Ray, E. D. & Heyes, C. M. Imitation in infancy: the wealth of the stimulus.
Developmental Science

SUPPORTING MATERIAL

Do human neonates imitate a range of gestures?

Eighteen gestures have been investigated in 37 experiments seeking evidence of imitation in infants younger than six weeks old. Of these 18 gestures, half have not yielded any positive reports of neonatal imitation: chin tapping (Abravanel & Sigafoos, 1984); cheek swelling (Fontaine, 1984); close eyes (Fontaine, 1984); arm waving (Lewis & Sullivan, 1985); making and unmaking a fist (Uzgiris, 1972); ear touching (Uzgiris, 1972); chest tapping (Abravanel & Sigafoos, 1984); hand-to-face (McKenzie & Over, 1983); hand-to-and-from-midline (McKenzie & Over, 1983). Studies of each of the remaining gestures are discussed below in turn.

Tongue protrusion

We discuss the data for tongue protrusion only briefly because they have already been subjected to close examination. Anisfeld (1991) reviewed all experiments on neonatal imitation of tongue protrusion, and conducted a meta-analysis comparing tongue protrusion frequency following modelling of tongue protrusion with cross target and spontaneous baseline measures of tongue protrusion responding. The analysis confirmed that neonates reliably match tongue protrusion.

Mouth opening

We found nine experiments reporting neonatal imitation of mouth opening, and 20 experiments that failed to find evidence of imitation of mouth opening. Four of the nine positive effects were found in a single longitudinal study (Kugiumutzakis, 1999), and a fifth study found evidence of imitation of mouth opening using a measure of gesture duration, but not using the standard measure of response frequency (Meltzoff & Moore, 1992). No studies have reported imitation of mouth opening in the absence of a reliable effect for tongue protrusion.

Anisfeld (1991) suggested that mouth opening imitation effects are unreliable because they are a side-effect of infants' imitation of tongue protrusion. In studies of neonatal imitation, the responses that are scored as tongue protrusion and mouth opening are antagonistic or 'competitive'; they cannot be performed simultaneously. Therefore, if observation of tongue protrusion provokes tongue protrusion, response competition will suppress ongoing mouth opening, and when tongue protrusion modelling ceases, the frequency of mouth opening will return to spontaneous levels. In a cross target comparison, this return to baseline levels could give the spurious impression that the infant is imitating mouth opening.

Only one study has reported that infant production of mouth opening following observation of mouth opening exceeded both spontaneous and cross target frequencies (Meltzoff & Moore, 1977).

Hand opening and closing

Vinter (1986) reported that in 4-day -old infants hand opening and closing increased from baseline, and in comparison with a cross target control, following exposure to a hand opening and closing model. Interestingly, studies of slightly older infants during face-to-face interaction (e.g. Fogel & Hannan, 1985; Legerstee, Corter & Kienapple, 1990) have found that the production of manual and facial gestures is interdependent. For example, Fogel and Hannan (1985) showed that pointing occurred before and after mouthing, and that spreading of the fingers occurred when infants looked away from their mothers. This interdependence raises the possibility that manual imitation effects are driven by facial responses. In Vinter's study, spreading the fingers would have counted as hand opening, and an imitation effect was reported only for the response, rather than modelling, period, when infants looked at their models significantly less. Therefore, it is possible that, rather than imitating hand opening and closing, the infants in this study were simply spreading their fingers when they looked away from the model.

Consistent with this hypothesis, neonatal imitation of hand opening and closing has not been found reliably. There are three published failures to find imitation of this gesture when it was modelled dynamically (Abravanel & Sigafoos, 1984; Fontaine, 1984, Jacobson, 1979), and one failure to find imitation in response to a static picture of an open hand (Vinter, 1986).

Lip protrusion and sequential finger movements

Imitation of lip protrusion and sequential finger movement has been reported once in an experiment that also investigated imitation of tongue protrusion and mouth opening (Meltzoff & Moore, 1977, Experiment 1). However, this study used a very unusual scoring method: categorical judgments of the presence/absence of imitation, rather than response frequency data. Judges looked at infant facial gestures and ranked four possible facial models - lip protrusion, mouth opening, tongue protrusion and passive face - in terms of the likelihood that each had preceded the infant's response. Then, in the process of analysis, ranks one and two, and ranks three and four, were collapsed to yield a dichotomous judgement of whether it was probable that the infant had imitated a particular gesture. Consequently, an infant's response to lip protrusion, for example, could have been scored as imitative even if the person who viewed the videos thought it most likely that the infant was responding to tongue protrusion rather than lip protrusion (Masters, 1983).

