies offers interesting implications for the study of alignment in general and specifically, alignment in mother-child interaction. It can indeed help us disentangle whether language alignment reflects conversational or purely linguistic competences, presupposing a shared representation. The children in our corpus are able to produce laughter at all time points, but nevertheless, they align significantly less than their mothers (lower mimicry). Although more data and deeper analysis are needed, this data indicates either that mimicry (also referred to as *alignment* in some works) is a process that (despite being considered automatic, Pickering & Garrod, 2006) presupposes quite developed social skills, or on the other hand that laughter is a much more complex and *linguistic* production than previously thought (Ginzburg et al., 2020).

We acknowledge several limitations in our study, notably the small sample size (four children), and the fact that averaging across children entails in an intrinsic way overlooking individual variability, which is in turn influenced by temperamental and personality factors (Proyer & Ruch, 2010). In particular, our conclusions regarding laughter arousal should be taken cautiously since the annotation of this feature has been reported to be highly subjective (see our inter-annotator agreement and El Haddad et al., 2019). Given that the current study is based only on American English data, one cannot expect all its findings to extend universally—both laughter and responses to others' laughter can be affected by cultural factors (e.g., Nelson, 2012; Tronick, 2007). Given this, an important future aim is for us to enlarge our dataset, not only in terms of laughs annotated, but also in terms of languages and cultures considered.

Embracing a dynamical approach to the study of interaction, as discussed briefly above, in further work, we would like to investigate in more detail the mutual influence of mothers and children with respect to laughter (Hsu & Fogel, 2003; Nomikou, 2015), since children do actively influence the timing and unfolding of the interaction (Gratier et al., 2015; Jaffe et al., 2001). This view is furthermore supported by studies showing how mothers of autistic children tend to laugh less over time, almost discouraged by the lack of responsiveness to laughter or by the frequent difficulty in inferring what their child's laughter is related to (Reddy et al., 2002). This also corroborates with studies showing how children's vocalizations can strengthen or weaken the establishment of the virtuous interactive social feedback loop, influencing importantly caregivers' behavior (e.g., Warlaumont et al., 2014).

We are also planning to conduct a more detailed temporal analysis—looking at which stages laughter is used similarly to other vocalizations to practice turn-taking and at which stages it is more crucial as a shared affective expression. Special attention will be devoted to laughter overlap during development, given the importance of co-vocalizing for early attachment (Stern et al., 1975) and its crucial role in the development of higher social

cognition (empathy, mentalizing, etc.) and promoting positive social effects (Rauchbauer & Grosbras, 2020). We would also like to enrich our annotation with information about visual attention from interactants, aiming to explore in more depth the role of laughter in attracting attention towards the self and towards external targets during development ("Background" section). Moreover, we would like to extend the age range of our participants to middle childhood or later to see at which time in development laughter behavior closely converges to adult use.

Finally, being fully aware that the analysis of only low-level features is giving us a limited perspective towards interactional dynamics, we are in the process of providing our analysis with more depth, looking in detail at the *referents* of laughter (*laughables*) and at how the laughs produced are used from a semantic and pragmatic perspective during the first years of life. This will also allow us to investigate whether mothers' responsiveness to laughter is also influenced by the function the child laughter is performing and by the object it is related to.

We hope that this and related work can contribute to establishing a benchmark for laughter use development, which might be compared with trajectories observed in clinical populations. Laughter might be an early means, along with other commonly analyzed behaviors (e.g., smiling, gazing, pointing, etc.), in identifying delays or atypicalities in communicative development and interactional dynamics, allowing for timely support.

Appendix A: Video Analyzed Details

The MLU (in morphemes) values reported are calculated over the full length of the videos partially annotated for laughter. These were computed using the MLU program in CLAN (MacWhinney, 2000). We excluded from the MLU calculation words that were unintelligible using the formula MLU +t*CHI –t%mor –syy -sxx @ for children and MLU +t*MOT –t%mor–syy -sxx @ for the mothers. We see that the children all have typical language development, with Naima standing out for her faster language development (Table 6).

