What am I supposed to be looking at? Controls and measures in inter-modal preferential looking

Article (Accepted Version)


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Abstract

Intermodal preferential looking (IMPL) is widely used in experimental studies of infant development, especially language development. Control measures vary, and it is not clear how these affect findings. We examined effects of parental awareness of stimuli. Infants (17-19mo) looked at paired pictures, one name-known and one name-unknown, each assigned target status in 50% of trials. Infants looked longer at a name-known target, regardless of parents’ awareness. When parents were aware, looking to a name-unknown target increased over a name-known non-target. There is evidence that infants’ looking at pictures in this paradigm is not due to direct matching of targets to novel names, but is influenced by additional cues present, in a way that could alter the conclusions of studies of infant word learning and other aspects of infant learning. Implications of these findings are discussed, emphasising replicability and theoretical conclusions drawn from studies using this method.

Keywords:
Intermodal preferential looking; Language development; Experimental techniques; Nonverbal cues
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Intermodal preferential looking

The intermodal preferential looking (IMPL) technique is so termed because it involves presenting an infant with stimuli in two modalities – hearing a word or sound whilst a choice of visual stimuli – pictures (moving or still) or objects – is presented to the infant in different locations. The infant’s looking times (in many studies, both latency of looking – the equivalent of reaction time – and time spent looking), to each stimulus is recorded and conclusions are drawn about infants’ knowledge from the differences between or preferences for one stimulus over another. Use of this technique in language development research is described in detail in an early paper by Thomas, Campos, Shucard, Ramsay, and Shucard (1981) and has since been used extensively in language acquisition research as well as for examining non-linguistic development (Bebko, Weiss, Demark, & Gomez, 2006).

In the context of language acquisition research, IMPL has been used to investigate development of the lexicon (Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987; Houston-Price, Plunkett, & Harris, 2005; Naigles & Gelman, 1995; Schafer, Plunkett, & Harris, 1999), syntax (Naigles, 1998) and phonology (Werker, Fennell, Corcoran, & Stager, 2002). It is also a useful technique for studying the skills of children with disabilities, who may not otherwise be able to respond (Cauley, Golinkoff, Hirsh-Pasek, & Gordon, 1989; Walker-Andrews, Haviland, Huffman, & Toci, 1994). Intermodal preferential looking (IMPL or alternative abbreviations) is the term of choice in most recent studies (Bailey & Plunkett, 2002; Golinkoff, Ma, Song, & Hirsh-Pasek, 2013; Houston-Price, Mather, & Sakkalou, 2007; Houston-Price et al., 2005; Tan & Schafer, 2005; Tincoff & Jusczyk, 1999) although older
papers use different terms (Ballem & Plunkett, 2005 among others: preferential looking; Forbes & Poulin-Dubois, 1997 among others: visual preference) and no name was given to the paradigm in Thomas et al.’s (1981) paper. Fernald, Zangl, Portillo, and Marchman (2008) describe frame-by-frame analysis of infants’ looking as “looking while listening”, described by Golinkoff et al. (2013) as “the next generation” of preferential looking.

Early studies using IMPL emphasised the benefits of the technique for experimental control. For example, the importance of presenting stimuli equally often on left and right sides is emphasised (Golinkoff et al., 1987). Likewise the need to control parent cuing (Thomas et al., 1981), and infants’ existing stimulus preferences (Schafer et al., 1999; Thomas et al., 1981) are discussed. Many studies recognise that infants’ visual stimulus preferences cannot be completely controlled and therefore experimenters collect data on baseline preference (prior to the onset of the auditory stimulus - see for example Reznick, 1990).

Parent cuing in IMPL

In some studies the need for control over the parent’s awareness of the stimuli is stressed. Infants are hypothesised to use intersensory redundancy (Gogate & Bahrick, 2001), joint attention (Baldwin, 1991), and cross-situational statistics (L. Smith & Yu, 2008) to assist with mapping words onto their meanings, especially when this mapping is at the limits of their abilities. When gesture is present during an object/word pairing, this will increase the probability that a young infant (around seven months of age) will map the object onto the word (Gogate & Bahrick, 2001). Older children (from 24 months upwards), too, benefit from multi-modal presentation of objects for which a word is to be learned (Scofield, Hernandez-Reif, & Keith, 2009). Smith (2005) suggests that cross-modal support provided by the parent, and
the ability of the child to benefit from this support, rely on humans’ multi-modal abilities present from infancy which enable social facilitation of learning.

