A DEVELOPMENTAL STUDY OF 9- AND 12-MONTH-OLD INFANTS' LEARNING FROM TELEVISED VIDEO

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ABSTRACT

Although infants are exposed to relatively high levels of television the impact of this exposure on learning is not completely known. Research has shown that infants learn significantly less from a televised demonstration than they learn from a live demonstration. It was hypothesized that providing 9- and 12-month-old infants with active experience with the task objects after a demonstration would increase learning from television. Overall, infants were able to solve means-end tasks quite well and transfer the modeled solution across several test trials with slightly different tasks. Surprisingly, the results showed that infants learned equally well from the live and video demonstrations and did not show a video deficit effect. In addition, no age differences were found. However, as expected, infants performed much better in the active training conditions compared to the passive conditions. Findings are discussed in terms of the perceptual impoverishment theory and the dual representation theory.

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Television appears to be playing an increasingly prominent role in the lives of infants and toddlers. We live in a digital age where young children are spending increasing amounts of time in front of computer and television screens. With the recent explosion of videos and television programming developed specifically for infants, it appears that very young children are exposed to more television than ever before. Presumably this media is entertaining but the kind of information or behaviors that these very young viewers acquire from watching them is not completely known. The remainder of the chapter that follows critically reviews contemporary literature concerning what infants can learn from video. Initial sections will discuss research on very young children's exposure and attention to television in general, followed by an examination of the methodologies used to assess learning from video. An additional focus of this review centers on a consistent finding in this area of research described as the *video deficit effect* (Anderson & Pempek, 2005), which researchers have recently found can be ameliorated (i.e., Barr, Muentener, Garcia, Fujimoto, & Chavez, 2007; Barr, Muentener, & Garcia, 2007; The review concludes with a summary and critique of the existing literature, followed by a discussion of the specific research questions and hypotheses suggested by the review and examined in this thesis.

Exposure to Television

It is estimated that the average household has a television set in use for about 6 hours per day (Roberts & Foehr, 2003). While both the Canadian Pediatric Society (2003) and the American Academy of Pediatrics (2001) have recommended restrictions on television exposure for children under 2 years, the introduction of videos and TV programming created specifically for—and directed to—babies such as the “Baby Einstein” series and TV programs such as

“Teletubbies” has substantially increased over the past decade. According to recent research conducted by Zimmerman, Christakis, and Meltzoff (2007), by 3 months of age, about 40% of children regularly watch television, DVDs, or videos. By 24 months, this increases to 90%. Among those who watch, the average viewing time is 1 hour per day for children younger than 12 months and more than 1.5 hours per day by 24 months. In short, these exposure numbers are staggering.

Attention to Television

Importantly, there is evidence that very young children are not only exposed to increasing amounts of television but that they also pay attention to the videos and series directed to them. Attention to television is typically inferred from overt looking at the screen (Anderson & Pempek, 2005), and using this criteria, it seems to be the case that infants are doing this. For example, when infants 12-15 months of age were shown videos aimed at babies, looking times ranged from 48% to 74% suggesting a considerable amount of interest (Barr et al., 2003). In addition, research on young children’s attention to the popular television program “Teletubbies” has shown greater levels of looking from 18- and 24-month olds than those observed in previous research looking at levels of looking from the same age group during the television show “Sesame Street” which is made for a slightly older target audience (Frankenfield, Richards, Lauricella, Pempek, Kirkorian, & Anderson, 2004). It appears that videos and TV programs that are made for infants and toddlers can gain high levels of sustained attention.

Learning from Television

If young children are paying attention to these programs, the next logical question is whether or not they are able to take this information and use it to act purposefully. Several

lines of research are involved in answering this question and determining what young children are able to learn from video. These include experiments conducted using imitation paradigms, deferred imitation tasks, object search and object placement tasks. Overall, the results suggest that infants are in fact able to learn from television from a very young age. It appears to be that infants are able to imitate televised actions from 6 months of age (Barr et al., 2007b); at 12 months of age they are able to successfully exhibit deferred imitation (Barr et al., 2007b); and by 24 months, they are able to show some success with object placement and retrieval (Deocampo & Hudson, 2005) although it is not mastered until 2.5-3 years of age (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998).

Imitation tasks. The earliest work on children's ability to learn from television focused on the imitation of televised behavior. In the classic studies conducted by Bandura and his colleagues (Bandura, Ross, & Ross, 1963) 3-5 year old children were exposed to either live or televised models demonstrating aggressive behavior toward an inflatable doll. When given the opportunity to play with the same doll afterwards, children displayed similar aggressive behavior regardless of the method of demonstration.

