It's not what you do...

Touchscreens can promote infant object-interlocutor reference switching

Kimberley M. Hudspeth & Charlie Lewis

Affiliations: Department of Psychology, Lancaster University, UK

Corresponding Author: Kimberley May Hudspeth, 112 Skinner Building, Bishop Grosseteste University, Longdales Road, Lincoln, Lincolnshire, LN1 3DY, UK.
telephone: +44 1522 527347
email: kimberley.hudspeth@bishopg.ac.uk

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Abstract

We re-examine whether the type of object played with influences parent-infant joint attention. A within-participants comparison of 24 parent-9-month-old dyads, used head-mounted eye-tracking to measure parental naming and infant attention during play with touchscreen apps on a tablet computer or matched interactive toys. Infants engaged in sustained attention more to the toy than the tablet. Parents named objects less in toy play. Infants exhibited more gaze shifts between the object and their parent during tablet play. Contrasting previous studies, these findings suggest that joint tablet play can be more interactive than with toys, and raise questions about the recommendation that infants should not be exposed at all to such technology.

Keywords; joint attention, sustained attention, infant development, screen time, triadic interaction, eye-tracking

Introduction

Between 2011 and 2013, the proportion of infants who interacted with mobile technology in the United States increased from 10% to 38% (Common Sense Media, 2013) and the pace of change has gathered speed (Common Sense Media, 2020; Kabali et al., 2015; Levine et al., 2019) particularly since the COVID-19 pandemic (Bergmann et al., 2022; New York Times, 2021; "UK Lockdown", 2020). This dramatic increase has been linked to parenting pressures, with screen time being used as an alternative to social interaction and childcare (Hartshorne et al., 2021). This comes despite advisory bodies worldwide recommending that parents should avoid exposing infants up to 18-24 months to digital media (Council on Communications and Media, 2016), with one hour per day at most beyond 24 months (World Health Organisation, 2019; American Academy of Pediatrics: Hill et al., 2016). Despite the call for monitoring of screen time exposure levels for young children, the majority of parents may underestimate their child's media use (Radesky et al., 2020).

Few studies have addressed how infants engage with these devices, particularly those under one year (Emond et al., 2021; Hourcade et al., 2015; Wan et al., 2021). Most research focusses on toddlers and pre-schoolers (Jusienė et al., 2020; Myers et al., 2017). Frequent touch screen users at 18 and 42 months are faster in exogenous visual search screen tasks (e.g., searching for a red apple amongst blue ones; Portugal et al., 2021a), but at the cost of being slower to disengage from a central to a peripheral stimulus (Portugal et al. 2021b). Two-year-olds will even cut out a parent attempting to share attention to the screen (Munzer et al., 2019b). Even infants fixate on a screen when the computer omits attention grabbing sounds (Sato et al., 2016). Toddler-parent dyads may take fewer conversational turns and exhibit fewer reciprocal vocalisations when interacting with computerised displays in both one- (Sosa, 2016) and two- (Munzer et al., 2019b, 2021) year-olds and high screen-time use has been correlated with poorer fine-motor skills at age 3 (Webster et al., 2019), decreased

endogenous attentional control (Portugal et al., 2021b), and less disengagement of attention at 42 months (Portugal et al., 2021b). In longitudinal research, screen use around the child's second birthday predicts less time reported in positive learning activities such as reading at age 3 (McArthur et al., 2021).

Children in the late preschool period may not learn from their attention to screens (e.g., Calvert et al., 2005), but other studies suggest that even young infants can learn from digital media (Anderson & Hanson, 2010; Barr, 2013; Griffith et al., 2020). Their engagement with interactive tablet videos correlates with faster early word acquisition (Kirkorian et al., 2016), despite concerns that apps for young children are not based on educational research (Rich, 2020). It has long been assumed that learning from any medium is maximised via joint engagement with a caregiver (Baldwin, 1995; Carpenter et al., 1998; Healey et al., 2019; Mundy & Jarrold, 2010; Tomasello & Todd, 1983; Vaughan Van Hecke et al., 2007). Simultaneous attention to a tablet may increase 15-month-olds' object identification, linking touch screen images to 3D (Zack & Barr, 2016), even when the other interactant is a peer (Lytle et al., 2018). Toddlers learn a word from a video when a caregiver provides verbal support and encouragement (Strouse & Troseth, 2014). Infants increasingly participate in shared attention 'within' screen technology, e.g., in video chat with a grandparent, and become highly skilled by their second birthdays (McClure et al., 2018). Additionally, caregivers can improve infant responsiveness when engaging with others over video chat (Myers et al., 2017). It is important to consider media use in terms of *what* the screens are being used for, as opposed to simply for *how long* they are being engaged (Radesky, 2021).