Many studies using IML have somewhat controlled for parent awareness and cuing. For example, in the experimental setup used by Thomas et al. (1981) “the mother sat behind and faced away from her infant and the displays and therefore did not know where the target objects were located nor how her baby was responding” (p.800). Naigles (1990) gave mothers a visor to wear during testing. Likewise in Golinkoff et al.’s (1987) study mothers were asked to close their eyes during testing, but it is not reported whether all complied. Swingley and Aslin asked parents to direct their gaze downwards (2000) and one infant was excluded from this study and likewise an infant from a later study from one of the same authors (Swingley, 2009) because the parent peeked at the display during testing. Other labs have used dark glasses with tape on the inside (Fernald et al., 2008).

However, in some studies parents have been allowed to view – and in many more studies to listen to – the stimuli presented. For example, Reznick and Goldfield (1992) positioned parents where “they could not influence the child’s gaze.” Parents “could see the slides but were discouraged from participating in any way” (p.408). Delle Luche, Durrant, Poltrock, and Floccia (2015) only asked parents not to interfere. Although in Reznick and Goldfield’s study infants were in a high chair, rather than on parents’ laps, it is not stated whether parents could or did touch their infants during testing. Halberda (2003) allowed parents to be visually and acoustically aware of the stimuli, but asked them to “maintain forward gaze and not cue the infants verbally or physically” (p. B25) whilst infants were seated on parents’ laps. Four infants had to be excluded from the study, because their parents violated these instructions. Golinkoff (1987) and Swingley (2009; Swingley & Aslin, 2000)
have a mechanism in their studies for preventing parents from seeing visual stimuli but not from preventing them from hearing auditory stimuli. In studies by many other authors (Candan et al., 2012; Dittmar, Abbot-Smith, Lieven, & Tomasello, 2008; Fernald et al., 2008; Forbes & Poulin-Dubois, 1997) parents have knowledge of children’s varying experience of auditory stimuli, too.

In some labs, the setup varies depending on the participant group with parents of some children being aware of the auditory stimuli, others the visual stimuli, and others both (Candan et al., 2012; Naigles, 1990; Naigles & Tovar, 2012); this depends in some studies on other variables that systematically vary. For example, in Candan et al. (2012) parents of Turkish and English learning children were told to close their eyes but it appears that parents of Mandarin learning children could see the visual stimuli. For children with autism, Naigles and Tovar (2012) recommend a setup where parents do not hear the stimuli, but can see them. The same lab uses a setup where the parents can hear, but not see, for other participant groups (Naigles & Gelman, 1995). Given infants’ sensitivity to even subtle gestures (Gogate & Bahrick, 2001), the effect of parent awareness of stimuli is worthy of further investigation.

**Scoring methods in IMPL**

A wide variety of outcome measures have been used in IMPL studies. Many studies use measures of the percentage of looking time to the target picture, either collapsing all looking time (e.g. Schafer et al., 1999), or just examining the percentage of all post-auditory-stimulus looking time that is to the target picture (e.g. Swingley & Aslin, 2000), or examining the difference between pre-auditory stimulus percentage and post-auditory stimulus percentage (Halberda, 2003; Houston-Price et al., 2007; Reznick, 1990; Reznick & Goldfield, 1992).