Aside from providing an ecologically valid measure of knowledge transfer (Barr et al., 2007a), it has been argued that imitation paradigms like the one used by Bandura provide an ideal tool for exploring what infants and toddlers learn from television because they do not rely on language comprehension or production (McCall, Parke, & Kavanaugh, 1977). More recently, researchers have continued to use this paradigm to assess the ability of younger children to learn from televised demonstrations. In a typical experiment, the infant is presented with a video demonstration of an experimenter engaging with an object. The demonstrated actions can

be either simple one-step actions, such as pulling apart an object (Meltzoff, 1988), or more complicated multi-step actions, such as removing a mitten from a puppet, shaking it and removing a bell inside (Barr & Hayne, 1999).

Meltzoff (1988) reported that 14 month olds were able to imitate a one-step action with a novel toy from a televised model when tested immediately after demonstration. Furthermore, Klein, Hauf, and Aschersleben (2006) found that 12 month olds also exhibit immediate imitation from a televised model. Until quite recently, it was believed that this was the earliest age infants were able to learn from television demonstrations. However, by reducing the demands of the task from imitation to simply observing and interpreting, researchers were able to show that infants as young as 6 months of age are able to understand televised actions (Hofer, Hauf, & Aschersleben, 2007). Compatible with these findings, Barr and her colleagues showed by increasing video exposure to twice that of a live demonstration, 6-month-old infants imitated actions from the televised demonstration (Barr et al., 2007b).

Deferred imitation tasks. Although seemingly compelling at first glance, the fact that an infant imitates a modeled action does not allow us to know for sure that the behavior and resulting effects have been learned from observation. This demonstration of behavior could simply be “mimicking” without true understanding or learning—a key debate that has been engaged in the developmental literature (c.f., Huang, Heyes, & Charman, 2002; Provasi, Dubon, & Bloch, 2001; Tomasello, 1999; Want & Harris, 2002). In an attempt to alleviate this possible explanation and determine the robustness of the imitation findings, researchers have often opted for deferred rather than immediate imitation tests (Barr et al., 2007b). In order to imitate from video successfully, the participant must pay attention to what is being displayed, encode

and form a representation of what is being observed including the object and target actions, and the representations must be reproduced at some later point (Barr et al., 2007a). However, when a delay interval is introduced and the representation is not used immediately but rather must be retained for an extended period of time, the attentional requirements—or cognitive load—imposed by this demand is considerably greater than immediately recalling the action to be used. It is for this reason that researchers argue that deferred imitation is a more complex representational task (Barr & Hayne, 2000). Even using this more cognitively demanding task, researchers have consistently reported that infants as young as 12 - 18 months of age show deferred imitation from televised demonstrations after a 24-hour delay (Meltzoff, 1988; Barr & Hayne, 1999; Barr et al., 2007a; Barr et al., 2007b).

Object search tasks. The research described above shows that infants are absolutely able to use video images of real events to guide their own behavior in an imitative manner both immediately and after a delay. As an extension of these findings, research conducted with older infants typically tests whether they are able to guide their own object search behavior based on information gained from video. In a typical object retrieval experiment, a toddler would be shown video of a model hiding a toy in an adjoining room and they would be encouraged to go into the room to find the toy where the model had hidden it (Schmitt & Anderson, 2002). Alternatively, there are two variations of this object retrieval task. The first version, an object placement task, involves having the participant watch as a toy is placed in another room and then asking them to put the toy in the same place (Schmitt & Anderson, 2002). This task is believed to be easier than the traditional object retrieval paradigm because the toddler is simply required to imitate the model's actions as opposed to actually having to generate search

behavior (Schmitt & Andersen, 2002). Similarly, a second variation of this task involves having the participant watch the model find a toy in the next room before they are given an opportunity to go into the room and find the toy themselves. In essence, the child is required to imitate the act of finding a toy (Deocampo & Hudson, 2005), which should also be less cognitively demanding.