Appendix B: Laughter Annotation Protocol

Laughter Annotation Guidelines

Laughter Tier

Modality: audio and visual (facial expressions, head movement, body movements)
Criteria: laughter should differ from smile by the fact it contains either a body movement, a head movement or audible laughter related sounds.
Values: Laughter (L) or Speech-laughter (SL)

Laughter: Standalone laughter, i.e. laughter not overlapping with speech from the laugher her/himself
Speech-laughter: Laughter which overlaps with speech from the laugher her/himself. [When one speaks and laughs at the same time!]

Table 6 Information about videos analyzed—age, mean length of utterance, video-links, and transcripts

Child	Time	Age	MLU	Video	Transcript	Minutes
Alex	1	01; 04.27	1(0)	010427	010427	30
	2	01; 06.14	1.1(0.3)	010614	010614	30
	3	02; 01.02	1.82(1.11)	020102	020102	30
	4	02; 06.06	2.32(1.51)	020606	020606	26.5
	5	03; 01.03	2.6(1.86)	030103	030103	30
Lily	1	01; 01.02	1.51(0.5)	010102	010102	31
	2	01; 06.11	1.33(0.54)	010611	010611	30
	3	02; 00.04	2.28(2.06)	020004	020004	30
	4	02; 06.04	3.15(2.31)	020604	020604	30
	5	03; 00.03		030003	030003	20.12
	5	03; 00.10		030010	030010	6.15
	5	sum	3.28(2.5)	–	–	26.27
Naima	1	01; 00.14	1.09(0.28)	010014	010014	30
	2	01; 06.04	2.82(2)	010604	010604	30
	3	02; 00.04	3.63(2.66)	020004	020004	30
	4	02; 06.11	3.11(2.9)	020611	020611	30
	5	02; 11.23		021123	021123	15.66
	5	03; 01.01		030101	030101	15
	5	sum	4.41(3.48)	–	–	30.66
William	1	01; 04.12	1.22(0.43)	010412	010412	26.08
	2	01; 06.05	1.27(0.66)	010605	010605	28
	3	02; 00.12	1.51(0.82)	020012	020012	30.04
	4	02; 06.12	2.39(1.73)	020612	020612	30.18
	5	03; 00.11	3.52(2.47)	030011	030011	27.73

Details:
Laughter: The segments start when an audio, facial expression or body movement event related to laughter is observed and stops when a breath intake is perceived whether audibly or visually (from the stomach, face, head, etc.). The breath intake is considered part of the laugh. If no breath intake is perceived the end of the segment is considered to be when the movement stops. In some cases breath intake sounds occurs after a relatively long delay. In this case, during this delay, if the participant is perceived as laughing than the breath intake marks the end of the laugh and is part of it. Otherwise the end of the laughter is the end of the sound or movement.
Speech-Laughter: The segments start when the laughter starts to happen and ends either with a breath intake sound or when the movement or sound ends. Speech-laughs can be as short as one vowel/consonant (30 ms) or as long as full sentences.

Arousal/Intensity Laughter Tier

Modality: audio and visual (facial expressions, head movement, body movements)
Values: low, medium, high

The arousal of the laughs are annotated subjectively based on the annotator's perception.
!! Laughter level of arousal/intensity do not correspond to acoustic intensity! There can be silent laughs very high on arousal!!

Alignment Tier

Modality: audio and visual (facial expressions, head movement, body movements)
Values: Isolated (i), Antiphonal (A), Coactive onset (C)

Isolated: The laugh is not preceded by any other laugh from the partner (within 1 sec).
Antiphonal: A laugh that start shortly after the onset of the partner's laughter and within 1 sec after the partner's laughter offset.
Coactive Onset: The interactants start laughing with the same onset time (considered same onset if the distance between the 2 laughs is less than 100 ms).

Response to Other's Laughter Tier

Modality: audio and visual (facial expressions, head movement, body movements)
Every time a laughter is identified, look/listen at the multi-modal reaction from the partner.
Values: Explicit, Implicit, None, No_vis

Explicit: the partner responds to the laughter with a Laughter him/her self, a Smile, an orienting Look, an Exclamation or with a Clarification Request.
Implicit: after the laughter the partner just continues with her/his activity, e.g. child is singing and looking at the mother, the mother laughs, and the child continues singing and looking at the mother.
None: no orienting attention behavior can be observed, neither continuation of activity.
No_vis: the multimodal reaction is not visible, either because the participant is giving the back to the camera or is off-camera.

