Making Sense of Infants' Differential Responses to Incongruity

Gina C. Mireault^a Vasudevi Reddy^b

^aNorthern Vermont University-Johnson, Johnson, VT, USA; ^bUniversity of Portsmouth, Portsmouth, UK

Keywords

Incongruity · Violation of expectation · Infancy · Sense-making · Cognitive development · Emotional development · Looking time · Laughter

Abstract

Infants show strikingly different reactions to incongruity: looking or smiling. The former occurs in response to magical events and the latter to humorous events. We argue that these reactions depend largely on the respective experimental methodologies employed, including the popular violation of expectation (VOE) paradigm. Although both types of studies involve infants' reactions to incongruity, their literatures have yet to confront each other, and researchers in each domain are drawing strikingly different conclusions regarding infants' understanding of the world. Here, we argue that infants are sensitive to and constrained by several contextual differences in the methodologies employed by incongruity researchers that afford one or the other reaction. We apply De Jaegher and Di Paolo's participatory sense-making framework to further understand what infants are sensitive to in these paradigms. Understanding infants' reactions to incongruity (i.e., VOE) is necessary to clear up claims

regarding the sophistication of their knowledge of physical and social phenomena. Attention to several simple methodological details is recommended.

© 2020 S. Karger AG, Basel

The Puzzle

Within the first six months of life, infants show two very different reactions to phenomena involving incongruity: looking (Baillargeon, 1994, 1998, 2004) or smiling (Mireault & Reddy, 2016). The question explored here is, why? Incongruous events that elicit looking are often described as “magical” and involving “tricks” (Walden, Kim, McCoy, & Karrass, 2007, p. 654), while those that prompt smiling are often described as “humorous” (Pien & Rothbart, 1976). However, both types of incongruous events share key qualities. For example, both involve novelty, captivating infants' attention by violating their expectations. Both are also nonthreatening, inconsequential, and not unpleasant (Warren & McGraw, 2016). What is it therefore that infants are sensitive to that predictably elicits these different responses? Is it due to differences in the nature of the events themselves, or something periph-

eral to the events, or other unintended aspects of the experimental procedures? Dissecting the ways in which these incongruities differ should give us important insights into infants' responses to and experiences of the physical and social world.

Unpacking Incongruity

Let's begin with the meaning of the word "incongruity," which refers to a disharmony, discordance, or inconsistency between two juxtaposed events or stimuli. For example, hearing a large muscled man speak in a high squeaky voice, seeing the sun floating in a night sky, or observing an object vanish before one's eyes are all incongruous events. The developmental literature commonly refers to these incongruous events as "violations of expectations" (VOE), meaning the discrepancy exists between what one *expects* to happen versus what one *experiences* (Charles & Rivera, 2009). The word "incongruity" is used to describe both magical and humorous events in studies investigating infants' reactions to them. For example, researchers exploring magical incongruities, typically referred to as VOE studies, have used the term as follows: "...even 2-year-olds' reasoning may be limited to recognizing after-the-fact incongruent events..." (Keen, 2003, p. 82), "...Experiment 4 revealed no significant increase in the strength of the incongruity preference..." (Powell & Spelke, 2018, p. 44), and "Seeing a hand carry an object out of the display did not prevent infants from detecting the incongruity of the result revealed behind the screen..." (Wynn & Chiang, 1998, p. 453). Similarly, those investigating humorous incongruities have employed the term: "Resolved incongruity, in addition to pure incongruity, may be appreciated even by infants" (Pien & Rothbart, 1976, p. 970), "...we would speculate that the infant laughs on those trials when the incongruity is fully processed..." (Sroufe & Wunsch, 1972, p. 1341), and "...infants ... copy incongruous actions paired with laughter..." (Esseilly, Rat-Fischer, Somogyi, O'Regan, & Fagard, 2016, p. 818). Therefore, the same experience – that of incongruity – leads puzzlingly to very different responses in infants.

The historical origins of the notion of incongruity – or of its earlier form, bisociation – might provide a starting point to explain this diversity of response. Koestler (1964/1975) coined the term bisociation to distinguish between routine thinking, which occurs in a single frame of reference and creative thinking that involves more than one frame of reference. Two important points in the no-

tion of bisociation are relevant here. First, bisociation, which Koestler linked to humor, is not limited to humor. It occurs in science and art too, working differently in each case and bringing about different cognitive and emotional byproducts. In science, bisociated frames of reference merge in a new synthesis, leading to progress in scientific discovery. In art, bisociated frames of reference are continuously juxtaposed, which is key to the perception of art. In humor, the juxtaposed frames of reference may be linked at one point (as in the sound of the word in a pun) and then suddenly switched to reveal a punch line. The second relevant point is that bisociation creates inherent instability – a cognitive/emotional disturbance – in the individual who experiences it. This cognitive/emotional disequilibrium is inherent in bisociation, which is to say, it is inherent in incongruity.