Research has consistently shown that 24-month-old infants have great difficulty with the object retrieval tasks (Schmitt & Anderson, 2002). Interestingly, however, their performance on the first trial is substantially better than on later search trials. That is, performance starts above chance and then deteriorates over trials (Schmitt & Anderson, 2002). Researchers have suggested that this indicates that they are able to absorb at least some information presented to them from the initial video images (Anderson & Pempek, 2005). The developmental reports describing the actual age that toddlers achieve competence with these tasks seems to be somewhat conflicting. Troseth and DeLoache (1998) found that 30-month-old infants did well with video in their study; however, Schmitt and Anderson (2002) reported that 30 month olds were only able to perform at an intermediary level. The researchers in this latter study argued that although 30-month-old infants performed better than 24 month olds, it is not until 36 months of age that they are able to perform well. Therefore, as a compromise stance, the age at which infants are proficient with object search tasks appears to be occur between 30 and 36 months of age, depending on small methodological or task differences. This suggests that it is around this age that infants are able to understand that representational media, such as video images, can refer to object and events in real life and can use this information to guide their behavior (Deocampo & Hudson, 2005).

Video Deficit Effect

Even after toddlers are able to use video images to appropriately guide their behavior during object retrieval tasks, their performance is still worse than toddlers who saw the event in a more naturalistic way (Schmitt & Anderson, 2002). This finding is typically referred to as the *video deficit effect* (Anderson & Pempek, 2005) and is not task specific; a similar pattern is shown with imitation tasks. Even after infants begin to learn and imitate actions from televised demonstrations, their performance is almost always inferior compared to live demonstrations suggesting that very young children learn less from television than real events (Barr & Hayne, 1999). These findings are remarkably consistent in indicating a video deficit for infants 30 months and younger.

Working backwards, findings revealed that 36-month-old infants imitate a video model as frequently as a live model (McCall et al., 1977). Consistent with this finding, Schmitt and Anderson (2002) found that it was not until 36 months of age that infants perform equally well on object search tasks involving watching a hiding event on television compared to through a window. This study also revealed that around 30 months of age infants begin to show signs of the video deficit effect. The 30-month-old infants, although better than the 24 month olds, had difficulty and were significantly poorer at finding the toy compared to those in the window condition. By 24 months, their performance in the televised condition was much diminished in comparison to the window condition (Schmitt & Anderson, 2002). Similarly, Troseth and DeLoache (1998) reported that 24 month olds, but not 30 month olds, were substantially less likely to find a hidden toy following a televised hiding event than after seeing the event through a window. A similar pattern is also revealed with the object placement tasks (Schmitt &

Anderson, 2002). Taken together, the results suggest that for object placement and search tasks at least, the video deficit effect occurs around the age of 24 months and persists until approximately 30-36 months.

In terms of imitation tasks, Barr and Hayne (1999) reported that 12- to 18-month-old infants were able to imitate action sequences from a live model after a 24 hour delay yet only 18 month olds were able to imitate the same action sequence demonstrated by a televised model. Furthermore, the 12 and 15 month olds were able to imitate the actions immediately after the video demonstration but their performance suggested a video deficit effect compared to the live demonstration. When the imitation procedure is used with older infants, the imitations were still poorer when based on video demonstrations in both 24- and 30-month-old infants (Hayne, Herbert, & Simcock, 2003). Interestingly, the youngest infants demonstrating an ability to learn from video (6 months of age) do not show the deficit effect and are able to learn equally well from video and live demonstrations (Barr et al., 2007b). Thus, it seems to be that infants' inability to use televised information as efficiently as live information develops at some point between 6 and 12 months of age and continues until 30 months of age.

Possible explanations. There have been many attempts by researchers to explain this video deficit effect. For instance, it has been suggested that infants simply have problems perceiving and interpreting actions shown on video (Hofer et al., 2007). It has also been suggested that if infants are in fact able to interpret the actions and the problem may lie in their ability to demonstrate their knowledge. That is, the video deficit may be due to the lack of an appropriate task rather than the infants' inability to imitate from television per se (Barr et al., 2007a). Another explanation may be that infants find it more difficult to generalize from a video display

than from a real object due to the lack of perceptual cues (Barr & Hayne, 1999). In line with this argument, Schmitt and Anderson (2002) have suggested that representations derived from videos are weaker than those derived from live demonstrations. It may also be that the participant's attention is less focused during the video demonstration compared to the live demonstration (Barr & Hayne, 1999). Although each of these explanations has received at least some minimal support in the literature, researchers are mostly only speculating about the possible underlying reasons (Hofer et al., 2007). On the other hand, with much support, the two most widely accepted theories to explain the video deficit effect are the perceptual impoverishment theory and the dual representation theory.

