What's in a look? How can we best measure infants' response to incongruity?

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Commentary on Mireault, G.C., and Reddy, V. "Making Sense of Infants' Differential Responses to Incongruity".

In this fascinating paper, Mireault and Reddy tackle the question of why infants respond to incongruity in some cases by longer looking and other cases by smiling or laughter. In our commentary, we provide further analysis of the degree to which different measures of infants' response can be taken as evident of a response to incongruity as such, and the level at which incongruity may be registered. We also look further at Mireault and Reddy's distinction between physical and social incongruities, pointing to one case in which a phenomenon traditionally interpreted as being about infants' physical understanding may actually have its roots at least partly in expectations arising from social cues, and another case where social incongruity is measured through the same measure as commonly used to measure physical incongruity. Our conclusion is that there is a complex interaction between social factors and physical understanding, that all cases of incongruity may lead to longer looking for one reason or another, and that whether infants additionally respond through amusement probably depends on the extent to which the event, the context, or both stimulate amusement.

As Mireault and Reddy point out, the Violation of Expectation (VoE) task has been widely used to measure infants' detection of physical incongruities, such as the appearance that one object has moved through another (Spelke et al., 1992) or that a numerical outcome is incorrect (Wynn, 1992). An issue that arises from this literature is that although it has been common to interpret the infant's response to incongruity as a surprise reaction, the only measure is accumulated looking to the general vicinity of the display. Just the same measure has a long and respectable history as a measure of infant perception, based on the fact that infants tend to look longer at perceptually novel events. However, use of the same measure to index detection of incongruity carries more risks, particularly given that a simple perceptual basis for any effect has to be ruled out. Often, those designing VoE tasks have been careful to set perceptual factors in opposition to the VoE interpretation, so that the

opposite effect would have been obtained if the looking times were based on perceptual novelty. In other words, the violation trial is perceptually familiar and the non-violation trial is perceptually novel. A good example here is Wynn's work on infant number, which Mireault and Reddy review. In the case of subtraction, Wynn presented 5-month-olds with two objects, which are then hidden by a screen, whereupon a hand comes in and removes one object. Then the screen is lowered, revealing either the correct outcome (one object) or the incorrect outcome (the original two objects). In the addition case, one object is placed and then screened, whereupon a second object is placed behind the screen. In this case, the correct outcome is two objects and the incorrect outcome is one object. Infants looked longer at the incorrect outcome in both cases, and Wynn argues that they understand simple operations of addition and subtraction.

However, this effect is open to alternative interpretations. Given that infants generally look longer at perceptually novel events, one might assume that Wynn's results could not have a simple perceptual basis, because infants looked longer at an outcome that actually matched what they saw before the screen came up. However, Wynn did not habituate infants to the original display, and we know that under these circumstances infants often show a familiarity preference (Hunter & Ames, 1988). Thus Cohen and Marks (2002) argue that Wynn's results can be explained largely in terms of a perceptual familiarity preference. At a rather higher level of interpretation, others argue that Wynn's results can be explained on a perceptual basis, as a matter of tracking the locations of multiple objects (Feigenson, Carey, & Hauser, 2002). Such object file accounts do not attribute numerical ability as such to infants, though they may represent a perceptual precursor of addition and subtraction (Uller, Carey, Huntley-Fenner, & Klatt, 1999). However, it is possible that in Wynn's task, infants do not track both objects. It could be the case that longer looking on

violation trials is based simply on noting the inappropriate presence or absence of the most recently manipulated (subtracted or added) object.

One way to resolve this problem is to look for alternative measures of infants' level of awareness in this task. Taking the subtraction task, if infants are looking longer because they detect a numerical error, one might expect them to distribute looking equally between the two objects in the violation outcome. Also, according to the familiarity preference account, looking should be equally distributed between objects and potentially other features of the display. Using an eye-tracker, Bremner et al. (2017) found that in subtraction violation, infants looked significantly longer at the object seen to be removed but still present than at the same object when, in the addition condition, it was appropriately present. This seems like support for a single object tracking interpretation focused on the object most recently manipulated. Such an account is in keeping with evidence that in the early months infants construct a perceptual awareness of object persistence (Bremner, Slater, & Johnson, 2015).