In sum, the nature of the incongruity or bisociation varies in different contexts and domains, as does the emotional experience of the disturbance. Studies of magical and humorous incongruities may represent these types of differences, affording different cognitive and emotional experiences. We therefore need to look at the details of both types of studies in order to understand what infants make of incongruities presented in these different experimental traditions and what might lead to their varying responses. Conclusions based on grouping together large numbers of studies that ignore the contextual specifics are likely to involve superficial explanatory glosses and will bump into problems sooner or later. Contextual factors such as local affordances or developmental histories may influence the infant's behavior, and we propose that it is in these details of the contexts where we can gain the most insight regarding what incongruity means to infants. Notably, Walden and Baxter (1989) credit Graziano (1987) when remarking that the "lack of understanding of the effect of contextual variations on behavior is one of the largest single obstacles blocking our understanding of complex social processes" (p. 1511). This observation remains relevant and requires exploration of the specific research contexts of magical and humorous incongruities.

Magical Incongruities

Baillargeon, Spelke, and Wasserman (1985) are generally credited with the paradigm-shifting VOE design which they first employed to examine whether very young infants understood object permanence (Charles & Rivera, 2009). The VOE paradigm, however, quickly became a

means for discovering how infants respond to events that violate a range of natural laws (e.g., gravity, continuity, solidity, etc.), and therefore appearing to be physically impossible or magical. VOE experiments involve presenting infants with screens that appear to pass through solid objects (Baillargeon et al., 1985), containers that appear to be impossibly placed in and occluded by smaller or transparent containers (Baillargeon & Wang, 2002; Hespos & Baillargeon, 2001; Wang, Baillargeon, & Brueckner, 2004), balls appearing to fall or roll through solid objects (Spelke, Breinlinger, Macomber & Jacobson, 1992), and objects appearing to roll along unsupported paths (Spelke et al., 1992), for example.

The VOE usually begins with a habituation phase to familiarize infants with the event, which occurs on a display in front of them, repeating the same trial until a predetermined reduction in looking has been reached (e.g., a 50% reduction in looking time) or a fixed number of trials has been completed (Charles & Rivera, 2009). Following habituation there are a series of test trials in which equal numbers of “possible” (i.e., consistent with natural laws, nonmagical) and “impossible” (i.e., inconsistent with natural laws, magical) events are presented, both of which are iterations of the initial habituated event. VOE studies generally adhere to the technique as described by Baillargeon et al. (1985) in their seminal experiment:

... a box was placed on a surface behind a wooden screen. The screen initially lay flat, so that the box was clearly visible. The screen was then raised, in the manner of a drawbridge, thus hiding the box from view. Infants were shown two test events: a possible event and an impossible event. In the possible event, the screen moved until it reached the occluded box, stopped, and then returned to its initial position... In the impossible event, the screen moved until it reached the occluded box – and then kept on going as though the box were no longer there! The screen completed a full 180-degree arc before it reversed direction and returned to its initial position, revealing the box standing intact in the same location as before (p. 195).

To know whether infants detect a difference between possible and impossible events, their looking times are compared based on the “...commonly held assumption that infants react to novel or surprising events with prolonged attention...” (Baillargeon et al., 1985, p. 196). Such studies, which tend to occur under tightly controlled laboratory conditions, have consistently shown that infants as young as 3.5 months look longer at events that break natural laws including those involving gravity, continuity, and solidity, and indicating that infants have detected the incongruity (Keen, 2003). Researchers have interpreted this to mean that infants have some knowledge regard-

ing the behavior of objects in accordance with natural laws such as gravity (Walden et al., 2007). Baillargeon has sometimes described these events – and infants’ prolonged looking at them – as akin to the impossibilities observed in magic shows.

Babies look longer at events they view as unexpected. It is a “whoa” look – a state of heightened attention. It’s like it is in everyday life. You expect something and then when it’s not what it should be, you tend to look longer, as when we watch a magic show. It’s the wow of the unexpected (Baillargeon, from Barlow, 2005).

Humorous Incongruities

Another line of research has investigated infants’ responses to incongruous social or behavioral events. The latter can also be characterized as VOEs (Sroufe & Wunsch, 1972) as they involve violations of social or behavioral norms. Like Baillargeon et al.’s (1985) initial study that set out to explore whether very young infants were aware of object permanence, these studies set out to explore whether very young infants were able to engage in social referencing. To do so, researchers explored whether infants rely on parental emotional signals (i.e., laughing and smiling) to interpret an incongruous event as amusing (e.g., Mireault, Crockenberg, Sparrow, Pettinato, Woodard, & Malzac, 2014).