Perceptual impoverishment theory. The perceptual impoverishment theory suggests that the video deficit effect is a direct result of poor perceptual encoding at the time of demonstration (Barr & Hayne, 1999; Schmitt & Anderson, 2002). More specifically, the 3D representation of the object and actions are degraded by looking at a televised image. That is, the cues that would normally be available when looking at the object and actions in a real-life 3D context, such as depth cues, texture, motion, and shadow gradients, are limited or poorly resolved on the 2D screen. Johnson (1997) argues that in order to properly encode object information and create an accurate representation, a minimum amount of this perceptual information is required. Furthermore, it has been suggested that younger infants require more of this information than older infants (Johnson, 1997). Researchers have suggested that because of the lack of necessary perceptual information, much more of the infant's limited cognitive resources must be used in order to identify objects, interpret the actions and perceive the 2D or 3D nature of the display (Schmitt & Anderson, 2002). As a result, there are fewer resources

available to devote to attending to the relevant task details and encoding these details.

Importantly, if initial encoding is compromised, it is likely that retrieval will be as well which is why we see such poor performance (Barr et al., 2007b).

According to Barr et al. (2007b) three lines of research provide support for the perceptual impoverishment theory. The first important finding is that video deficit effect disappears as infants get older. Johnson (1997) argued that younger infants require more perceptual information than older infants to create an object representation. A key component of the video deficit effect is that the infants need more information than what is available to them from the 2D stimuli. However, as infants get older, they require less of this information and are able to form representations from the 2D stimuli, despite the lack of perceptual information. The reduction of the video deficit effect over time is a fairly consistent finding. For example, Schmitt and Anderson (2002) compared infant performance on an object search task after being shown a televised hiding event in an adjacent room or watching the event through a window. The performance of 24-month-old infants in the televised condition was very poor in comparison to those in the window condition. By 30 months of age, infants improved considerably and by 36 months there was no evidence of a video deficit. However, other research conducted with younger infants found that 6 month olds were able to learn equally well from a live demonstration and a televised demonstration (Barr et al., 2007a). The fact that there is no video deficit found in infants of such a young age is surprising based on Johnson's (1997) argument.

A second line of research providing support for the perceptual impoverishment theory has used event-related potentials to demonstrate that infants actually process 2D and 3D images at different rates (Carver, Meltzoff, & Dawson, 2006). It seems to be that 18-month-old infants

process 2D images more slowly than they process 3D objects. The infants in this study were presented with 3D toys or 2D pictures of toys and it was found that they were able to recognize a familiar 3D object very early in the attention process but recognized a 2D picture of a familiar toy significantly later.

Taking this finding into account, researchers attempted to reduce the video deficit effect by increasing exposure to target information by repeatedly showing the action sequence demonstrations (Barr et al., 2007a; Barr et al., 2007b). Since 2D information takes longer to process than 3D, providing infants with more time to process the 2D information should enable them to create stronger representations and use these representations to perform at the same level as infants provided with 3D information. This is precisely what was found. The video deficit was ameliorated by increasing the duration of exposure to the video demonstrations (Barr et al., 2007a; Barr et al., 2007b).

Dual representation theory. The second major theory used to explain the video deficit effect is the dual representation theory (Troseth & DeLoache, 1998). Dual representation requires that the young child understand both the abstract and concrete natures of a symbolic or representational medium. More specifically, a symbol is concrete in that it is an object in its own right but is also abstract in that it can be used to convey information about something else (DeLoache, Pierroutsakos, & Troseth, 1996). To demonstrate dual representational understanding within a particular medium, a viewer must be able to represent both the abstract and concrete aspects as well as understand the relationship between the two (DeLoache, Pierroutsakos, & Troseth, 1996). As an example, in the object search paradigm toddlers are shown an experimenter hiding a toy either on a television screen or through a window. If the

children are successful in retrieving the toy in both conditions, then they are presumably able to understand the representational nature of television. In other words, they understand that what they see on television can be used to provide information about current circumstances in real life rather than within the television set itself (Schmitt & Anderson, 2002).