Appendix C: Supplemental Examples Extracted from the Providence Corpus (Demuth et al., 2006)

(13) *Example from Providence Corpus—Naima 010014 (263–267)*—Mother laughter mimicry
Mum: ring around the rosies
Mum: a pocket full of posies
Mum: ashes, ashes
Mum: we all go down
Child: <laughter/>
Mum: <laughter/>

(14) *Example from Providence Corpus—Alex 030103 (398–401)*—Child laughter mimicry
Child: No this one!
Mum: Alright! Can I use the pen?
Child: No! [screaming]
Mum: <laughter> Stop it! </laughter>
Child: <laughter/>
Mum: Stop that screaming!

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Availability of Data and Materials The videos annotated for the current work are all publicly available on the CHILDES database at https://phonbank.talkbank.org/access/Eng-NA/Providence.html. Our full annotation dataset, all indexed videoclips referred to throughout the manuscript, and materials related to the statistical analysis are available at: https://osf.io/48fmd/?view_only=a3bcf69ab71f43fdac820b1e46c6e5de.

Code Availability The R scripts used for the statistical analysis are available at https://osf.io/48fmd/?view_only=a3bcf69ab71f43fdac820b1e46c6e5de.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

References

Addyman, C., Fogelquist, C., Levakova, L., & Rees, S. (2018). Social facilitation of laughter and smiles in preschool children. *Frontiers in Psychology, 9*, 1048.
Apte, M. L. (1985). *Humor and laughter: An anthropological approach*. Cornell University Press.
Argyle, M. (1988). Social cognition and social interaction. *The Psychologist, 1*(5), 177–183.
Asada, M. (2016). Modeling early vocal development through infant–caregiver interaction: A review. *IEEE Transactions on Cognitive and Developmental Systems, 8*(2), 128–138.
Bachorowski, J.-A., & Owren, M. J. (2001). Not all laughs are alike: Voiced but not unvoiced laughter readily elicits positive affect. *Psychological Science, 12*(3), 252–257.
Baron-Cohen, S. (1989). Perceptual role taking and protodeclarative pointing in autism. *British Journal of Developmental Psychology, 7*(2), 113–127.
Baron-Cohen, S. (1997). *Mindblindness: An essay on autism and theory of mind*. MIT Press.
Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. arXiv preprint arXiv:1506.04967.
Bavelas, J. B., & Chovil, N. (2000). Visible acts of meaning: An integrated message model of language in face-to-face dialogue. *Journal of Language and Social Psychology, 19*(2), 163–194.
Bekinschtein, T. A., Davis, M. H., Rodd, J. M., & Owen, A. M. (2011). Why clowns taste funny: The relationship between humor and semantic ambiguity. *Journal of Neuroscience, 31*(26), 9665–9671.
Bloom, K., D'Odorico, L., & Beaumont, S. (1993). Adult preferences for syllabic vocalizations: Generalizations to parity and native language. *Infant Behavior and Development, 16*(1), 109–120.