These studies tend to involve infants as young as 4 months observing an emotionally neutral experimenter present familiar household objects to caregivers in ordinary (e.g., rolling a ball) and unexpected (e.g., wearing the ball as a clown nose) ways (Mireault et al., 2014; Mireault, Crockenberg, Sparrow, Cousineau, Pettinato, & Woodard, 2015). Caregivers are instructed either to show positive affect (laugh and smile) toward the event or to remain neutral toward it. Habituation trials are not required since the events and objects are within the ordinary experience of infants and because the randomized, repeated-measures design controls for extraneous variables that might affect infants’ responses. These experiments generally adhere to the technique as described by Mireault, Crockenberg, Heilman, Sparrow, Cousineau, & Rainville (2018):

Infants watched while a research assistant showed parents two ordinary events (narration of playing with a ball or drinking from a cup, or read a book) and two absurd events (ball worn as a clown nose and continuously poked while saying “beep,” book or cup worn like hat and continuously raised and lowered while saying “joop”), in a within-subjects randomized design. Each absurd

event was presented twice: once with parents exhibiting neutral affect and once with parents exhibiting positive affect towards the event (i.e., smiling and laughing). Except for parental affect (neutral and positive), which was counter-balanced for the absurd events, the absurd events were identical. Parental affect was not manipulated during ordinary events in order to preserve their ordinary nature. Thus, there were six randomized conditions each lasting 45 s: two ordinary events, two absurd-neutral events, and two absurd-positive events. The absurd-neutral and absurd-positive events were identical with the exception of parental affect.

All events were performed for the parent by an experimenter who remained affectively neutral, and each event was separated by 10 s (p. 5).

To know whether infants detect a difference between incongruous and ordinary events, researchers focus on infants' rates of smiling and laughing, although they also measure looking times. Such studies, which tend to occur under naturalistic conditions in infants' homes, have consistently shown that infants as young as 5 months smile and laugh more at incongruous events, indicating that they have detected the incongruity (Mireault et al., 2018; Sroufe & Wunsch, 1972). Since they smile and laugh towards the incongruous events even when parents are emotionally neutral, infants are not simply mimicking parental laughter or relying on parental affect to interpret the incongruity as amusing. Looking times tend to reveal inconsistent results depending on the measure employed (i.e., frequency, duration, latency to look away, etc.) and thus do not provide as stable a metric as smiling and laughing. However, looking times have confirmed infants' ability to detect these social and behavioral incongruities, with 6-month-olds taking longer to look away, for example, although 4-month-olds do not differ significantly in their looking times (Mireault et al., 2018). Since infants smile and laugh at such incongruities beginning at 5 months, researchers have applied the same inference used in the VOE literature (Walden et al., 2007) interpreting infants' detection of and reaction to incongruity to mean that they have some knowledge regarding social norms. For example, in considering why infants often find their mirrored reflections humorous, Addyman speculated:

Conversation and social interaction involve turn-taking, but the person in the mirror is breaking these conventions by doing everything at the same time (Addyman, 2014).

In sum, both types of incongruity share some central features. Both involve an event that is outside of infants' expectations and that is therefore initially captivating. Both are harmless, nonthreatening, inconsequential

(Warren & McGraw, 2016) and not specifically unpleasant (Walden et al., 2007). However, these incongruities also differ in important ways that may provide insight into infants' social-emotional and cognitive processes and reveal what they are sensitive to.

Differences between “Magical” and “Humorous” Incongruity Studies

The Possibility of Events

In both magical and humorous incongruity studies, there is a violation of some sort of expectancy. In the former it is a violation of natural laws such that the event appears to be physically impossible. In the latter, the violations involve social practices such that the event does not entertain impossibility. In the simplest comparison, one set of events is impossible and therefore no sense can be made of them, leading to longer looking, while the other set of events is merely odd, allowing more sense to be made of them and leading to other reactions, like smiling. Could the disparity in infants' reactions be due to this striking difference in the events as VOE researchers contend? Even were this the case, privileging infants with knowledge of the laws of physics still does not explain the difference in responses. For example, why should longer looking be the response rather than distress? Why respond to the possible-but-odd with smiling, and conversely why *not* respond to the impossible with laughter? Does the physically impossible somehow directly elicit a more fundamental shock?

There are reasons to suggest that this may not be the case. First, infants have also been observed to look longer at physically-possible-but-socially-unexpected events. For instance, Fantasia, Markova, Fasulo, Costall, & Reddy (2016) reported that 3-month-olds reacted with more frequent gaze shifts to a VOE. Mothers were instructed to reach for their babies and then stop with arms outstretched before actually picking up the baby. In another study (Fantasia, Fasulo, Costall, & Lopez, 2014), mothers were instructed to sing/play one of their customary action rhymes to their babies, but to do so either without sound or without gesture. Infants reacted with stunned expressions (wide open eyes), body stilling, and more frequent looking away when confronted by those incongruities, which cannot be accounted for by the “impossibility” explanation as these actions by the mother were certainly physically possible. Similarly, infant body stilling has been reported in still face studies (Tronick, Adamson,

Als, & Brazelton, 1975) at the onset of the mother's still face, also not fitting within the impossibility explanation. These findings show that social incongruities, like physical incongruities, can also evoke longer looking, and this further indicates that the two types of events are reasonable to compare.