Very young infants and toddlers often do not understand the abstract-concrete distinction and therefore do not appreciate or are not sensitive to the difference between an object displayed on a television screen and the real object it represents (Barr et al., 2007b). Therefore, young infants do not exhibit a video deficit effect because they pay no attention to the differences between 2D and 3D stimuli and represent them in the same way (Barr et al., 2007b). On the other hand, as infants get a little bit older, they understand the difference between the 2D and 3D objects but find it difficult to make sense of the relationship connecting them (Barr et al., 2007b). Therefore, they fail to apply information presented to them on video to guide their actions in real life and the video deficit begins to develop (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998). Finally, dual representation is achieved as children come to understand the representational relationship that can exist between video and reality and the differences between the two (Troseth & DeLoache, 1998). In addition, the video deficit diminishes as they come to understand that video information can be used to guide their actions in the real world (Barr et al., 2007b). However, research shows that this does not appear to be case until around 2.5 to 3 years of age (Schmitt & Anderson, 2002; Troseth & DeLoache, 1998).

Aside from object search studies, results from recent imitation studies also appear to provide support for the dual representation theory. Researchers found that 6 month old infants were able to imitate a televised action sequence and importantly, showed no evidence of a video

deficit effect which suggests that they treated the 2D video demonstration and the 3D live demonstration similarly (Barr et al., 2007b). Additional support for this theory stems from research demonstrating the development of symbolic understanding. For example, 9-month-old infants do not appear to recognize the difference between real objects and those presented on a television screen (Pierroutsakos & Troseth, 2003). The researchers found that these young infants attempted to manually explore and interact with televised objects in the same way they would with real objects. However, by 19 months of age, the infants seemed to believe that the objects on the screen were not real and therefore simply pointed at the screen rather than attempting to explore or interact with them.

Additional support for the dual representation theory stems from recent research conducted by Diener, Pierroutsakos, Troseth, and Roberts (2008). In this study, a variety of objects used to elicit different emotions (i.e., a scary mask to elicit fear) were shown to infants through either a live or on a video presentation one after the other. Using a repeated-measures design, the researchers found that the infants' affective reactions were consistent across both demonstration types.

Reducing the video deficit effect. With a better understanding of the potential explanations for the video deficit, attempts to reduce the effect have been implemented for both imitation and object search paradigms. Many of the explanations and resulting methodologies have incorporated the idea of a “trade-off” between the systems of action and cognition. The *cognition-action-trade-off hypothesis* (Boudreau & Bushnell, 2000), which suggests that the cognitive and motor demands of a task are continually competing for the infant's limited processing resources, may be invoked in the current discussion. Thus, when the required task

demands are not balanced and fall heavily in one direction or the other, a decrease in performance for the other system is often the result. For example, if the cognitive demands of a task are increased, motor performance is greatly reduced; however, if the cognitive demands are decreased, we will likely see an increase in performance. With respect to learning from television and reducing the video deficit effect, this hypothesis seems to be a common theme throughout the literature. Thus far, the results have yielded mixed findings.

Many researchers have tried to reduce the demands of the imitation or object search task to increase performance with some success. In one study, Barr and Hayne (1999) found that removing the delay from a deferred imitation paradigm and testing 15-month-old infants immediately after a video demonstration did not improve performance. However, when they removed the delay and demonstrated an easier task, not only were the 15 month olds able to imitate the target actions, but they learned equally well from both live and video demonstrations.

In an experiment conducted by Schmidt, Crawley and Anderson (2007), they attempted to reduce the demands of object search tasks in two experiments. In the first, the search space was no longer an adjacent 3D room but a 2D felt board. However, this change did not improve performance and the toddlers still displayed a video deficit effect. In a second experiment, the researchers simply told the children where the toy was hidden instead of having them watch a hiding event through a video or on a screen. Unfortunately, this change did not improve performance either. If a real person told the children where the toy was hidden they successfully retrieved it but if the same person told them where the toy was hidden via closed-circuit television, they were not able to retrieve it.

Other developmental scholars have made an attempt to reduce the demands of the object search tasks in another way. That is, rather than have children watch a hiding event and then have them go into the adjacent room and retrieve the object, Schmitt and Anderson (2002) gave the children the same toy as they had seen during the hiding event and asked them to return it to where it should go. Presumably, this task is easier to complete because the child is simply imitating the actions of the experimenter rather than actually generating search behavior for themselves. Although the difference between the television and window conditions was reduced, the children still performed more poorly if they saw the toy placement on television rather than looking through a window.