The literature summarised above suggests that the impact of screen media on the quality of infant-caregiver-object triadic interaction is not yet fully understood. Most research focusses on older children (Carr & Dempster, 2021), and there is a greater concern with the interruptive power of screens, i.e., in terms of 'technoference' (Corkin et al., 2021), or as a

background distractor during interactions, which can negatively influence the quality of joint attention episodes (Sato et al., 2016).

There is a prevailing assumption in policy statements (World Health Organisation, 2019) and research (Munzer et al., 2019b; Sato et al., 2016) that computer screens grab attention to the exclusion of social interaction. This is resonant with studies showing that screens in general do not lead to learning – the 'video deficit effect' that peaks at 15 months (Barr, 2010). We term this the Social Inhibition hypothesis. We examined how interactive touchscreen media can influence infant-caregiver interactions, at the age when joint attention is emerging (Tomasello, 1995). We reasoned that modern touchscreen technology is more comparable to toys in 3D, compared with more traditional (and passive) screen media such as televisions – the focus of most research to date (Barr, 2010). Current software offers more similar affordances in the way tablets can be held, grabbed, lifted, placed, and touched (Hiniker et al., 2015). The appeal of many toys is that they have inbuilt sounds which are comparable to such displays in contemporary screens. We set up a study in which both touchscreen activities and toys were designed to be interacted with – each omitting a sound and/or motion when touched (tablet) or manipulated (toy) – and examined infants' attention to the object and to their accompanying parent while they engaged with the toy or tablet., we surmised that tablets with such software would hold the infant's attention more than toys during the interaction, resulting in more infant sustained attention, fewer looks between the object and social partner, and reduced caregiver language input. We termed this the Social Facilitation hypothesis, that more interactive software would reduce sustained attention and increase infant-caregiver interaction.

We focussed particularly on joint attention. We defined this as inherently social, as two social partners mutually share an experience of an object (Tomasello, 1995). We selected participants in late infancy, as mutual engagement in activities grows most rapidly from nine

to ten months (Carpenter et al., 1998), accompanied by the emergence of social referencing and gestures like giving, showing and pointing (for a review, see Guevara & Rodríguez, 2023). Infants' ability to engage in joint attention has been measured in a variety of ways, often within discrete controlled trials (Brooks & Meltzoff, 2005; Reid & Striano, 2005; Scaife & Bruner, 1975), or in their responses to bids (Kasari et al., 1990; Osorio et al., 2011). Many researchers have used coordinated looking (Brooks & Meltzoff, 2008; Butterworth, 1995; Koşkulu et al., 2021; Yu & Smith, 2013), for a predetermined duration (e.g., 500ms in Yu et al., 2019). This, however, presents us with a conceptual challenge as it does not require interactants to monitor the other's attention, let alone share the experience (Tomasello, 1995). The literature which cautions against the exposure of young children to screen time assumes that tablet computers grab children's attention to the detriment of joint attention coupled with a decrease in the parent's interactive and language bids which solicit such exchanges (e.g., Sato et al., 2016). This is potentially damaging, as a key component of joint attention is the ability to alternate attention between the stimuli and social partner (Carpenter & Liebal, 2011; Field, 1981; Osório et al., 2011; Tomasello, 1995). We assessed the nature of infants' concentration on tablets and matched toys by examining their sustained attention for periods of three or more seconds to the object of play or caregiver (Ruff & Lawson, 1990; Yu & Smith, 2016) and compared these with the frequency of their gaze shifts (as a measure of social engagement) between the object (toy or screen) and the caregiver during the interaction. Given the recent interest in parental naming during sustained attention (e.g., Yu et al., 2019) and a longstanding research interest in parents' use of nouns to how adults offer new words in child-directed speech across different languages (e.g., Clark and Wong, 2002), we examined parents' use of nouns to assess references or instructions to act on the objects discussed. We added verb use as these are also used more by adults to one-year-olds when

the interaction does not refer to toys, but nouns are used more when the same interaction refers to the provided toys (e.g., Goldfield, 1993).