Second, children and adults do laugh at magical and seemingly impossible events as evidenced by the popularity and "fun" of magic shows, suggesting that amusement is a complex emotional response not simply attained by the nature of the stimulus. It could be argued that these types of mis-expected actions by mothers do in fact constitute a social impossibility for infants and thus lead to longer looking. What then are the factors that distinguish them from social incongruities that lead to smiling? Perhaps a more graded consideration of what constitutes the impossible is needed, as well as attention to the greater complexity in infants' understanding of social actions and practices.

Familiarity of Context

As Sroufe and Wunsch (1972) observed in infants' differential reactions to stimuli, "...context and stimulus may be inseparable" (p. 1340). The studies of magical incongruities are traditionally carried out in carefully controlled laboratory settings that might be described as "familiar-context deprived" in which the infant watches objects moving across a display. The standardized setup controls the potential effects of an experimenter's presence, minimizes the distraction of an experimenter, and maximizes the infant's attention to the events. These qualities are in part why studies of physical incongruities include habituation trials, to ensure infants acclimate to these highly unusual situations. That is, the infant has no history with events in which objects behave in unusual ways; the habituation trials provide the infant with that experience. Studies of humorous incongruities, by contrast, are often carried out in infants' homes in an attempt to minimize the distraction of a novel laboratory environment and to preserve the setting in which infants are likely to encounter humorous events (Mireault et al., 2015; Sroufe & Wunsch, 1972). They might be described as "familiar-context rich." Of relevance is Walden & Baxter's (1989) note that infants smile less when studies are conducted in laboratory settings than in the familiar context of the home. Thus, the laboratory context of VOE studies narrows the possibility of infants' smile response even if researchers were attending to it as a dependent variable.

Social Embodiedness and Embeddedness

Relatedly, one key difference between the two sets of studies may lie in the extent to which the incongruities presented are socially embodied and embedded. In studies of magical incongruities, objects appear to be behaving independently as disembodied entities, i.e., there is no one acting on the objects or performing the events. As explained by Spelke et al. (1992),

...the infant viewed the display from a reclineable seat surrounded by a curtain... (p. 612) and ...a hand entered the display and removed the ball... (p. 610) and ...the presenter disappeared behind the display... lowered the screen and presented the ball in her right hand ... while introducing her left hand through the bottom opening... (p. 612).

The complete absence of people or the involvement of partially occluded people performing the events also makes it strangely "disembodied," depriving the event of any social context that might aid the infant in making sense of it. In studies of humorous incongruities, by contrast, the events involve a person who manipulates an object, such that objects do not appear to be behaving independently – or behaving at all; instead, the event is the experimenter's behavior *with* the object. Further, infants are in the presence of a parent and an experimenter who presents or performs the event. Even in studies in which parents and experimenters do not engage with the infant, both social partners are wholly visible. The incongruity is both socially embodied and socially embedded. As described by Mireault et al. (2014),

infants were seated in a high chair between the researcher and the parent ... seating arrangement allowed the infant to see both the parent and the event presented by the researcher... The effect of this configuration was to place the infant in the role of observing the event and the parent's reaction to it and ...The researcher presented three events with each of two objects (ball and book) to parents while infants observed and ...the opened book was repeatedly placed upside down on the researcher's head while she said "joop joop"; the ball was worn as a clown nose and poked with her finger while she said "beep beep"... (p. 539).

Repetition and Duration of Events

Another key feature that may explain infants' different reactions to these incongruities is that, unlike magical events, humorous events are of longer duration and are presented with repetition (Sroufe & Wunsch, 1972; Mireault, Sparrow, Poutre, Perdue, & Macke, 2012;

Mireault et al., 2014, 2015). Duration may well be crucial, as infants initially look at novelty before smiling or laughing. Their latency to smile may reflect the time it takes for them to make sense of the incongruity with the available social information and challenges the snapshot approach to measuring meaningful infant reactions.