In a similar modification, Deocampo and Hudson (2005) had children watch an experimenter find a toy as opposed to hiding a toy. In the test condition, children were asked to find the toy the same way the experimenter did. Again, the children were simply imitating the experimenter's behavior rather than having to generate their own behavior which should make the task easier. Quite unexpectedly, children performed much worse on this condition than in the standard object retrieval task. The researchers argued that this finding may have resulted because it is counterintuitive to find an object that has already been found. With this in mind, the researchers created a condition whereby multiple toys were hidden in each hiding location to eliminate the problem of finding a found toy but 24 month olds did not perform well in this condition either. Modifying the retrieval task by making it a necessary part of a goal based activity (i.e., a banana must be found in order to feed a toy dog) also did not help the toddlers. However, this goal-based approach did help with the imitation manipulation. Basically, in order to help 24 month olds achieve even a moderate level of success, very specific conditions are

necessary. In this case, an easier imitation task as opposed to a retrieval task and it must include a goal-based activity.

In another clever manipulation, Troseth and DeLoache (1998) were interested in what would happen if children did not realize that they were watching a video. The researchers convinced the children that they were looking through a window when they were in fact watching a video. More than half of the children who were actually watching video but were told they were looking through a window performed perfectly - just like children who observed hiding events through a window. Although the mean level of performance in the video window condition was no closer to that of the real window condition, this group significantly outperformed the standard video group.

On the other hand, there have been some findings that would suggest it is perhaps better to increase the cognitive demands. For example, Barr and Hayne (1999) found that creating a more complex video presentation that more closely resembles real television viewing improved task performance for 15 and 18 month olds. Surprisingly, by increasing the amount of information that the infant can pay attention to—and thereby drastically increasing the cognitive demands—performance is improved. Yet, using only close up shots during demonstrations did not improve performance. Notwithstanding, it may be that this finding may not be related to the action-cognition trade-off hypothesis per se. Rather, it may simply be that providing more realistic context for infants to learn from television is what is important. After all, with the artificial contexts of the imitation and object search paradigms, there is no doubt that learning from a televised model is limited in comparison to learning from a live model.

Overall, it seems to be that while reducing task demands by actually changing the nature of the task is somewhat beneficial for younger children, the video deficit effect becomes more and more difficult to reduce in this way as they get older. However, the research described in the next two sections discusses how reducing the task demands through repetition and experience are able to decrease the video deficit effect with considerably more success.

Benefit of repetition. Recent studies have consistently shown that not only does repetition enhance learning from television, but the additional exposure also seems to ameliorate the video deficit effect (Barr et al., 2007b). For example, Barr and Hayne (1999) initially reported that 12-, 15-, and 18-month-old infants were able to imitate a live model after a 24 hour delay but only 18 month olds were able to do this following a televised demonstration. In addition, even though they were able to imitate, their performance level was considerably lower than the infants who viewed a live demonstration. The researchers also reported that a similar pattern was found when imitation levels were assessed immediately after the demonstration. That is, 12 and 15 month olds were still not able to imitate the televised actions. Using an easier task, 15 month olds were able to imitate both live and televised actions (Barr & Hayne, 1999) and when the amount of exposure to the target actions on video was doubled from 3 demonstrations to 6 demonstrations, there was considerable improvement (Barr et al., 2007a). Expanding on this research, Barr et al. (2007b) were interested in whether or not a video deficit was evident following these additional demonstrations. It was found that increasing the number of presentations enhanced the 12 month olds' imitation performance from video in comparison to the live demonstration group but both the 15 and 18 month old groups continued to show the deficit. In a second experiment, the researchers quadrupled the number of presentations shown

to the 15 month old group in either a single session with 12 demonstrations or 2 sessions with six demonstrations each shown over two days. It was reported that infants in the 2 session group performed considerably better than chance and did not exhibit a video deficit whereas infants in the single session group did not.

Interestingly, the researchers also showed that very young infants are able to imitate televised actions with sufficient repetition. It was previously believed that the youngest that infants were able use televised information to guide their own actions was 12 months of age (Klein et al., 2006). However, when Barr et al. (2007b) presented 6-month-old infants with 6 action demonstrations they were able to imitate the televised actions after a 24 hour delay and showed no evidence of a video deficit.

Benefit of experience. As is the case for most learning that infants engage in, experience plays a central role and this may also be the case for learning from television. It may be that when infants demonstrate poorer performance using televised information in comparison to live information, this is simply the result of inexperience rather than an inability to learn from television. Several researchers argue that this might be the case. For example, Troseth and DeLoache (1998) found that giving children experience with the object retrieval task in a representational medium for which they already have dual representation understanding allows them to perform better with a more difficult medium later on. Similarly, Deocampo and Hudson (2005) reported that toddlers transferred success from an imitation object search task to a more complicated object retrieval task. In addition, young children also seem to benefit from experience extracting information from television in general. Troseth (2003) allowed children to view themselves live and on prerecorded video at home for 2 weeks. After the extensive

experience using television in a novel way that highlighted the informational function, children's performance on object retrieval tasks improved.