Methods

Participants

We recruited thirty-three parent-infant dyads who had volunteered at the Babylab at Lancaster University, following ethical approval from the University Ethics Committee (FST18070, 30/04/2019). Nine infants were excluded due to fussiness (M_{age} = 9.14 months, *SD* = .52), and twenty-four were included in analyses (M_{age} = 9.09 months, *SD* = .5). Parents on the database of infants were contacted and agreed to attend the lab to participate. For details of sample ethnicity and gender, see Table 1. SES of this volunteer sample was mixed, with primarily white-collar participants. They provided written informed consent on arrival at the BabyLab and were compensated a set rate for their travel expenses (£10) and a book for the infant to take home.

Procedure

While infants familiarised themselves with the laboratory, caregivers first completed a questionnaire involving demographic questions and a measure of their infant's current touchscreen contact (Cristia & Seidl, 2015). The infants were then seated at a table in a highchair, with their caregiver beside them at a 90-degree angle, facing a screen at the other end of the table, to prevent the infant becoming distracted. Positive Science, LLC (Franchak et al., 2010) head mounted eye trackers were then set up and calibrated for both the caregiver and infant (See Figure 1). A wall-mounted remote camera also captured the interaction and sound. Parents were informed that we were investigating how infants engage with toys and tablets during play and were not given specific details regarding how to engage with their infant, to ensure that communication between them was as natural as possible. Infant-caregiver dyads then engaged in two play sessions, with either the toys or the tablet, for six

minutes. Conditions were counterbalanced to control for order effects. The age-appropriate mental assessment tasks from the Bayley Scales of Infant Development, Second Edition (1993) (BSID II) were then administered at the table, following which the corresponding motor assessment was conducted on the floor space in the lab. Caregivers were then debriefed and thanked for their participation.

Figure 1: Positioning of participants and their eye trackers in the tablet condition

Stimuli

The tablet used was an Amazon Fire 7 For Kids, with a yellow (gender neutral) 'child-proof' cover, with applications aimed at very young infants. All dyads began on the same app (RosiMosi LLC, 2012) as it provided several simple interactive scenes (farmyard, aquarium, zoo, balloon popping) which produced sounds and animations when tapped. Two apps also aimed at young infants were installed in case the infant did not find the first engaging (an interactive piano keyboard (Superb Apps, 2015) and a popular 'baby shark' app (The Pinkfong Company, 2016) but these were very rarely utilised. Toys suggested to be age-

appropriate and gender-neutral (Alexander et al., 2009) (pop-up toy with three animals that emerged when buttons were manipulated, stackable helter-skelter with marbles and a rainmaker) were selected. The aim was to equate the interactive components of the apps and the 3D toys. For example, both pressing a cow on the app or a button on the pop-up toy produced a visual and auditory change in the object pressed, while some icons, like the sun, produced more general animations across the screen, equivalent to the motion produced of the marble on the helter-skelter.

Outcome Variables

The outputs of the eye-tracker and video were analysed in Blender (Blender.org, n.d.). The blended data files for maternal and infant looks were coded to identify periods of looking at either the object/tablet or the caregiver: [1] *sustained attention* was defined as infant looks of three seconds or longer in duration (Yu et al., 2019) [2] *Caregiver language use* was measured in both the total number of object names/labelling (nouns) and verbs used in the period, excluding repetitions when the gaps between words were less than one second. [3] We identified an *infant gaze shift* when he or she alternated their attention between the object and the caregiver (and vice versa). We tallied the total number of these shifts for each infant.

Three infants became distressed before the end of the six-minute play periods (range 5 mins – 5 mins 32 secs), due to the discomfort/distraction of the head-mounted eye tracker. The activity was terminated, and their data scaled. Intra-rater reliability was obtained by re-coding 10% of the data two years after it was first coded. Intraclass correlation was calculated using the ICC() function from the *psych* package (Revelle, 2018) in R Studio (R Core Team, 2022) and confirmed consistency of 94% for visual attention and 99% for gaze shifts.