The repetitious nature of humorous incongruities may allow another route for infants to evaluate them as amusing for two reasons. One is anticipation (often credited for why peekaboo is funny; Nomikou, Leonardi, Radkowska, Raczaszek-Leonardi, & Rohlfing, 2017). Another is that repetition may help infants understand the *intentionality* of the behavior, a feature necessary for perceiving a joke (Hoicka & Gattis, 2008). Research suggests that young infants may be able to infer others' intentions based on repetition (Gergely & Csibra, 2003; Gergely, Nádasdy, Csibra, & Biró, 1995; Mireault et al., 2018; Tauzin & Gergely, 2018). Repetition could also offer infants in these situations a preparedness, a readiness-to-interact and a readiness for emotional participation with others (Di Paolo & De Jaegher, 2012) that allows for easier grasping of the incongruity. Analyses that consider the standard "action arcs" of humorous versus magical interactions specific to violations of timing may shed further light on how infants distinguish incongruities (Rossmanith, Costall, Reichelt, López, & Reddy, 2014).

Making Sense of Incongruity

How might the differences described above explain why, when confronted with some sorts of incongruities infants look while towards others they smile? Our argument is that infants are involved participants in these situations, actively seeking to make sense of the incongruities with which they are confronted. They use not only a wider range of information from the experimental contexts than is perhaps intended by the investigators, but are also engaged in a dynamic process of sense-making revealed in their responses. As De Jaegher and Di Paolo (2007) argue, sense-making is an active process:

Organisms do not passively receive information from their environments, which they then translate into internal representations whose significant value is to be added later. Natural cognitive systems are simply not in the business of accessing their world in order to build accurate pictures of it. They actively participate in the generation of meaning in what matters to them; they enact a world. Sense-making is a relational and affect-laden process grounded in biological organization (p. 488).

Based on this, we propose that it is not simply the type of incongruous event that leads infants to one or the other reaction. It is necessarily in the relation between infant and event not only in the present moment, but also in the infant's history with objects and with people – including their emotional expressions – that converge to create a given context. Richer contexts must afford greater opportunity for sense-making resulting in more ample and active emotional reactions like smiling and laughing, compared to looking or stunned reactions when sense-making is hindered by an impoverishment of relations. A more complete explanation, we suggest, comes from thinking about the role that people and context play in the presentation of incongruities. To this point, in replications of Baillargeon and Graber's (1987), Wynn's (1992), and Simon, Hespos, and Rochat's (1995) studies involving physical incongruities, Walden et al. (2007) and Dunn and Bremner (2017) found that infants looked more frequently to caregivers' faces (i.e., social looking) during unexpected or expectancy-violating events than at expected or simply novel events. They concluded that infants search the social environment for information about unusual events, highlighting the important knowledge the social context may or may not afford. This finding in particular emphasizes the significance of the social context both for infants' understanding of incongruities and for our understanding of infants' experience of them.

We are arguing that in one type of incongruity – those that are humorous – there is information available for infants to "make sense" of it, while in the other – those that are magical – the only information available is the incongruity itself. The inability to "make sense" of the incongruity may be the reason for longer looking times and stunned expressions. Until the infant makes sense of the event, the only option is to just look at it.

Studies of humorous incongruities necessarily involve people as a central part of the violation who – even when they do not actually offer emotional information – alter the context the infant is in. But what is it about people and context that enables sense-making? The presence of involved others in an experimental situation could be significant in different ways. Mere presence is not enough; the involved others seem to need to be coparticipants in order for infants to respond to incongruity with an emotion instead of with simply looking. As coparticipants, social partners – even when they are emotionally neutral – jointly attend to the incongruity, and inadvertently invite participatory sense-making in a reality that is necessarily shared. That infants search the social environment when confronted with bizarre incongruous events

(Dunn & Bremner, 2017; Walden et al., 2007) strongly supports the idea that they attempt, and in fact prioritize, sense-making when the opportunity exists.

Additionally, these social partners must not create further barriers to sense-making. For example, Sroufe and Wunsch (1972) observed that a mechanical version of peekaboo in which “items were presented in an automated fashion” elicited less laughter from infants, raising questions about factors such as “spontaneity of the agent, uneven cadence, and uncertain termination point” (p. 1337). The mechanical and automated action seems to afford less possibility for rich emotional reactions by infants and indeed by adults. This automated or mechanical quality may in fact also characterize the actions of the mothers in the still face studies, or those instructed to reach for their infants without completing the action of picking them up, or to perform a normal game without sound as described above (Fantasia et al., 2014, 2016; Tronick et al., 1975), and thus lead to an inability to make sense of the event.

The presence of involved others can open doors to emotional reactions, particularly smiling, towards incongruity. Multiple studies with adults have shown that for smiling and laughter to be expressed, social partners – and *not* humor, per se – are requisite (Panksepp, 2000; Provine, 2004; Scott, Lavan, Chen & McGettigan, 2014). LaFrance (2011) has even reported this effect in 10-month-olds who were less likely to smile when alone than when in the presence of other people, and Addyman, Fogelquist, Levakova, and Rees (2018) reported the same effect in toddlers watching cartoons. When people are a central part of the context – as is the case in studies of humorous incongruity – the infant relates to the event differently because the presence of another being with the potential for evaluative reactions has opened up the infant’s own potential reactions to the event, inviting emotional responses from the infant of a more typical kind – like laughter, for instance. Walden et al. (2007) and Dunn and Bremner (2017) validate this interpretation having shown that infants look more frequently to their social partners when presented with magically impossible incongruities that belong to the VOE tradition.