Some studies have compared raw looking times to each visual stimulus
(Golinkoff et al., 1987; Naigles, 1990; Werker et al., 2002). Other studies use a
difference score between raw target and non-target looking (Naigles, 1990, 1998;
Naigles & Gelman, 1995) or between the longest target look and the longest non-
target look (Bailey & Plunkett, 2002; Houston-Price et al., 2005). It is also possible
to compare the percentage of looking that is to the target picture to chance (50%)
using one-sample t-tests, but only on a condition-by-condition basis (Schafer et al.,
1999). In addition, some studies examine the latency of infants’ look to the target
stimulus, analogous to reaction time in adult psycholinguistic experiments (Swingley
& Aslin, 2000), and some studies go further and examine the time course of looking
over the whole trial (although this is also known as the Looking While Listening
procedure, it seems to be a further development of IMPL; Fernald et al., 2008;
Swingley, 2012). For a useful review of different measures of infant looking, see
Delle Luche et al. (2015).

Inherent in the decision of which looking time measure to analyse are
assumptions about the independence of various aspects of looking time. It can be
argued that looking time to target and non-target are not independent of each other
because they are both measured during a limited exposure time. For this reason,
researchers have commonly (though not universally) suggested examining the
percentage of overall looking time that is to a particular visual stimulus. For
consistency with many other studies, this measure will be analysed in the current
study.

However, this measure implies that variations in actual length of time spent
looking between trials are not “interesting”. Differences in raw looking time may be
observed (and be interesting) between different trials or conditions. For example, in
comparing different parent conditions or different types of auditory stimulus, it is
helpful to know whether in one condition or another there is increased looking as well as increased preference. In many IMPL trials, infants’ looking time is very short (indeed, it rarely even approaches the total time for which visual stimuli are displayed). Efforts are frequently made to increase infants’ overall looking time; it is easy to see why researchers might feel that parents being able to see and hear, rather than being behind a blindfold and headphones, might increase looking time.

Analyses that compare post-auditory-stimulus preference to pre-auditory-stimulus preference (such as subtracting percentage of all looking time to target during a baseline period from the same measure during a post-auditory stimulus period as in Reznick, 1990; Reznick & Goldfield, 1992) are also frequently used in order to account for preferences for each visual stimulus that are not related to an auditory stimulus association. However, this also makes an assumption that looking time in different portions of a trial, but to the same pictures, are independent. In fact, habituation is a very relevant phenomenon – infants tend to look longer when visual stimuli are first exposed, in this case before the auditory stimulus is presented, then decrease their looking. Longer pre-auditory stimulus looking may lead to shorter post-auditory stimulus looking. For this reason it is not always possible, even with equal time allocated to pre- and post-auditory stimulus display, to compare the two looking periods directly. This lends merit to approaches such as those of Naigles (1990) and Golinkoff and colleagues (1987) that examine separately raw looking times after the auditory stimulus has been presented; this should enable us to determine whether infants prefer one visual stimulus to the other.

Logically, any difference in raw pre-auditory stimulus looking time to target versus non-target pictures indicates either a preference for or familiarity of one object over the other, because no “instruction” has yet been heard. If such differences are
found only after the auditory stimulus, they are likely to be due to an association of the auditory and visual stimuli.

In addition, several authors assess infants’ latency of looking to a target stimulus, comparing it to their latency of looking to a non-target stimulus. Although this has not always been included, we will examine pre-auditory stimulus target and non-target latencies as well as comparing post-auditory stimulus target and non-target latencies.

Measures to be examined

We will therefore compare a variety of methods of assessing infants’ preference for a target picture: raw looking times before and after the auditory stimulus (as in Golinkoff et al., 1987), latency of looking to pictures before and after the auditory stimulus (comparable to Swingley & Aslin, 2000), and proportion of looking to each visual stimulus (compared both between conditions and to chance – 50% - as in Schafer et al., 1999). Combining different analysis methods with different auditory stimulus conditions can lead us to further inferences about what infants are doing in response to the auditory stimulus.

The current study

Our study will investigate the impact of parental awareness on IMPL. It will compare infants’ looking to pictures associated with a known and an unknown word when parents can see and hear the stimuli, versus when parents cannot see or hear the stimuli. It is hypothesised that when parents can see and hear auditory and visual stimuli but are asked not to influence their children’s behaviour, infants’ looking will be influenced, probably in the direction of increased looking at the targets. Finally, we coded the variety of behaviours (not just speaking, pointing, or repeating the stimulus – the types of interactions that are included as experimental manipulations in
some studies) that parents engage in when they are aware of the stimuli. We expect these behaviours to occur whether those targets have names that are known or unknown to the infant, as it is assumed all targets are known to the parents. Note, the current study is not designed to investigate theoretical issues in language development, but rather to examine the difference that experimental controls used in data collection make to the conclusions that are drawn from studies using IMPL.