The lesson to be learned here is that simple looking time may not be the best measure of VoE. As Mireault and Reddy point out, one strategy has been to use social looking as an alternative. Measurement of social looking need not be restricted to looking to the caregiver and there is some indication that social looking to the experimenter might be particularly relevant as an index of violation of expectation (Slaughter & McConnell, 2003; Stenberg, 2009; Stenberg & Hagekull, 2007; Striano & Rochat, 2000). As a supplement to the conventional measure of looking duration, some investigators have measured infants' looks to the parent or experimenter when VoE events are presented in relation to violations in object identity, structure and numeracy (Dunn & Bremner, 2017; Shuwairi et al., 2010; Walden et al., 2007). The convergence of the two measures in these papers led the authors to conclude that infants detected an error in the impossible outcomes. Therefore, this measure complements looking time data in violation of expectancy work on numerical ability.

Like looking time measures, though, infant social looking behaviour in these contexts has the potential to measure infants' response to perceptual novelty rather than impossible outcomes. Perceptual features, such as novelty, are inherent aspects of violations of physical laws and our measures must facilitate a distinction between infant response to each component. Thus, Dunn & Bremner (2017) compared both measures in response to the lawful appearance of a novel object compared with an object whose identity changed unlawfully. Whilst both conditions contained novelty, only the latter involved violation of physics. Accumulated looking increased in response to both conditions, yet social looking only showed a significant increase in violation conditions. Therefore, social looking has proven a more specific, complimentary index of VoE than traditional looking time measures alone that have previously been interpreted as evidence for understanding in a plethora of cognitive domains.

In summary, we would go rather further than Mireault and Reddy in their contrast between physical and social incongruity, by suggesting that many of the findings from the literature on physical incongruity are at least ambiguous, and that some may be evidence of rather low-level precursors of knowledge as such. Taking Wynn's number task, infants appear to be looking both at the array and at adults because they have detected that something is wrong. But they are probably not engaged in counting, though at some level they detect incongruity regarding the object that should be absent or present in the violation condition.

Another example provides evidence that a little later in infancy a phenomenon long believed to reflect a limitation in infants' knowledge of physical reality may actually be much to do with interpretation of social cues. Piaget's Stage IV (A not B) search error is seen when 9-month-old infants search correctly for a hidden object in one location (A) but when they continue to search at A when they subsequently see the object hidden at a new location (B). Although this is not a task primarily used to measure response to physical incongruity, the

case seems relevant to the present discussion, particularly because recent work (Dunn & Bremner, (2020) has measured social looking in the task. There have been various interpretations of this error, in terms of limited object concept (Piaget, 1954), memory interference (Harris, 1973), spatial coding of object location (Butterworth, 1975), and use of memory to inhibit past responses (Diamond, 1988). However Topál et al. (2008) demonstrated that the error was significantly reduced when the hider was either not fully visible or averted gaze. This, along with many other manipulations of the task, led to reduced, but at-chance reaching on B trials, which can be difficult to interpret (Wellman, Cross, Bartsch & Harris, 1987). In this instance, at-chance reaching can be equally explained by either improved accuracy in a subset of infants or random reaching due to distraction and confusion response to the experimenter's odd and unnatural social behaviour. Typically, the error is indexed through reaching accuracy on the first B trial and, like VoE studies, alternative measures are required to understand more about what AB errors might be telling us about development.