This approach of participatory sense-making questions the assumption that infants passively perceive physical or humorous incongruities. The picture in both cases appears more complex. Infants even in the early months certainly have experience with the laws of physics and the patterns of behavioral practices and can detect violations of these. The reactions to each, however, depend on the sense that can be made of them; the nature of the context-

ual experience such as repetition, timing, familiarity, and the involvement of other people, determine infants’ responses to each. The deprivation or wealth of other contextual factors is what must lead to looking or smiling, respectively. A rich context allows richer emotional reactions – or more broadly – for emotional participation with others and an emotional readiness to interact.

Future Directions to Make Sense of Infants Making Sense of Incongruity

Studies of infants’ reactions to physical and social incongruities have existed as separate lines of inquiry, finding that infants respond quite differently and leading to different explanations regarding infants’ understanding of the world. We suggest merging these lines of research to discover why infants respond differently to the general phenomenon of incongruity and propose several variables that deserve further investigation. For example, research should determine how infants’ responses to magical incongruities are altered by social context, something that could be easily tested by having infants observe a social partner carry out impossible events (instead of a partially occluded or videoed person). Whether infants react differently – potentially with smiling instead of looking – to impossible events performed by a familiar other (e.g., sleight-of-hand) is also worth examining given the rich social history infants and caregivers share. Crucially, it is worth investigating whether infants’ responses to impossible events are influenced by repetition or duration and the opportunity to share the events with others, common characteristics of events that evoke smiling. Ultimately, each of these variables could maximize infants’ opportunities for sense-making, manifested in reactions other than looking, and shed further light on how infants come to understand unexpected and expectancy-violating events.

Incongruity research has done much to reveal infants’ sensitivity to the unexpected, but it has yet to explain what it is precisely that infants are sensitive to – whether it is their knowledge of simple physics or their use of social context. The disparity in infants’ reactions – primarily looking or smiling – likely has less to do with whether an incongruity is physical or social, impossible or possible, magical or humorous, unresolved or resolved, and instead more likely reflects contextual variables that systematically differ between these two research paradigms and that either deprive or provide infants with opportunities for sense-making.

Statement of Ethics

As this is a theoretical and conceptual paper, ethical approval for research involving human participants was not required.

Disclosure Statement

The authors have no conflicts of interest to declare.

Funding Sources

Some of the first author's research, which is cited throughout, was supported by the National Institutes of Health (1R15HD071935-01) and the Vermont Genetics Network (via NIH INBRE1 P20 RR16462).

Author Contributions

This paper was co-authored with joint effort in both conceptualization and writing.