Method

Participants

Infants were recruited through invitation letters circulated at local nurseries in the south-east of England. In total 22 infants aged 17 to 19 months participated, with a mean age of 18.3 months (SD = 1.00). Infants were excluded if they had a history of hearing loss or developmental delay, or if either parent or any caregiver spoke a language other than English to them. Infants were brought to the lab by their mother in all cases. No infants were excluded for other reasons.

Stimuli

Choice of stimuli. On arrival at the lab, parents completed a 74-item checklist of words likely to be known by infants of this age, chosen to be a) imageable and b) likely to be known by more than 15% of 16-month-olds (Dale & Fenson, 1996). Parents indicated whether their child knew each word on the list (either in comprehension or production). For each infant 8 to 10 words that were known and 8 to 10 that were not known were chosen, attempting to balance the number of times each word was used as a known and an unknown stimulus; the stimulus pool and the number of times each word was used as a known or an unknown stimulus is shown in Appendix 1. For a few words (e.g. aeroplane, train, onion) it became clear part way through testing that all infants either knew or did not know the word, so balancing
was not possible for some words.

Stimuli used were hence different for each infant, based on their word knowledge as reported by parents. The experimenter also checked that each infant would be familiar with physical or depicted exemplars of all of the words, whether or not they knew the word. Hence visual stimuli were all of familiar objects.

**Visual stimuli.** Visual stimuli were adapted from clipart taken from a CD-ROM of common infants’ vocabulary (Dorling Kindersley, 2000), with additional items acquired from a variety of websites, and consisted of a colour picture of each item on a white background, 300 by 300 pixels, the picture taking up 75% to 90% of the white area in at least one dimension. Pictures were presented in pairs, one of which was a name-known picture and one a name-unknown picture, with order and side counterbalanced. Pictures were presented for 6 seconds followed by an inter-trial interval of 6 seconds of plain black.

**Auditory stimuli.** The sentence “Look! Look at the X” was digitally recorded in a sound-proof setting using an intonation patterned on naturalistic UK English child-directed speech for each stimulus and was played to the child starting simultaneously with the onset of the two pictures. Sound files had a mean length of 2300 msec (range 2100 to 2600).

**Setup.** Visual stimuli were projected using a digital projector onto a screen facing the infant, who was seated on their mother’s lap. The projected pictures (white background with photograph of the stimulus) were approximately 30cm square, on a black background, with a 30cm space between the two pictures, and the infant and mother were seated on a chair approximately 1m from the screen. Auditory stimuli were presented via a central pair of speakers located behind the projection screen and a central digital video camera located between the two pictures recorded infants’ faces
and mothers’ faces and upper bodies (mothers for participants 13 through 22 only).

**Paradigm.** Infants were presented with two blocks of 20 pairs of pictures, in which one picture had a known name and the other did not. Each known-name picture was always paired with the same unknown-name picture for a given child and the child heard the names for both pictures. Thus, the child encountered each picture in four configurations across the two blocks: Left picture is known, known name is heard; right picture is known, known name is heard; left picture is known, unknown name is heard; right picture is known, unknown name is heard. The known-name picture appeared once as the target and once as the non-target each of the two blocks.

During one block the mother wore a sleep mask and headphones, over which she could hear classical music (the “Unaware” condition). During the other block, mothers could see and hear the stimuli (the “Aware” condition); the order of blocks was counterbalanced across mothers. There was a short break between the two blocks during which infants and mothers could move around the laboratory or play, in order to maintain infants’ attention during the second block, and to enable mothers to put on or take off the headphones and sleep mask. Mothers reported that they could not hear or see the stimuli during the Unaware block.