Bornstein, M. H., & Manian, N. (2013). Maternal responsiveness and sensitivity reconsidered: Some is more. *Development and Psychopathology, 25*(4pt1), 957–971.
Bornstein, M. H., Tamis-LeMonda, C. S., Hahn, C.-S., & Haynes, O. M. (2008). Maternal responsiveness to young children at three ages: Longitudinal analysis of a multidimensional, modular, and specific parenting construct. *Developmental Psychology, 44*(3), 867.
Bowlby, J. (1969). *Attachment and loss v. 3* (Vol. 1). Random House.
Branigan, H. P., Pickering, M. J., Pearson, J., & McLean, J. F. (2010). Linguistic alignment between people and computers. *Journal of Pragmatics, 42*(9), 2355–2368.
Branigan, H. P., Pickering, M. J., Pearson, J., McLean, J. F., & Brown, A. (2011). The role of beliefs in lexical alignment: Evidence from dialogs with humans and computers. *Cognition, 121*(1), 41–57.
Bridgett, D. J., Laake, L. M., Gartstein, M. A., & Dorn, D. (2013). Development of infant positive emotionality: The contribution of maternal characteristics and effects on subsequent parenting. *Infant and Child Development, 22*(4), 362–382.
Brugman, H., & Russel, A. (2004). Annotating multi-media/ multi-modal resources with ELAN. In *Proceedings of the fourth international conference on language resources and evaluation (LREC'04)*, Lisbon, Portugal. European Language Resources Association (ELRA).
Buckley, B. (2012). *Children's communication skills: From birth to five years*. Routledge.
Camaioni, L. (1992). Mind knowledge in infancy: The emergence of intentional communication. *Early Development and Parenting, 1*(1), 15–22.
Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen-through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior and Development, 21*(2), 315–330.
Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development, 63*, i–174.
Chapman, A. J. (1973). Social facilitation of laughter in children. *Journal of Experimental Social Psychology, 9*(6), 528–541.
Chapman, R. S. (2000). Children's language learning: An interactionist perspective. *The Journal of Child Psychology and Psychiatry and Allied Disciplines, 41*(1), 33–54.
Charman, T., Baron-Cohen, S., Swettenham, J., Baird, G., Cox, A., & Drew, A. (2000). Testing joint attention, imitation, and play as infancy precursors to language and theory of mind. *Cognitive Development, 15*(4), 481–498.
Chartrand, T. L., & Lakin, J. L. (2013). The antecedents and consequences of human behavioral mimicry. *Annual Review of Psychology, 64*, 285–308.
Cohn, J. F., & Tronick, E. Z. (1987). Mother–infant face-to-face interaction: The sequence of dyadic states at 3, 6, and 9 months. *Developmental Psychology, 23*(1), 68.
Collis, G. M. (1985). On the origins of turn-taking: Alternation and meaning. In *Children's Single-word Speech* (pp. 217–230).
Cosentino, S., Sessa, S., & Takanishi, A. (2016). Quantitative laughter detection, measurement, and classification—a critical survey. *IEEE Reviews in Biomedical Engineering, 9*, 148–162.
Cuffari, E. C., Di Paolo, E., & De Jaegher, H. (2015). From participatory sense-making to language: There and back again. *Phenomenology and the Cognitive Sciences, 14*(4), 1089–1125.
Curran, W., McKeown, G. J., Rychlowska, M., André, E., Wagner, J., & Lingenfelser, F. (2017). Social context disambiguates the interpretation of laughter. *Frontiers in Psychology, 8*, 2342.
Dale, R., & Spivey, M. J. (2006). Unraveling the dyad: Using recurrence analysis to explore patterns of syntactic coordination between children and caregivers in conversation. *Language Learning, 56*(3), 391–430.
Davila Ross, M., Menzler, S., & Zimmermann, E. (2007). Rapid facial mimicry in orangutan play. *Biology Letters, 4*(1), 27–30.
Davila-Ross, M., Allcock, B., Thomas, C., & Bard, K. A. (2011). Aping expressions? chimpanzees produce distinct laugh types when responding to laughter of others. *Emotion, 11*(5), 1013.
De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making. *Phenomenology and the Cognitive Sciences, 6*(4), 485–507.
Demuth, K., Culbertson, J., & Alter, J. (2006). Word-minimality, epenthesis and coda licensing in the early acquisition of English. *Language and Speech, 49*(2), 137–173.
Denby, J., & Yurovsky, D. (2019). Parents' linguistic alignment predicts children's language development. In *Proceedings of the 41th annual conference of the cognitive science society* (pp. 1627–1632).
Devillers, L., & Vidrascu, L. (2007). Positive and negative emotional states behind the laughs in spontaneous spoken dialogs. In *Interdisciplinary workshop on the phonetics of laughter* (p. 37).
Ekman, P., & Friesen, W. V. (1975). *Unmasking the face: A guide to recognizing emotions from facial cues*. Prentice Hall.

Fernández, R., & Grimm, R. (2014). Quantifying categorical and conceptual convergence in child-adult dialogue. In *Proceedings of the annual meeting of the cognitive science society* (Vol. 36).

Fogel, A. (1990). The process of developmental change in infant communicative action: Using dynamic systems theory to study individual ontogenies. *Individual Differences in infancy: Reliability, Stability, Prediction*, 341–358.

Fogel, A. (1977). Temporal organization in mother-infant face-to-face interaction. *Studies in Mother-Infant Interaction, 119*, 151.

Fogel, A. (1982). Social play, positive affect, and coping skills in the first 6 months of life. *Topics in Early Childhood Special Education, 2*(3), 53–65.