References

- Addyman, C. (2014, March 14). Why do babies laugh? That's what a scientist set out to learn... with tantalizing results. Daily Mail. Retrieved from <https://www.dailymail.co.uk/health/article-2580540/Why-babies-laugh-Thats-scientist-set-learn-tantalising-results.html>
- Addyman, C., Fogelquist, C., Levakova, L., & Rees, S. (2018). Social facilitation of laughter and smiles in preschool children. *Frontiers in Psychology*, 9, 1048. <https://doi.org/10.3389/fpsyg.2018.01048>
- Baillargeon, R. (1994). How do infants learn about the physical world? *Current Directions in Psychological Science*, 3(5), 133–140. <https://doi.org/10.1111/1467-8721.ep10770614>
- Baillargeon, R. (1998). Infants' understanding of the physical world. In M. Sabourin, F. Craik, & M. Robert (Eds.), *Advances in psychological science*, Vol. 2. Biological and cognitive aspects (pp. 503–529). London UK: Psychology Press/Erlbaum.
- Baillargeon, R. (2004). Infants' physical world. *Current Directions in Psychological Science*, 13(3), 89–94. <https://doi.org/10.1111/j.0963-7214.2004.00281.x>
- Baillargeon, R., & Graber, M. (1987). Where's the rabbit? 5.5-month-old infants' representation of the height of a hidden object. *Cognitive Development*, 2(4), 375–392. [https://doi.org/10.1016/S0885-2014\(87\)80014-X](https://doi.org/10.1016/S0885-2014(87)80014-X)
- Baillargeon, R., Spelke, E. S., & Wasserman, S. (1985). Object permanence in five-month-old infants. *Cognition*, 20(3), 191–208. [https://doi.org/10.1016/0010-0277\(85\)90008-3](https://doi.org/10.1016/0010-0277(85)90008-3)
- Baillargeon, R., & Wang, S. H. (2002). Event categorization in infancy. *Trends in Cognitive Sciences*, 6(2), 85–93. [https://doi.org/10.1016/S1364-6613\(00\)01836-2](https://doi.org/10.1016/S1364-6613(00)01836-2)
- Barlow, J. (2005, April 14). Psychological reasoning begins earlier than had been thought, study shows. Illinois News Bureau. Retrieved from <https://news.illinois.edu/view/6367/207318>
- Charles, E. P., & Rivera, S. M. (2009). Object permanence and method of disappearance: Looking measures further contradict reaching measures. *Developmental Science*, 12(6), 991–1006. <https://doi.org/10.1111/j.1467-7687.2009.00844.x>
- De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making: An enactive approach to social cognition. *Phenomenology and the Cognitive Sciences*, 6(4), 485–507. <https://doi.org/10.1007/s11097-007-9076-9>
- Di Paolo, E., & De Jaegher, H. (2012). The interactive brain hypothesis. *Frontiers in Human Neuroscience*, 6, 163. <https://doi.org/10.3389/fnhum.2012.00163>
- Dunn, K., & Bremner, J. G. (2017). Investigating looking and social looking measures as an index of infant violation of expectation. *Developmental Science*, 20(6), 1–6. <https://doi.org/10.1111/desc.12452>
- Esseilly, R., Rat-Fischer, M., Somogyi, E., O'Regan, K. J., & Fagard, J. (2016). Humor production may enhance observational learning in 18-month-old infants. *Cognition and Emotion*, 30(4), 817–825. <https://doi.org/10.1080/02699931.2015.1036840>
- Fantasia, V., Fasulo, A., Costall, A., & López, B. (2014). Changing the game: Exploring infants' participation in early play routines. *Frontiers in Psychology*, 5(522), 522. <https://doi.org/10.3389/fpsyg.2014.00522>
- Fantasia, V., Markova, G., Fasulo, A., Costall, A., & Reddy, V. (2016). Not just being lifted: Infants are sensitive to delay during a pick-up routine. *Frontiers in Psychology*, 6(2065), 2065. <https://doi.org/10.3389/fpsyg.2015.02065>
- Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Sciences*, 7(7), 287–292. [https://doi.org/10.1016/S1364-6613\(03\)00128-1](https://doi.org/10.1016/S1364-6613(03)00128-1)
- Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, 56(2), 165–193. [https://doi.org/10.1016/0010-0277\(95\)00661-H](https://doi.org/10.1016/0010-0277(95)00661-H)
- Graziano, W. G. (1987). Lost in thought at the choice point: Cognition, context, and equity. In J. C. Masters & W. P. Smith (Eds.), *Social comparison, social justice, and relative deprivation: Theoretical, empirical, and policy perspectives* (pp. 265–294). Mahwah, NJ: Lawrence Erlbaum Associates.
- Hespos, S. J., & Baillargeon, R. (2001). Infants' knowledge about occlusion and containment events: A surprising discrepancy. *Psychological Science*, 12(2), 141–147. <https://doi.org/10.1111/1467-9280.00324>
- Hoicka, E., & Gattis, M. (2008). Do the wrong thing: How toddlers tell a joke from a mistake. *Cognitive Development*, 23(1), 180–190. <https://doi.org/10.1016/j.cogdev.2007.06.001>
- Keen, R. (2003). Representation of objects and events: Why do infants look so smart and toddlers look so dumb? *Current Directions in Psychological Science*, 12(3), 79–83. <https://doi.org/10.1111/1467-8721.01234>
- Koestler, A. (1964/1975). *The act of creation*. London, UK: Pan Books.
- LaFrance, M. (2011). *Lip service: Smiles in life, death, trust, lies, work, memory, sex, and politics*. New York, NY: W.W. Norton & Co.
- Mireault, G. C., Crockenberg, S. C., Heilman, K., Sparrow, J. E., Cousineau, K., & Rainville, B. (2018). Social, cognitive, and physiological aspects of humour perception from 4 to 8 months: Two longitudinal studies. *British Journal of Developmental Psychology*, 36(1), 98–109. <https://doi.org/10.1111/bjdp.12216>
- Mireault, G. C., Crockenberg, S. C., Sparrow, J. E., Cousineau, K., Pettinato, C., & Woodard, K. (2015). Laughing matters: Infant humor in the context of parental affect. *Journal of Experimental Child Psychology*, 136, 30–41. <https://doi.org/10.1016/j.jecp.2015.03.012>
- Mireault, G. C., Crockenberg, S. C., Sparrow, J. E., Pettinato, C. A., Woodard, K. C., & Malzac, K. (2014). Social looking, social referencing and humor perception in 6- and 12-month-old infants. *Infant Behavior and Development*, 37(4), 536–545. <https://doi.org/10.1016/j.infbeh.2014.06.004>