Mothers were not given details of the purpose of the experimental manipulation before testing but were told to try not to “tell their child what to do” or to “help their child”, regardless of the condition. Mothers who enquired about the purpose of the manipulation were asked to wait until after testing, at which point they were debriefed. Parent behaviour was videoed in addition to infant looking for half of the infants.

Testing started when infants were attending to the screen, and could be paused between trials if infants looked away. An attention getter sound (chimes) and display
(red circles on a black background) were used if infants looked away between trials and did not return their own gaze to the visual display.

**Analysis Strategy**

After testing infants’ looking was coded frame-by-frame by one of three observers (Author 1, Author 2 or a student volunteer), who could see which two pictures that infants viewed during each trial but who could not hear the sound that infants heard, and did not know which of the pictures was name-known and which was name-unknown for each particular infant. For half of the infants, parent behaviour was also coded (see below for details). Onset and offset of looks to each picture were noted. For each trial the following were coded:

- total time spent looking at each picture before and after the auditory stimulus ended, examined in ANOVAs 1 and 2a respectively.
- proportion of all post-sound looking to each picture, examined in ANOVA 2b.
- latency of the first look to each picture, examined in ANOVA 3.
- latency of the first look to each picture after the auditory stimulus ended, examined in ANOVA 4.

Many previous studies categorise baseline looking as looking before the auditory stimulus starts (Houston-Price et al., 2007; Schafer et al., 1999). Although it might be possible for infants to identify the referent of the auditory stimulus before its offset, it would not be possible to code the disambiguation point for each individual infant (e.g. an infant who knew “cat” but not “camera” might have an earlier disambiguation point than one who knew both), so the end of each sound file was taken as the point at which to code post-stimulus looking.

Note, this also takes into account Swingley & Aslin (2000)’s concerns about
minimum possible reaction times to a visual stimulus. Where a look started before 
the offset of the sound file but continued after its offset, the infant was still counted as 
looking at the picture after the sound file, but only the portion of the look after the 
sound file was counted. In contrast to Swingley & Aslin, we did not exclude looks 
starting more than 2 sec after the offset of the sound file.

Mothers’ behaviour during the Aware block was coded in the same way by an 
observer (Author 2) who was unaware of the auditory stimulus or which picture was 
name-known, who coded whether the mother spoke, pointed, moved her head, or 
looked and in which direction. Although sound was not available for the mothers’ 
videos, it was possible to lip-read some infants repeating the stimulus noun, but no 
mother could be seen to do this.

In this study, for each of the dependent variables, initially a 2x2x2 within 
participants ANOVA was carried out which compared the effects of the Target status 
of each picture (whether it was named during the trial or not), the Known status of 
each picture (whether parents indicated infants knew a word for the picture), and the 
parent Condition. Additional analyses found no significant effect of order in which 
the two parent conditions occurred, so we collapsed across this variable.

Results

The results of the main ANOVAs are shown in Table 1, and discussed below.

Degrees of freedom are presented in subscripts, to avoid multiple parentheses.

[Table 1 about here]

Baseline time spent looking: before offset of auditory stimulus – ANOVA 1.

No significant main effects or interactions were found.

Time spent looking after offset of auditory stimulus – ANOVA 2a.

An interaction was found between parent condition, Known status, and Target status.
In the Aware condition, infants look more at the target for both name-known and name-unknown targets. However in the Unaware condition, this was only the case for name-known targets. This interaction can be seen in Figure 1.

[Figure 1 about here]

Post-hoc analyses were used to examine the difference between target and non-target looking in four conditions: Unaware known-name target, Unaware unknown-name target, Aware known-name target and Aware unknown-name target. These confirmed the interaction found above. For name-known targets, looking was significantly longer to the target in both Unaware and Aware conditions ($t_{21} = 6.26, p < .001, d = 1.73$ for Unaware, $t_{21} = 5.16, p < .001, d = 1.89$ for Aware). For name-unknown targets looking was longer to the target in the Aware condition and this approached significance ($t_{21} = 1.80, p = .086, d = .63$) but for name-unknown targets in the Unaware condition there was little difference between looking at the target and the non-target ($t_{21} = .04, p > .1, d = 0.01$).