Results

Nine infants refused to wear an eye tracker and/or became fussy, so testing was ended. Therefore, twenty-four sets of looking data were included in the analysis (M = 9.09, SD = .5, 54.17% Male). The audio was corrupted on two files, so 22 sets of data were included for analyses involving parental language. A priori power analyses were conducted using G*Power version 3.1.9.6 (Faul et al., 2009), to inform us of the minimum required sample size necessary to obtain results of sufficient power. Post hoc power analysis for a matched pairs t-test, with an effect size d = 1.16, at a significance criterion of α = .05, has power > .99. G*Power suggests we would need a minimum sample size of 7 to achieve power = 80% in a matched pairs t-test, which was exceeded in all analyses (including missing values). Data were sufficiently normal to allow for parametric analyses. All questionnaire responses and the infants' psychometric test data are presented in Table 1. Means and standard errors for all variables are presented in Figure 2.

Table 1 Participant characteristics: from the 24 participants whose looking time data was included in the analysis

Caregiver Relationship	Mothers	22
	Fathers	2
Ethnicity	White	23
	Asian	1
Age of infant (months)	Mean(sd)	9.09 (.5)
Gender	Male	13
	Female	11
Birth Order	1	11
	2	12
	3	1
Bayley II Mental Scale	Mean(sd)	72.54(3.48)
Bayley II Motor Scale	Mean(sd)	55.29(2.29)
Older sibling that has not reached developmental milestones	Speech Delay	1
Touchscreen Use Frequency*	0	0
	1	17
	2	3
	3	2
	4	1
	5	1
Things Infants Use Touchscreens to Look At	Photos	11
	Videos	11
	Puzzles	0
	Facetime	12
	Baby Apps	1
	Other	6
Parental Report: Gestures Used When Engaging With Touchscreen	Open Hand Hit	20
	Tap	8
	Flick	4
	Press and Drag	4
	Swipe	3
	Pinch	3
	Spread	0

* Parental-reported infant touchscreen use frequency: 0 = “never seen or touched; there are no tablets or smartphones at home”, 1 = “never used such technology, although he/she may have seen me and other family members interact with one”, 2: has occasionally used such technology, but not more than once a month”, 3 = “occasionally uses such technology, but not more than once a week”, 4 = “regularly uses such technology, but not more than once a day”, 5 = “uses such technology every day”

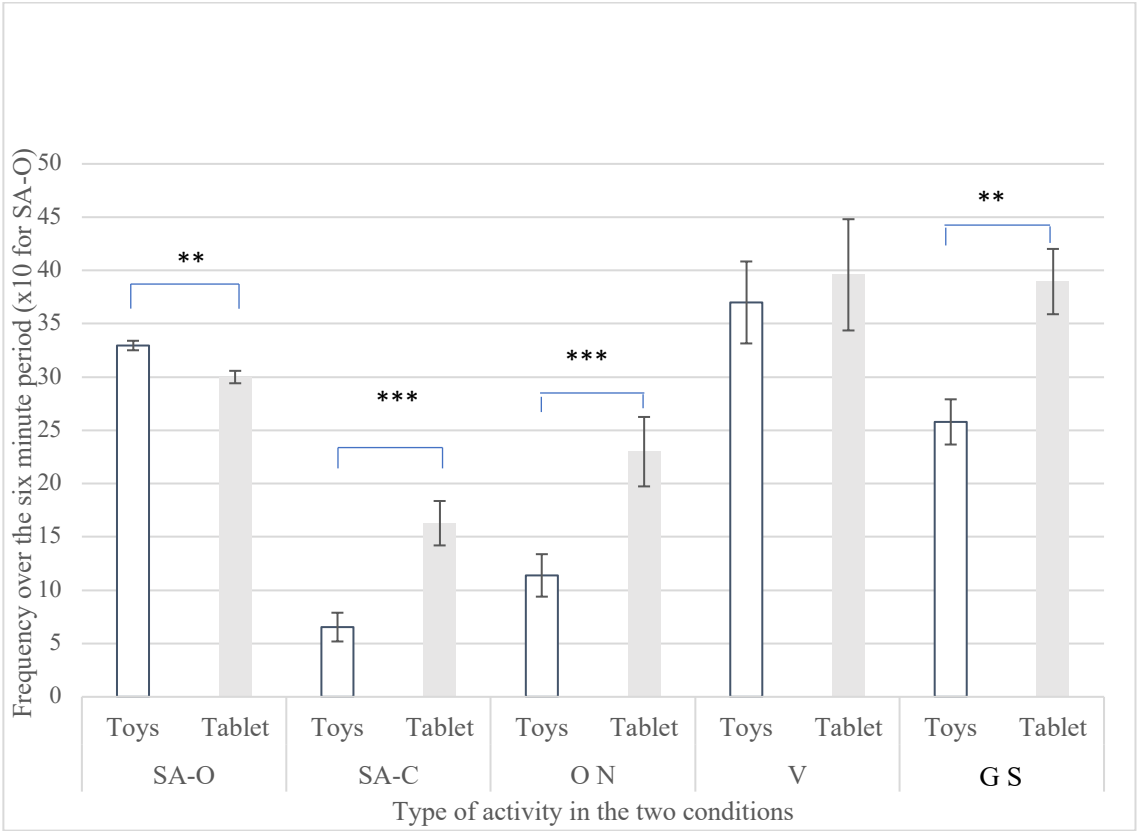
We conducted a series of analyses to test the two contrasting hypotheses outlined in the introduction. Within this controlled laboratory environment, infants looked at the object of attention for the majority of the exposure period. Compared with sustained attention to the toys (M = 329.59 seconds seconds/ 360 maximum possible, SD= 21.83), children engaged significantly less ($t(23) = 3.54$, $p = .002$, $d = 1.16$) to the tablet (M =300.01 seconds, SD = 28.57). There was no significant relationship between time spent in sustained attention during tablet play and toy play ($r(22) = -.31$, $p = .14$).