Three failures to replicate neonatal matching of lip protrusion have since been published, one using the same scoring procedure as Meltzoff & Moore (1977) (Koepke et al., 1983), and two that used standard and less problematic cross target and baseline comparisons of gesture frequency (Heimann, Nelson & Schaller, 1989). Koepke et al. (1983) also failed to find imitation of sequential finger movements, as did Lewis and Sullivan (1985), using measures of gesture frequency.

A single study (Reissland, 1988) reported that neonates imitate lip-pursing and lip-broadening, the gestures serving as cross target controls for one other. However, lip-pursing gestures often involve anterior lip movement and are therefore likely to elicit partial or complete tongue protrusion . Therefore, given that this study scored all oral behavior in the anterior-posterior plane as lip-pursing, tongue protrusion responses to lip pursing models would have counted as evidence of the imitation of lip pursing. Elicitation of tongue protrusion by lip pursing models could also explain, via response competition, apparent imitation of lip-broadening.

Index finger extension

Nagy and his colleagues found an increase in the frequency of index finger extension from baseline after modelling (Nagy, Compagne, Orvos, Pal, Molnar, Janszky, Loveland & Bardos, 2005). The procedure had three important features: First, the gesture scoring criteria were broad; extension of up to three fingers counted as imitation. Second, during testing the infants lay on their backs with their heads turned to the side. This position elicits the asymmetric tonic neck reflex, in which infants extend the arm ipsilateral to the head position and look at their hands (van der Meer, van der Weel & Lee, 1995). Third, the model's hand was located close to the infant's hands. Given these three features of the design, it is plausible that, rather than imitating, the infants in this study were making preliminary reaching movements towards the model's hand (Hofsten, 2004; Meltzoff & Moore, 1979). Consistent with this, Fontaine (1984) found no evidence of imitation of index finger extension using a procedure in which the scoring criteria distinguished the movements of each finger, and all gestures were modelled in front of the infants' faces, not at the end of their arms.

Head movements

Two experiments have reported neonatal imitation of head movements (Maratos, 1982; Meltzoff & Moore, 1989). Infants track moving objects with their head and eyes (Bloch & Cochan, 1992; von Hofsten & Rosander, 1996), and this 'perceptual tethering' may explain apparent imitation of head movements. Alert to this problem, Meltzoff and Moore isolated and analysed the number of infant head movements during response periods (when the model's head was still) which had not been preceded by head movements during gesture modelling. Most infant head turns were excluded under these conditions, suggesting that perceptual tethering was largely responsible for the primary effect. While head turning remained more frequent after modelling of head turning (on average infants made one response), than after modelling of tongue protrusion (.33), such low rates of responding make it likely that this residual effect was due to response competition. Maratos (1983) found that the head movement imitation effect disappeared at three-months.

Blinking

Using a longitudinal cross target design, Kugiumutzakis (1999) reported that infants blink more often in response to blinking than to tongue protrusion and mouth opening combined. (This effect persisted until 4.5-months and then disappeared.) In infants, blinking decreases during physical activity and increases in response to novel visual stimulation (Bacher & Smotherman, 2004). Therefore, this effect may be have been driven by response competition (i.e. the physical activity involved in tongue protrusion, and/or by the novelty value of a rapidly blinking adult model). Supporting the former hypothesis, Abravanel and Sigafoos (1984) and Fontaine (1984) failed to find neonatal imitation of blinking in the absence of a reliable tongue protrusion effect.

Facial expressions

Imitation of happy, sad and surprised expressions has been reported in neonates (Field, Woodson, Cohen, Greenberg, Garcia & Collins, 1983; Field, Woodson Greenberg & Cohen, 1982). In these studies, which used an unusual procedure, coders judged 1) which expression an infant was likely to have observed on the basis of her response, and 2) infant gaze fixation. Anisfeld (1991) and Kaitz, Meschulach-Sarfaty, Auerbach & Eidelman (1988) have argued that these data do not provide evidence of neonatal imitation because infant gaze fixation was reported to differ among observed expressions. Therefore, the coders could have used gaze fixation, rather than topographic features of the infants' facial expressions, as the basis for their judgements. Kaitz et al. (1988) replicated the procedure but allowed their judges to give a 'don't know' answer when guessing the modelled expression, and did not require them to code infant gaze. They found no evidence of imitation under these conditions, suggesting that the effects reported by Field et al. were due, not to imitation of emotional expressions, but to the coders' implicit knowledge of the directions in which infants tend to look when they are happy, sad and surprised. This is an intriguing finding, but it does not provide evidence of neonatal imitation.

Thus, our review of research on imitation in human neonates failed to find compelling evidence that very young infants can imitate a range of actions.

Additional References

The following is a list of publications cited in this Supporting Material but not in the main body of the article.

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