**Proportion of time spent looking after offset of sound – ANOVA 2b.**

Significant main effects were found of Target status and Known status.

**Proportion of looking time to target compared to chance.** For each combination of side, Known status, and Aware vs Unaware condition, the proportion of looking time that was to the target was compared to chance (0.5). When the target was name-known looking to the target was always significantly greater than chance, regardless of condition (L Aware $t_{21} = 3.91, p = .001, d = 0.83$, R Aware $t_{21} = 3.55, p = .002, d = 0.76$, L Unaware $t_{21} = 2.87, p = .009, d = 0.61$, R Unaware $t_{21} = 5.66, p < .001, d = 1.21$).

This analysis of proportions replicates the findings of ANOVA 2a for raw looking times: infants looked longer to targets when they were name-known, but
when a target was name-unknown, looking time was longer to the target overall when parents could see and hear, but was equal to looking time to non-targets when parents could not see or hear.

**Baseline latency: latency of first look in trial – ANOVA 3.**

No significant main effects of Known status, Target status or parent condition or interactions were found.

**Latency of first look after offset of sound – ANOVA 4.**

Latency of first look was coded as the first look that started or continued after the offset of the auditory stimulus. If a look started before the offset of the sound but continued after it, the latency was coded as the time of offset of the sound. An ANOVA revealed no significant main effects of Known status, Target status, or parent condition or interactions on the latency of the first look after the sound finished.

**Parent interaction effects**

For half of the parents, parent bodies were filmed and parent behaviour was coded. All parents were observed to either point, look, move their head or speak at some point during the Aware block. The most common behaviour was speaking (13% of trials, 60% of parents) followed by looking to a name-unknown non-target (11% of trials, 20% of parents). Parents looked both to targets and non-targets (7% of trials versus 4.5% of trials), and both to name-known and name-unknown pictures (4% of trials versus 7.5% of trials). An ANOVA revealed no main effects of Target status or Known status, and there was no interaction. However, only half of these parents looked to one side or the other (the rest of parents, and some of these parents, pointed or spoke).

Although parents varied widely in the type of potential cues they made, all
parents performed some potential cue behaviour. An ANCOVA was carried out, covarying the proportion of trials on which each parent performed some potentially cuing behaviour, and examining infant looking time (after offset of sound). A main effect of target that approached significance was found ($F_{1,8} = 4.34, p = .071, \eta^2 = .35$), but no other effects were found. It seems that although parent condition may be able to explain some aspects of looking behaviour, it is not clear that all differences in infant looking between the Aware and Unaware conditions can be explained by the presence or absence of parent cuing behaviour.

**Discussion**

**Parent awareness and parent cueing**

Parents’ awareness of stimuli and ability to interact with their infants during an IMPL experiment have been shown in our study to have a crucial effect on infants’ looking. Patterns of looking were different when parents were aware of auditory and visual stimuli. When hearing a name-unknown target infants looked more at the corresponding picture only when parents could see and hear – possibly either due to parents giving infants support in the form of looking, gesturing or shifting seating position, or due to infants’ own awareness that parents could see and hear leading to an increase in their own interest or an attempt to engage parents’ interest. When parents could not see and hear looking was equal to the name-unknown target and the name-known non-target.

Parent awareness did not simply influence infants to look more overall, nor did it influence looking at target/non-target, or name-known/name-unknown pictures equally. Rather, allowing parents to see and hear stimuli altered infants’ looking in a way that would lead researchers to draw different conclusions from the same experimental paradigm – when parents could see and hear the stimuli infants behaved
as if they were applying a linguistic principle, variously termed mutual exclusivity, (Markman, 1990); N3C, (Mervis & Bertrand, 1994); disjunctive syllogism, (Halberda, 2003) and when parents could not see and hear the stimuli they did not. Note that our study was not intended as a test of these linguistic principles, but rather an experiment to see what conclusions might be drawn in attempts to test such theories of language development, where controls are either in place or not in place.