However, some results suggest that in order to be beneficial, this experience must be in the same domain for which the children already have at least some representational understanding. Research has shown that young children cannot be taught to perform the object retrieval task using a representational medium for which they have not yet achieved dual representational competence (Troseth & DeLoache, 1998). In addition, using several methods, researchers have been unable to show 24-month-old toddlers the connection between a representation and its real-life match. These results have been shown using photos as the representational medium (DeLoache & Burns, 1994) as well as video images (Troseth, 2003; Troseth & DeLoache, 1998). In each case, these "within-medium" attempts were unsuccessful. Nonetheless, as described above, a "between-medium" benefit seems to exist.

Summary of Literature

Overall, the collective of scholarship reported above suggests that infants are able to use televised information to guide their behavior from a very early age. Moreover, infants are able to imitate actions demonstrated by a televised model from approximately 6 months of age (Barr et al., 2007b). Furthermore, this ability continues to develop and by 12 months infants are able to demonstrate learning through a more cognitively demanding deferred imitation task (Barr et al., 2007a).

Notwithstanding the above, it is also around this time that infants begin to demonstrate a video deficit effect suggesting that they are able to learn less from television than from equivalent real-life experiences (Anderson & Pempek, 2005), although before this age they seem

to learn equally well from both mediums (Barr et al., 2007b), an effect that is also shown in object retrieval studies. For example, if 24 month olds were shown a hiding event through a window, they correctly retrieved the toy but if they saw the hiding event on a video screen their performance was very poor (Schmitt & Anderson, 2002). The results from both imitation studies and object search tasks show that this deficit remains intact until approximately 3 years of age (Schmitt & Anderson, 2002).

The two major theories that are used to explain this phenomenon are the perceptual impoverishment theory and the dual representation theory. The first argues that learning from video is impaired due to problems encoding 2D input and forming an accurate representation as compared to a real 3D presentation (Barr et al., 2007b). On the other hand, the dual representation theory suggests that the video deficit occurs when toddlers begin to understand that there are differences between 2D objects presented on a video and 3D objects in real life yet are unable to fully grasp the relationship between the two resulting in a failure to apply information presented to their actions (Troseth & DeLoache, 1998; Barr et al., 2007b). Taken together, these two theories are not mutually exclusive and there has been compelling scientific support for both in the previous literature cited.

Heavily guided by these possible explanations, attempts to reduce the video deficit effect have yielded mixed results for both imitation and object search tasks. However, the most successful attempts at reducing the deficit have involved additional exposure to the necessary information through repetition and experience.

Although questions surrounding this area of research have come a long way in a very short amount of time, there are several questions that remain to be answered. First, given that infants

do not use televised information as efficiently as real information to guide their behavior, how do young children view television in relation to the real world? If very young infants do not exhibit the video deficit effect in the way that older infants do, what can be inferred about how they understand representational media? Researchers have consistently suggested that the ability to learn from television is likely constrained by both perceptual factors and general cognitive development (Troseth & DeLoache, 1998). What is the relative contribution of each of these factors?

Second, for most of the experiments described in the proceeding sections where comparisons between live and video demonstrations are designed, an effort is made to ensure that the similarities between the two conditions are as high as possible. This approach, however, typically creates a somewhat artificial learning context. Still, Barr and Hayne (1999) found that by applying standard techniques of video production (editing, zoom shots, and sound effects) to the demonstrations, performance improves. This begs the question of whether or not the findings from this research have any direct relevance for infants' and toddlers' understanding of and learning from professionally produced television programs.

Third, are younger infants able to use televised information presented to them to guide behavior for more cognitively demanding tasks than imitation (i.e., problem solving)?

Fourth, findings reported by Barr et al. (2007a, 2007b) revealed that the video deficit effect was absent in research conducted with 6 month olds but evident in the 12 month age group. That is, 6 months olds are able to learn equally well from live and video demonstrations but 12 month olds imitate significantly less target actions after following a video demonstration

compared to a live demonstration. At what age specifically do infants begin to have trouble learning from video and display the video deficit effect?