In addition to the standard measure of accuracy on the first B trial, Dunn & Bremner (2020) investigated the consistency of infant response using error run (Butterworth, 1975) and infant expectation of outcome using social looking (Walden et al., 2007; Dunn & Bremner, 2017). Investigating the effects of more natural social environment manipulation than that of Topál and colleagues, who removed social cues, we directed the social cues of the experimenter on B trials to either the B location or the A location. When the experimenter looked to location B, infants showed significantly better search accuracy on the first B trials compared to the standard version and when the experimenter looked to location A. Again, however, reaching on the first B trial was reduced to at-chance levels. But significantly shorter error runs suggested this was not the result of random reaching but improved performance. Further, infants initiated more social looking when the object was not found at

the A location on B trials indicating that they expected the object to be found there. Interestingly, infants also initiated more social looking when they correctly searched at location B yet the experimenter had been looking at location A. This suggests that infants actively attempt to interpret their social environment and that there is a resulting violation of an expectation that adults should be helpful in the social information that they provide. Thus, though search behaviour suggests other processes must be recruited during the A-not-B task, the index of infant social looking behaviour has provided support for the role of the social environment on infant search behaviour during the AB task. This provides an illustration a developmental task that is commonly used to investigate infant's cognitive understanding of physical reality yet likely has much to do with social embeddedness.

Mireault and Reddy suggest that one way of distinguishing the magical from the humorous is that tests of the former are socially disembodied or disembedded. However, there are cases in which social incongruity is measured through VoE. For example, Onishi and Baillargeon (2005) found evidence that 15-month-olds had theory of mind because they reacted with longer looking at false belief events in which an adult responded on the basis of knowledge that they could not possess. In simple terms, infant and adult saw an object placed in one hiding location, whereupon, out of the adult's sight, the object was moved to another location. Infants showed prolonged looking when the adult searched in the new location. Secondly, VoE was used as a measure of infants' understanding of human agency (Woodward, 1998). It was found that 6- to 9-month-old infants looked longer when a human agent redirected their action to a new object than when they directed a new act to the original object. No such effect was obtained when a robot arm exerted the reaches, so this looks like a case of detection of social (human action) incongruence. The first example involves social embeddedness, and both of these examples appear to involve social embodiment. Thus a

distinction based on presence or absence of social embodiment and embeddedness does not seem to solve the problem.

Our conclusion is that although the distinction between magical and humorous incongruity certainly needs to be explained, the reality of the distinction is even more complex than Mireault and Reddy describe. Although they set out asking why longer looking occurs in some cases and smiling or laughing in others, they recognise that some situations lead both to longer looking and humour, and we may wonder whether all situations producing humour would also produce longer looking if this was measured. Thus, maybe the question should be (in addition to understanding the basis of longer looking) why some situations also produce humour. Additionally, tasks that appear on the face of it to measure physical knowledge may really measure social expectation. Our suspicion is that the arousal of amusement, likely in addition to longer looking, may depend not just on whether the event is inherently humorous, but in part on the social setting in which the event occurs (specifically, is there someone ready and willing to share the amusement?). As Mireault and Reddy recognise, infants sometimes show amusement in response to physical incongruity. Conjuring of the sort used with infants provides a good example here. The apparent production of a small object from an infant's ear is an example of physical incongruity, and is certainly magical in a way standard VoE tasks may not be. This in itself might lead to longer looking. But the particular form of social setting of the event makes it amusing. Would the infant smile or laugh if the same event was executed by an adult in a deadpan fashion? Mireault and Reddy present evidence that the effect would be the same, but that was in a case in which (for instance) a ball was worn as a clown nose, a situation in which the humour is in the act itself. Our suggestion is that there may be other cases in which the humorous context makes for the amusement, not the event. We would suggest that there are plenty of examples of experimental work where the event is socially embedded and embodied

but the response is longer looking alone because there is nothing socially amusing about the setting. Additionally, as the example above indicates, not all humour producing events are possible but odd, as Mireault and Reddy suggest. The point of conjuring is to create the impression of an impossible event.

To conclude, much of this commentary largely offers further analysis of the problem, albeit from a different perspective. In that sense, we have not been engaged in a critique of Mireault and Reddy's paper that questions their arguments. Our hope is that this further analysis provides some modest extension and clarification in the attempt to answer this complex question.