Some previous researchers have stressed ensuring parents are blind and deaf to stimuli (Naigles, 1990; Thomas et al., 1981), but others have not, or have controlled parents looking more informally, usually by asking parents to close their eyes, seating them where they cannot see, or just asking them not to influence the child’s looking (Golinkoff et al., 1987; Halberda, 2003; Houston-Price et al., 2007; Reznick & Goldfield, 1992; Swingley, 2009; Swingley & Aslin, 2000). Our findings suggest that researchers should pay close attention to this factor. Although the sample size is small, the moderate effect size suggests that parents produce more potentially cueing behaviour in target conditions than in non-target conditions; they do not however change their behaviour between known and unknown conditions. We cannot distinguish from these data between the effects of parent visual awareness and parent auditory awareness, and it is true that more is known about infants’ awareness of parent ability to use visual than auditory stimuli, but many of the studies that fail to control for parent awareness do not in fact control for either type of awareness.

Although some previous researchers have emphasised analysing proportional looking time (e.g. Schafer et al., 1999) or looking time differences (e.g. Golinkoff et al., 1987), others have analysed raw looking time, and analysing this enabled us to draw conclusions about the potential influences of different conditions on infants’ overall attention – an important consideration in IMPL studies. Using this analysis,
we found no decrease in looking to the stimuli overall by infants when parents’
attention was withdrawn from the stimuli. Informally, researchers often cite infants’
distraction when parents are blindfolded or wear headphones as a reason to allow
parents to see stimuli – but in our study, infants did not appear to be distracted, and
total looking time over all conditions was the same whether or not parents could see
and hear the stimuli. Although it may turn out that either blindfolding or masking
noise is sufficient to control for parent awareness, it is reassuring to know that even
when both are done it does not reduce infant looking time. Nevertheless, some
researchers allow parents to be aware of stimuli for reasons specific to the population
they are studying, which means that we need to examine the effect of parent
awareness in these populations too (Candan et al., 2012; Naigles & Tovar, 2012). For
example, if parents from one cultural group are reluctant to be blindfolded because
they wish to see the stimuli that their child sees, it would be possible to show the
parent the stimuli either before the study takes place (with the child distracted or
playing elsewhere) or after the experimental session.

As we predicted and as discussed above, it is difficult to draw conclusions
about the mechanism of this effect of parent awareness. This could be a parent effect
(parents cue infants when they are aware of the stimuli), a child effect (infants’
attention is increased when they know parents are aware, or infants attempt to engage
parents more in some conditions), or both. Likewise it could be a conscious effect
(e.g. infants actively try to find parents’ cues which in the past have given them
reliable information about stimuli) or a subconscious effect (e.g. infants feel parent
movement in one direction and this causes them to move or look in that direction).
Alternatively, although overall looking time does not increase when parents are
aware, it is possible that infants’ distress or distraction when parents are not aware
leads to additional task demands, which do not decrease overall looking time, but instead alter task performance.

**Choice of data for analysis**

Some previous studies have examined proportions of looking, collapsing target and non-target looking into the same variable. Indeed, it could be said that whatever statistic can possibly be calculated from IMPL data has been used by at least one infant laboratory. Here, we compared baseline and post-auditory stimulus looking times as well as pre- and post-auditory stimulus latencies were compared. Our approach enables us to examine differences that have not been seen in other studies, while still controlling for them.

Different statistics taken from the same trial may or may not inter-corrrelate, depending on a variety of factors including whether or not looking times to one picture or the other, or in different portions of the trial, are independent. However, our analyses find differences in some comparisons but not in others, in some cases, suggesting that studies using different outcome measures may come to different conclusions. It has proved helpful to compare a variety of measures in this study – for example, we found no target effects on looking time before the auditory stimulus was heard, meaning effects are not due to an inherent preference for the target picture but rather depends on hearing the auditory stimulus.