Infants spent longer sustaining their attention to their caregiver in the tablet (M = 16.29 seconds, SD = 10.21) than the toy (M = 6.54, SD = 6.60) condition, $t(23) = 3.72$, $p = .001$, $d = 1.13$. Again, there was no significant relationship between time spent attending to the caregiver between conditions ($r(22) = -.13$, $p = .55$). Infants also made significantly more gaze shifts in the tablet condition (M = 38.96, SD = 15.01) than the toy condition (M = 25.79, SD = 10.39), $t(23) = 3.19$, $p = .004$, $d = 1.02$. Their shifts in looking were not correlated between conditions ($r(22) = -.24$, $p = .26$).

We checked that infant attention to the object was not influenced by their developmental levels, assessed by the Bayley II Mental ($r_{toy}(22) = .13$, $p = .55$; $r_{tablet}(22) = .25$, $p = .25$), or Motor ($r_{toy}(22) = .07$, $p = .74$; $r_{tablet}(22) = -.12$, $p = .59$) scale scores, even though infants' scores on the former correlated with total caregiver naming ($r(20) = .47$ $p = .02$). In contrast to previous analysis (Portugal et al., 2021) we found no difference between those with (N= 7) vs. without (N= 17) experience groups in the time spent sustaining attention to the touchscreen $t(9.15) = 1.31$, $p = .22$, $d = .62$). We tested the role of parental language in the interaction by examining the parent's object naming and verbs in each condition. Significantly more nouns were used by the caregiver in the tablet condition (M = 21.86, SD = 15.95) $t(22) = 3.96$, $p = .001$, $d = .86$) than the toy condition (M = 10.50 , SD =

9.84), see Figure 2, but there was no difference between conditions in the number of verbs used by caregivers $t(22)=.57$, $p = .57$, $d = .12$).

The number of infant gaze shifts was negatively associated with sustained attention to the object in both the toy ($r(22) = -.88$, $p < .001$) and the tablet condition ($r(22) = -.45$, $p = .03$). However, infant gaze shifts were positively associated with sustained looking to the caregiver in both the toy ($r(22) = .63$, $p < .001$) and the tablet ($r(22) = .43$, $p = .04$) conditions.



SA-O = Infant sustained attention to the object; SA-C = Infant sustained attention to the caregiver; O N = Caregiver object naming (nouns regarding the toy/tablet); V = caregiver use of verbs; G S = Infant gaze shifts between the object and caregiver

* $p < .05$
** $p < .01$
*** $p < .001$

Figure 2: Mean frequency (with S.E. bars) of infant bouts of sustained attention to the object and caregiver, parental language, and changes in infant attention in each condition