Fogel, A., Dickson, K. L., Hsu, H.-C., Messinger, D., Nelson-Goens, G. C., & Nwokah, E. (1997). Communication of smiling and laughter in mother-infant play: Research on emotion from a dynamic systems perspective. *New Directions for Child and Adolescent Development, 1997*(77), 5–24.

Fontaine, J. R., Scherer, K. R., Roesch, E. B., & Ellsworth, P. C. (2007). The world of emotions is not two-dimensional. *Psychological Science, 18*(12), 1050–1057.

Fridlund, A. J. (1991). Sociality of solitary smiling: Potentiation by an implicit audience. *Journal of Personality and Social Psychology, 60*(2), 229.

Fuchs, S., & Rathcke, T. (2018). Laugh is in the air? In *Proceedings of laughter workshop 2018, Paris, France* (pp. 21–24).

Fusaroli, R., Rączaszek-Leonardi, J., & Tylén, K. (2014). Dialog as interpersonal synergy. *New Ideas in Psychology, 32*, 147–157.

Fusaroli, R., & Tylén, K. (2012). Carving language for social coordination: A dynamical approach. *Interaction Studies, 13*(1), 103–124.

Ginzburg, J., Mazzocconi, C., & Tian, Y. (2020). Laughter as language. *Glossa: A Journal of General Linguistics, 5*(1), 104.

Goldstein, M. H., King, A. P., & West, M. J. (2003). Social interaction shapes babbling: Testing parallels between birdsong and speech. *Proceedings of the National Academy of Sciences, 100*, 8030–8035.

Goldstein, M. H., Schwade, J. A., & Bornstein, M. H. (2009). The value of vocalizing: Five-month-old infants associate their own noncry vocalizations with responses from caregivers. *Child Development, 80*(3), 636–644.

Gratier, M., Devouche, E., Guellai, B., Infanti, R., Yilmaz, E., & Parlato-Oliveira, E. (2015). Early development of turn-taking in vocal interaction between mothers and infants. *Frontiers in Psychology, 6*(1167), 236–245.

Griffin, H. J., Aung, M. S., Romera-Paredes, B., McLoughlin, C., McKeown, G., Curran, W., & Bianchi-Berthouze, N. (2013). Laughter type recognition from whole body motion. In *2013 Humaine association conference on affective computing and intelligent interaction* (pp. 349–355).

El Haddad, K., Cakmak, H., & Dutoit, T. (2018). On laughter intensity level: Analysis and estimation. In *Proceedings of laughter workshop, Paris, France*.

El Haddad, K., Chakravarthula, S. N., & Kennedy, J. (2019). Smile and laugh dynamics in naturalistic dyadic interactions: Intensity levels, sequences and roles. In *2019 International Conference on Multimodal Interaction* (pp. 259–263).

Hilbrink, E. E., Gattis, M., & Levinson, S. C. (2015). Early developmental changes in the timing of turn-taking: A longitudinal study of mother–infant interaction. *Frontiers in Psychology, 6*, 1492.

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review, 26*(1), 55–88.

Hoicka, E., & Gattis, M. (2008). Do the wrong thing: How toddlers tell a joke from a mistake. *Cognitive Development, 23*(1), 180–190.

Hoicka, E., Jutsum, S., & Gattis, M. (2008). Humor, abstraction, and disbelief. *Cognitive Science, 32*(6), 985–1002.

Hough, J., Tian, Y., de Ruiter, L., Betz, S., Schlangen, D., & Ginzburg, J. (2016). Duel: A multi-lingual multimodal dialogue corpus for disfluency, exclamations and laughter. In *10th Edition of the language resources and evaluation conference.*

Hsu, H.-C., & Fogel, A. (2001). Infant vocal development in a dynamic mother-infant communication system. *Infancy, 2*(1), 87–109.

Hsu, H.-C., & Fogel, A. (2003). Stability and transitions in mother-infant face-to-face communication during the first 6 months: A microhistorical approach. *Developmental Psychology, 39*(6), 1061.

Hsu, H.-C., Nwokah, E. E., & Fogel, A. (1998). Characteristics of infant laughter during the first six months of life. *Infant Behavior and Development, 21*, 470.

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001) Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of the Society for Research in Child Development*, i–149.