- Mireault, G. C., & Reddy, V. (2016). Humor in infants: Developmental and psychological perspectives. Berlin, Germany: Springer Science + Business Media. <https://doi.org/10.1007/978-3-319-38963-9>
- Mireault, G., Sparrow, J., Poutre, M., Perdue, B., & Macke, L. (2012). Infant humor perception from 3- to 6-months and attachment at one year. *Infant Behavior and Development*, 35(4), 797–802. <https://doi.org/10.1016/j.infbeh.2012.07.018>
- Nomikou, I., Leonardi, G., Radkowska, A., Rączaszek-Leonardi, J., & Rohlfing, K. J. (2017). Taking up an active role: Emerging participation in early mother–infant interaction during peekaboo routines. *Frontiers in Psychology*, 8, 1656. <https://doi.org/10.3389/fpsyg.2017.01656>
- Panksepp, J. (2000). The riddle of laughter: Neural and psychoevolutionary underpinnings of joy. *Current Directions in Psychological Science*, 9(6), 183–186. <https://doi.org/10.1111/1467-8721.00090>
- Pien, D., & Rothbart, M. K. (1976). Incongruity and resolution in children's humor: A reexamination. *Child Development*, 47(4), 966–971. <https://doi.org/10.2307/1128432>
- Powell, L. J., & Spelke, E. S. (2018). Human infants' understanding of social imitation: Inferences of affiliation from third party observations. *Cognition*, 170, 31–48. <https://doi.org/10.1016/j.cognition.2017.09.007>
- Provine, R. R. (2004). Laughing, tickling, and the evolution of speech and self. *Current Directions in Psychological Science*, 13(6), 215–218. <https://doi.org/10.1111/j.0963-7214.2004.00311.x>
- Rossmannith, N., Costall, A., Reichelt, A. F., López, B., & Reddy, V. (2014). Jointly structuring triadic spaces of meaning and action: Book sharing from 3 months on. *Frontiers in Psychology*, 5, 1390. <https://doi.org/10.3389/fpsyg.2014.01390>
- Scott, S. K., Lavan, N., Chen, S., & McGettigan, C. (2014). The social life of laughter. *Trends in Cognitive Sciences*, 18(12), 618–620. <https://doi.org/10.1016/j.tics.2014.09.002>
- Simon, T. J., Hespos, S. J., & Rochat, P. (1995). Do infants understand simple arithmetic? A replication of Wynn (1992). *Cognitive Development*, 10(2), 253–269. [https://doi.org/10.1016/0885-2014\(95\)90011-X](https://doi.org/10.1016/0885-2014(95)90011-X)
- Spelke, E. S., Breinlinger, K., Macomber, J., & Jacobson, K. (1992). Origins of knowledge. *Psychological Review*, 99(4), 605–632. <https://doi.org/10.1037/0033-295X.99.4.605>
- Sroufe, L. A., & Wunsch, J. P. (1972). The development of laughter in the first year of life. *Child Development*, 43(4), 1326–1344. <https://doi.org/10.2307/1127519>
- Tauzin, T., & Gergely, G. (2018). Communicative mind-reading in preverbal infants. *Scientific Reports*, 8(1), 9534. <https://doi.org/10.1038/s41598-018-27804-4>
- Tronick, E., Adamson, L.B., Als, H., & Brazelton, T.B. (1975, April). Infant emotions in normal and perturbed interactions. Paper presented at the Biennial Meeting of the Society for Research in Child Development, Denver, CO.
- Walden, T. A., & Baxter, A. (1989). The effect of context and age on social referencing. *Child Development*, 60(6), 1511–1518. <https://doi.org/10.2307/1130939>
- Walden, T., Kim, G., McCoy, C., & Karrass, J. (2007). Do you believe in magic? Infants' social looking during violations of expectations. *Developmental Science*, 10(5), 654–663. <https://doi.org/10.1111/j.1467-7687.2006.00607.x>
- Wang, S. H., Baillargeon, R., & Brueckner, L. (2004). Young infants' reasoning about hidden objects: Evidence from violation-of-expectation tasks with test trials only. *Cognition*, 93(3), 167–198. <https://doi.org/10.1016/j.cognition.2003.09.012>
- Warren, C., & McGraw, A. P. (2016). Differentiating what is humorous from what is not. *Journal of Personality and Social Psychology*, 110(3), 407–430. <https://doi.org/10.1037/pspi0000041>
- Wynn, K. (1992). Addition and subtraction by human infants. *Nature*, 358(6389), 749–750. <https://doi.org/10.1038/358749a0>
- Wynn, K., & Chiang, W.-C. (1998). Limits to infants' knowledge of objects: The case of magical appearance. *Psychological Science*, 9(6), 448–455. <https://doi.org/10.1111/1467-9280.00084>