Discussion

Previous research suggests that computer screens hook young children in more than other objects like toys or books (Munzer et al., 2019b), to the detriment of cooperative interaction with a caregiver (Carr & Demster, 2021; Sato et al., 2016), in keeping with many studies which show little generalisation from TV and video to objects in the child's environment (reviewed by Barr, 2010). These data all add to a Social Inhibition hypothesis tested here – that children's focus on screens prevents the enriched parent-child interaction that normally leads to learning (Lauricella et al., 2016). In contrast, we found that the attention-grabbing toys used here elicited more sustained attention than their electronic equivalents. This coincided with more looking at the caregiver, more caregiver object naming and more shifting of attention when infants played with a tablet, thus supporting the Social Facilitation hypothesis. The results are also different to the literature on parental access to the child's attention when the latter is facing a screen (Munzer et al., 2019) and the finding that shared screen viewing to a television can reduce the quality and quantity of caregiver language input on less interactive screen media (Lavigne et al., 2015) and tablet computers (Sosa, 2016). Our results therefore suggest that touchscreens do not necessarily encourage solipsistic activity on the part of the young child. That there was less en-face interaction and fewer shifts in the infants' looks in the toy condition does not imply that directives should be issued to parents for toys to be withheld from infants. Rather it alerts researchers and professionals to the possibility that the objects that children are exposed to are not as important as the activities which we share with them (Lewis & Gregory, 1987).

Nevertheless, throughout these observations the infant's sustained attention to the object was over ten times as long as that to the caregiver. Both the tablet and the toys grabbed the child's attention. While electronic toys have been deemed to be detrimental to the quality of joint attention (Sosa, 2016), recent evidence using the technology employed in this study

shows that the infant's increased sustained attention during triadic (infant-caregiver-object) interaction predicts later language ability, even when infant-caregiver interaction is taken into account (Yu et al., 2019). This suggests that the role of the parent in such activity may be more about keeping the infant on task than the adult imparting knowledge on her offspring.

Our findings should be tempered by the size and characteristics of the sample, as a majority were white and white collar, and the simplicity of the manipulation made to compare toys and tablets. It is possible that the infants engaged in more social interaction with the caregiver due to the unfamiliar nature of the touchscreen, and were seeking guidance or assistance due to the novelty of the stimulus. Whilst many parents reported their infants had "used" touchscreens for FaceTime and photo/video viewing, the majority indicated this was through 'watching' someone else control the device as opposed to the infant handling it themselves. Different results may have been obtained had the infants had more screen experience. This should be explored in further studies. The contrast between our findings and those of other similar experiments may also stem from the age of the infants. Longer looking at tablets have been found in toddlers over the age of 12 months (Aziz, 2013; Portugal et al., 2021b) so comparisons of infants and toddlers should be made to test our results further.

These results should only be considered in one context of which the touchscreen was used, that is, interactively during joint play within a laboratory setting with provided tablets, software and toys. Whilst in everyday life screens are used for a variety of activities, such as during car rides or at mealtimes to keep infants happy or on task, this is a very different kind of passive screen use which was not explored in this investigation. While observed sessions in the laboratory may lack ecological validity, recent research has shown lab-based interactions are highly comparable to those in the home (Suarez-Rivera et al., 2022).

Future studies should also seek to establish more precisely young infants' capacity for performing touchscreen-appropriate gestures. Most existing literature relies on parental self-

report (Cristia & Seidl, 2015), or uses very broad categories (e.g., 0-2 years, Livingstone, 2016), which makes it difficult to establish capabilities at specific ages. Some experimental studies suggest that infants only explore touchscreens with appropriate gestures by 15 months of age (Ziemer et al., 2021). However, Ziemer et al.'s (2021) research focuses on infant's exploration of screens alone, rather than shared interactions which are modelled, scaffolded and supported by a caregiver.

Our findings may be reassuring for those concerned about the seemingly all-consuming power of computer technology for infant attention. Using touchscreens with software designed to elicit a reaction seemed to promote social interaction. If our results are confirmed and extended, current advice that screen time should be discouraged for children under 18 months of age (Hill et al., 2016) should perhaps be modified to emphasise the engagement in co-viewing with screen media (Padilla-Walker et al., 2020). Our finding that parents named objects on the tablet more than they did the toys supports the idea that touchscreen technology may have educational value (Couse & Chen, 2010; Ginsburg, 2014; Haßler et al., 2016; Kosko & Ferdig, 2016; Montrieux et al., 2015), as caregiver naming is related to language acquisition (Ambridge et al., 2015; Diessel, 2007; Ellis, 2002). Touchscreens have the potential to present a variety of images and means for learning and social interaction.

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