Kenderdine, M. (1931). Laughter in the pre-school child. *Child Development, 2*(3), 228–230.
Kohler, K. J. (2008). 'Speech-smile', 'speech-laugh', 'laughter'and their sequencing in dialogic interaction. *Phonetica, 65*(1–2), 1–18.
Kret, M. E., Venneker, D., Evans, B., Samara, I., & Sauter, D. (2021). The ontogeny of human laughter. *Biology Letters, 17*, 0319.
Krippendorff, K. (2012). *Content analysis: An introduction to its methodology*. Sage.
Ku, L.-C., Feng, Y.-J., Chan, Y.-C., Wu, C.-L., & Chen, H.-C. (2017). A re-visit of three-stage humor processing with readers' surprise, comprehension, and funniness ratings: An erp study. *Journal of Neurolinguistics, 42*, 49–62.
Leonardi, G., Nomikou, I., Rohlfing, K. J., & Rączaszek-Leonardi, J. (2016). Vocal interactions at the dawn of communication: the emergence of mutuality and complementarity in mother-infant interaction. In *2016 Joint IEEE international conference on development and learning and epigenetic robotics (ICDL-EPIROB)* (pp. 288–293).
Lücking, A., Ptock, S., & Bergmann, K. (2011). Assessing agreement on segmentations by means of staccato, the segmentation agreement calculator according to thomann. In *International gesture workshop* (pp. 129–138).
MacWhinney, B. (2000). *The childes project: Tools for analyzing talk: Volume i: Transcription format and programs, volume ii: The database*. MIT Press.
Malatesta, C. Z., & Haviland, J. M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development*, 991–1003.
Malatesta, C. Z., Culver, C., Tesman, J. R., Shepard, B., Fogel, A., Reimers, M., & Zivin, G. (1989). The development of emotion expression during the first two years of life. *Monographs of the Society for Research in Child Development*, i–136.
Martin, R. A. (2010). *The psychology of humor: An integrative approach*. Elsevier.
Mayo, O., & Gordon, I. (2020). In and out of synchrony—behavioral and physiological dynamics of dyadic interpersonal coordination. *Psychophysiology, 57*(6), e13574.
Mazzocconi, C., Tian, Y., & Ginzburg, J. (2016). Multi-layered analysis of laughter. In *Proceedings of SemDial*.
Mazzocconi, C., Maraev, V., & Ginzburg, J. (2018). Laughter repair. In *Proceedings of Demdial 2018 (aixdial), the 22nd workshop on the semantics and pragmatics of dialogue, Aix-en-Provence ,, France.*
Mazzocconi, C., Maraev, V., Somashekarappa, V., & Howes, C. (2021). Looking for laughs: Gaze interaction with laughter pragmatics and coordination. In *Proceedings of the 2021 international conference on multimodal interaction* (pp. 636–644).
Mazzocconi, C., Tian, Y., & Ginzburg, J. (2020). What's your laughter doing there? A taxonomy of the pragmatic functions of laughter. *IEEE Transactions on Affective Computing, 2020*, 1.
McGhee, P. E. (1977). A model of the origins and early development of incongruity-based humour. In *It's a funny thing, humour* (pp. 27–36). Elsevier.
McGhee, P. E. (1979). *Humor: Its origin and development*. WH Freeman.
McKeown, G., & Curran, W. (2015). The relationship between laughter intensity and perceived humour. In *The 4th interdisciplinary workshop on laughter and other non-verbal vocalisations in speech, Enschede, Netherlands* (pp. 27–29).
Mireault, G. C., & Reddy, V. (2016). *Humor in infants: Developmental and psychological perspectives*. Springer.
Misiek, T., Favre, B., & Fourtassi, A. (2020). Development of multi-level linguistic alignment in child-adult conversations. In *Proceedings of the workshop on cognitive modeling and computational linguistics* (pp. 54–58).
Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders, 20*(1), 115–128.
Nelson, J. K. (2012). *What made Freud laugh: An attachment perspective on laughter*. Routledge.
Nomikou, I. (2015). *The collaborative construction of early multimodal input and its significance for language development*. Unpublished Doctoral Thesis, Bielefeld University.
Nomikou, I., Rohlfing, K. J., & Szufnarowska, J. (2013). Educating attention: Recruiting, maintaining, and framing eye contact in early natural mother–infant interactions. *Interaction Studies, 14*(2), 240–267.
Norris, M. R., & Drummond, S. S. (1998). Communicative functions of laughter in aphasia. *Journal of Neurolinguistics, 11*(4), 391–402.
Nwokah, E. E., Hsu, H.-C., Davies, P., & Fogel, A. (1999). The integration of laughter and speech in vocal communicationa dynamic systems perspective. *Journal of Speech, Language, and Hearing Research, 42*(4), 880–894.