**Future Directions**

We have examined one very basic assumption and control that is used – or not – in research using IMPL, as well as in many other lab paradigms with infants such as eye tracking and EEG recordings. Our data challenge some of the assumptions and make some important methodological recommendations. We would urge cautious interpretation of studies that have been carried out with parents potentially able to see
and/or hear stimuli. Other studies excluded parents who appeared to be looking at visual stimuli, but some have not. When we did not specifically tell parents not to look at the stimuli, we observed several types of parent behaviours, which may have potentially cued infants, including looking at stimuli, but also including gestures and turning the head to the side. Blindfolding parents and providing masking auditory stimuli did not cause infants to decrease their looking times overall, thus it would seem advisable for blindfolds and auditory masking to become standard in infant testing setups, rather than attempting to exclude some trials or some infants for relatively subjective reasons, or relying on parents to be honest about their looking at stimuli. Some labs cite cultural reasons or the presence of learning disabilities as reasons to avoid blindfolds and masking (Candan et al., 2012; Naigles & Tovar, 2012), but again in these settings an investigation of the true impact of experimental controls is warranted before they are removed; a possible additional control might be, for example, pre-training of parent and child with parent awareness to become familiar to the setting, with blindfold and auditory masking in the testing session itself.

Although our findings appear to be broadly similar when raw looking times and when proportion of looking time are analysed, in a few analyses different results were obtained, and some analyses are only possible using one or the other measure. It is not possible to determine whether a condition influences overall looking time without analysing raw looking times, for example. Given that the choice of analysis seems to be highly variable between IMPL studies, as discussed above, further work on the differences between different analysis methods together with careful consideration of assumptions is warranted. Assumptions of independence between pre- and post-auditory stimulus looking times, and of non-independence of looking
times to two visual stimuli, in particular, would be helpfully investigated by studies in which the pre- and post-auditory stimulus time available is varied.

**Additional questions**

Our study suggests a number of other questions relating to IMPL. A study enabling closer examination of the parent behaviours that cue an infant, and the results of strict attempts to control parent behaviour, would be helpful. Instructing parents to keep still, look at their infant rather than at the stimuli, and not to speak, may or may not affect infants’ behaviour in the same way: if infants are being directly cued by parent behaviour, then when parents reduce their cues, infant behaviour may change. If on the other hand, infants are changing their behaviour because of their awareness that parents can see visual stimuli, asking parents to remain motionless and not look at stimuli, but not blindfolding them, may still affect results. Generally, researchers exclude children where parents have obviously interfered with a trial (Naigles & Tovar, 2012), but behaviour may not need to be obvious for children to perform differently. Children may also behave differently due to their knowledge that their parent can see, rather than due to any specific behaviour on the part of the parent.

To our knowledge, there are no data to confirm whether infants of this age are aware of others’ ability to hear auditory stimuli; this would also be helpful to investigate. Some studies (Swingley, 2009) restrict parents’ viewing of stimuli without auditory interference, and this may be sufficient for, for example, novel word learning studies, especially where two novel words are presented. However, where any real words are used, parents will be able to judge online whether their child knows a word or not, and again could potentially react in a way that influences children’s behaviour.
Whenever studies show theoretically “mature” behaviour (as with infants’ looking at name-unknown targets) it would be helpful to know what the impact of parent cues, or of infant awareness of parent awareness, might be on this behaviour. Is this effect a general one that leads to behaviour that might be classified as more “mature”, or does parental awareness only affect behaviour in certain circumstances?

**Conclusions**

We have made an important contribution both to the literature on the IMPL paradigm but also to the body of knowledge on infant testing in general. Labs vary widely in their use of parent controls and also in their elimination of trials and infants based on the types of behaviours we have observed here, that appear to be able to alter the findings of a study in a manner that could potentially direct theories about children’s abilities in one way, or another. Tighter control of parent awareness should not alter infants’ cooperativeness but could avoid elimination of infants and trials in a way that can lead to study bias.

**Author note**

We would like to acknowledge the assistance of members of the info-childes mailing list who enthusiastically responded to a plea for information on methodology in their labs’ studies. In particular, Letitia Naigles responded extremely kindly by sending us details of her lab’s whole body of work in this area with notations on the methodology used.

Portions of the data from this study formed part of the BSc dissertation of Author 2.

**References**


Dorling Kindersley.