References

Bremner, J.G., Slater, A.M., Hayes, R.A., Mason, U., Murphy, C., Spring, J., Gaskell, D., & Johnson, S.P. (2017). Young infants' visual fixation patterns in addition and subtraction tasks support an object tracking account. *Journal of Experimental Child Psychology, 162,* 199-208. doi: 10.1016/j.jecp.2017.05.007

Bremner, J.G., Slater, A.M., & Johnston, S.P. (2015). Perception of object persistence: the origins of object permanence in infancy. *Child Development Perspectives, 9,* 7-13. doi: 10.1111/cdep.12098

Butterworth, G. (1975). Object identity in infancy: The interaction of spatial location codes in determining search errors. *Child Development, 46,* 866-870.

Cohen, L.B., & Marks, K.S. (2002). How infants process addition and subtraction events. *Developmental Science*, **5**, 186-212.

Dunn, K., & Bremner, J.G. (2017). Investigating looking and social looking measures as an index of infant violation of expectation. *Developmental Science, 20,* e12452. doi: 10.1111/desc.12452

Diamond, A. (1988). Abilities and neural mechanisms underlying AB performance. *Child Development*, *59*(2), 523-527. DOI: 10.2307/1130330

Dunn, K., & Bremner, J.G. (2020). Use of social looking as a measure of infant expectation in the A not B search task. *Developmental Science, 23(3).* e12921. doi: org/10.1111/desc.12921

Feigenson, L., Carey, S. & Hauser, M. (2002). The representations underlying infants' choice of more: Object files versus analog magnitudes. *Psychological Science, 13***,** 150-156.

Harris, P.L. (1973). Perseverative errors in search by young infants. *Child Development, 44,* 28-33.

Hunter, M. A., & Ames, E. W. (1988). A multifactor model of infant preferences for novel and familiar stimuli. *Advances in Infancy Research, 5,* 69–95.

Onishi, K.H., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science, 308,* 225-258.

Piaget, J. (1954). *The construction of reality in the child*. New York: Basic Books.

Shuwairi, S. M., Tran, A., DeLoache, J. S., & Johnson, S. P. (2010). Infants' response to pictures of impossible objects. *Infancy*, *15*(6), 636-649.

Slaughter, V., & McConnell, D. (2003). Emergence of joint attention: Relationships between gaze following, social referencing, imitation, and naming in infancy. *The Journal of Generic Psychology*, 164(1), 54-71.

Spelke, E.S., Breinlinger, K., Macomber, J., & Jacobson, K. (1992) Origins of knowledge. *Psychological Review, 99*, 605-632. doi: 10.1037/0033-295X.99.4.605

Stenberg, G. (2009). Selectivity in infant social referencing. *Infancy*, *14*(4), 457-473.

Stenberg, G., & Hagekull, B. (2007). Infant looking behavior in ambiguous situations: Social referencing or attachment behaviour? *Infancy*, *11*, 111-129.

Striano, T., & Rochat, P. (2000). Emergence of selective social referencing in infancy. *Infancy*, *1*(2), 253-264.

Topál, J., Gergely, G., Miklósi, Á., Erdőhegyi, Á., & Csibra, G. (2008). Infants' perseverative search errors are induced by pragmatic misinterpretation. *Science*, *321*, 1831-1834. DOI: 10.1126/science.1161437

Uller, C., Carey, S., Huntley-Fenner, G., & Klatt, L. (1999). What representation might underlie infant numerical knowledge? *Cognitive Development*, *14*, 1-36.

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. DOI: 10.1111/j.1467-7687.2006.00607.x

Wellman, H. M., Cross, D., & Bartsch, K. (1987). Infant search and object permanence: A meta-analysis of the A-not-B error. *Monographs of the Society for Research in child Development*. DOI: 10.2307/1166103

Woodward, A.L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition, 69,* 1-34.

Wynn, K. (1992). Addition and subtraction by human infants. *Nature, 358*, 749-750. doi: 10.1038/358749a0