Nwokah, E. E., Hsu, H.-C., Dobrowolska, O., & Fogel, A. (1994). The development of laughter in mother-infant communication: Timing parameters and temporal sequences. *Infant Behavior and Development, 17*(1), 23–35.
O'Connell, D. C., & Kowal, S. (2005). Laughter in Bill Clinton's My Life (2004) interviews. *Pragmatics: Quarterly Publication of the International Pragmatics Association (IPrA), 15*(2), 275–299.
Owren, M. J., & Bachorowski, J.-A. (2003). Reconsidering the evolution of nonlinguistic communication: The case of laughter. *Journal of Nonverbal Behavior, 27*(3), 183–200.
Papafragou, A., Cassidy, K., & Gleitman, L. (2007). When we think about thinking: The acquisition of belief verbs. *Cognition, 105*(1), 125–165.
Patterson, M. L. (1985). The evolution of a functional model of nonverbal exchange: A personal perspective. *Sequence and Pattern in Communicative Behavior*, 190–205.
Patterson, M. L. (1976). An arousal model of interpersonal intimacy. *Psychological Review, 83*(3), 235.
Pedroso, F. (2008). Reflexes. In M. M. Haith & J. B. Benson (Eds.), *Encyclopedia of infant and early childhood development* (pp. 11–23). San Diego: Academic Press. https://doi.org/10.1016/B978-012370877-9.00133-X
Piaget, J. (1945). *Play, dreams, and imitation in childhood*. Norton.
Pickering, M. J., & Garrod, S. (2006). Alignment as the basis for successful communication. *Research on Language and Computation, 4*(2–3), 203–228.
Polimeni, J., & Reiss, J. P. (2006). Humor perception deficits in schizophrenia. *Psychiatry Research, 141*(2), 229–232.
Proyer, R. T., & Ruch, W. (2010). Enjoying and fearing laughter: Personality characteristics of gelotophobes, gelotophiles, and katagelasticists. *Psychological Test and Assessment Modeling, 52*(2), 148–160.
Rączaszek-Leonardi, J., Nomikou, I., & Rohlfing, K. J. (2013). Young children's dialogical actions: The beginnings of purposeful intersubjectivity. *IEEE Transactions on Autonomous Mental Development, 5*(3), 210–221.
Rakoczy, H., Tomasello, M., & Striano, T. (2004). Young children know that trying is not pretending: A test of the" behaving-as-if" construal of children's early concept of pretense. *Developmental Psychology, 40*(3), 388.
Rauchbauer, B., & Grosbras, M.-H. (2020). Developmental trajectory of interpersonal motor alignment: Positive social effects and link to social cognition. *Neuroscience & Biobehavioral Reviews, 118*, 411–428.
Reddy, V. (1991). Natural theories of mind: Evolution, development and simulation of everyday mind-reading. In A. Whiten (Ed.), *Playing with others' expectations: Teasing and mucking about in the first year.* Basil Blackwell.
Reddy, V. (2001). Infant clowns: The interpersonal creation of humour in infancy. *Enfance, 53*(3), 247–256.
Reddy, V. (2008). *How infants know minds*. Harvard University Press.
Reddy, V., Williams, E., & Vaughan, A. (2002). Sharing humour and laughter in autism and down's syndrome. *British Journal of Psychology, 93*(2), 219–242.
Reisenzein, R., Horstmann, G., & Schützwohl, A. (2019). The cognitive-evolutionary model of surprise: A review of the evidence. *Topics in Cognitive Science, 11*(1), 50–74.
Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology, 39*(6), 1161.
Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development, 81*(1), 6–22.
Samson, A. C. (2013). Humor (lessness) elucidated–sense of humor in individuals with autism spectrum disorders: Review and introduction. *Humor, 26*(3), 393–409.
Sauter, D., Evans, B., Venneker, D., & Kret, M. (2018). How do babies laugh? *The Journal of the Acoustical Society of America, 144*(3), 1840–1840.
Saxton, M. (2009). The inevitability of child directed speech. In *Language acquisition* (pp. 62–86). Springer.
Smoski, M., & Bachorowski, J.-A. (2003). Antiphonal laughter between friends and strangers. *Cognition & Emotion, 17*(2), 327–340.
Sroufe, L. A., & Wunsch, J. P. (1972). The development of laughter in the first year of life. *Child Development, 43*, 1326–1344.
Steglich-Petersen, A., & Michael, J. (2015). Why desire reasoning is developmentally prior to belief reasoning. *Mind & Language, 30*(5), 526–549.
Stern, D. N., Jaffe, J., Beebe, B., & Bennett, S. L. (1975). Vocalizing in unison and in alternation: Two modes of communication within the mother-infant dyad. *Annals of the New York Academy of Sciences, 263*(1), 89–100.

Stevenson, M. B., Ver Hoeve, J. N., Roach, M. A., & Leavitt, L. A. (1986). The beginning of conversation: Early patterns of mother-infant vocal responsiveness. *Infant Behavior and Development, 9*(4), 423–440.
Sullivan, K., Winner, E., & Hopfield, N. (1995). How children tell a lie from a joke: The role of second-order mental state attributions. *British Journal of Developmental Psychology, 13*(2), 191–204.
Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development, 72*(3), 748–767.
Team, R. C. (2016). *R: A language and environment for statistical computing*. Computer Software Manual.
Thompson, R. A. (1991). Emotional regulation and emotional development. *Educational Psychology Review, 3*(4), 269–307.
Tomasello, M., et al. (1995). Joint attention as social cognition. In *Joint attention: Its origins and role in development* (pp. 103–130).
Tomasello, M., Call, J., Nagell, K., Olguin, R., & Carpenter, M. (1994). The learning and use of gestural signals by young chimpanzees: A trans-generational study. *Primates, 35*(2), 137–154.
Tronick, E. (2007). *The neurobehavioral and social-emotional development of infants and children*. WW Norton.
Trouvain, J. (2001). Phonetic aspects of "speech-laughs". In *Proceedings of the 2nd conference on orality and gestuality* (pp. 634–639).
Trujillo, J. P., & Holler, J. (2021). The kinematics of social action: Visual signals provide cues for what interlocutors do in conversation. *Brain Sciences, 11*(8), 996.
Urbain, J., Niewiadomski, R., Mancini, M., Griffin, H., Cakmak, H., Ach, L., & Volpe, G. (2013). Multimodal analysis of laughter for an interactive system. In *International conference on intelligent technologies for interactive entertainment* (pp. 183–192).
Vettin, J., & Todt, D. (2004). Laughter in conversation: Features of occurrence and acoustic structure. *Journal of Nonverbal Behavior, 28*(2), 93–115.
Warlaumont, A. S., Richards, J. A., Gilkerson, J., & Oller, D. K. (2014). A social feedback loop for speech development and its reduction in autism. *Psychological Science, 25*(7), 1314–1324.
Washburn, R. W., Sptiz, R. A., & Goodenough, F. L. (1972). *Facial expression in children: Three studies*. Ayer Company Pub.
Wilkie, I., & Saxton, M. (2010). The origins of comic performance in adult-child interaction. *Comedy Studies, 1*(1), 21–32.
Young, P. T. (1937). Laughing and weeping, cheerfulness and depression: A study of moods among college students. *The Journal of Social Psychology, 8*(3), 311–334.
Young, R. D., & Frye, M. (1966). Some are laughing; some are not—Why? *Psychological Reports, 18*(3), 747–754.
Yurovsky, D., Doyle, G., & Frank, M. C. (2016). Linguistic input is tuned to children's developmental level. In A. Papafragou, D. Grodner, D. Mirman, & J. C. Trueswell (Eds.), *Proceedings of the 38th annual meeting of the cognitive science society, Cogsci 2016, Philadelphia, PA, August 10–13, 2016*. cognitivesciencesociety.org.
Zigler, E., Levine, J., & Gould, L. (1966). Cognitive processes in the development of children's appreciation of humor. *Child Development, 37*, 507–518.

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