Finally, additional exposure to televised material through repetition seems to improve performance and ameliorate the video deficit effect with younger infants (Barr et al., 2007a; Barr et al., 2007b). Are there other ways to reduce this effect? For instance, research with toddlers has shown that with increased experience either through repeated practice with a particular search task or more exposure to using television as an informational medium, performance improves (Troseth, 2003). Is it possible that experience would also have an impact on the performance of younger infants?

Purpose of Proposed Study

Inspired by the literature and guided by the questions described above, the current study seeks to extend previous developmental science in this area and contribute to the core question concerning what young infants can learn from video. It is hoped that this study will add to the current literature in a variety of ways: first, by determining the robustness and generality of the findings from imitation tasks; second, by providing support for the perceptual impoverishment or dual representation theories; and lastly, to investigate whether other forms of exposure, aside from repetition, can ameliorate this effect in younger infants.

It seems to be generally well established that very young infants are able to use televised information to guide their actions in a variety of ways. It has been reported that infants can duplicate televised actions in an imitative manner at 6 months of age (Barr et al., 2007b). By 12 months they are able to remember and use televised information to reproduce actions 24 hours later (Barr et al., 2007b). Imitation is generally considered to be a lower level form of learning

and in order to develop a complete picture of what infants are able to learn from television, we must also consider higher forms. The question to be addressed in the proposed study is whether infants are able to use televised information to solve a more cognitively demanding analogical reasoning task using televised information. In addition to being more cognitively demanding, this task requires that the infant apply the presented information to a novel situation, a potentially much higher form of learning. Previous research conducted by Chen, Sanchez, and Campbell (1997) determined that infants were able to do this effectively by 12 months of age. The methodology used for this study is similar to that used by Chen et al. (1997) with several important modifications (see methods section for details).

The findings from this research also have the potential to provide support for one or both of the two major theories explaining children's ability to learn from video. First, if the older age group outperforms the younger age group, this would be in line with the perceptual impoverishment theory. This theory asserts that younger infants require more information to properly encode information and develop a complete representation (Johnson, 1997). On the other hand, should the younger age group perform better than the older age group, these findings would support the dual representation theory since this theory argues that younger infants have less developed symbolic understanding and therefore do not recognize the difference between the 2D video image and 3D test object (Troseth & DeLoache, 1998).

Lastly, the results from the proposed research will likely be able to provide some insight into the role of experience in infants' ability to learn from television. Research conducted with older infants has revealed that they greatly benefit from having experience and that performance improves both with additional exposure to a specific task (Troseth & DeLoache, 1998; Deocampo

& Hudson, 2005) as well as more practice using television as an informational medium in general (Troseth, 2003). Similar to giving infants task specific experience (Troseth & DeLoache, 1998), a unique component of the proposed study entails having the infants be actively involved in their initial training session during one condition. During the session, the infant will be encouraged to interact with the objects on their own after the initial demonstration. The question is whether providing the infant with active experience during training will facilitate their understanding of the information presented to them and thereby enhance problem solving ability.

As findings from research with older infants suggests that increased exposure through experience is beneficial for object search performance, findings from research conducted with younger children suggest that additional exposure to target information by increasing the number of demonstrations also improves performance (Barr et al., 2007a; Barr et al., 2007b). It was suggested that because 2D stimuli takes longer for infants to process than 3D stimuli, giving infants extra time to process the stimuli in its entirety may enhance encoding and retrieval of 2D attributes (Barr et al., 2007b). Perhaps we can also apply this logic to experience. For example, it may be that active experience also improves encoding and retrieval. Researchers have suggested that the video deficit may stem from either the slow processing of 2D information or the cognitive load (attentional demands) associated with the transfer from 2D to 3D (Barr et al., 2007a). The repetition studies seem to have tackled the first issue relating to slower processing. As for the second cognitive load possibility, it may be that having extra experience reduces the cognitive load therefore making the transfer easier. The effect of the degraded perceptual cues offered by the television screen may be minimized when infants are given previous exposure to objects in real life. With the cognitive load reduced, it is likely that an increase in performance,

consistent with findings for means-end problem solving (e.g., Boudreau & Bushnell, 2000; Needhan, 2000), will be revealed.

Although the benefit of experience finding with older infants is compelling, the question of whether or not younger infants will benefit in the same way has not yet been explored. However, research from other areas suggests that they may benefit as well. For example, after having the opportunity to play with an object, 7- to- 11-month olds were shown two videos simultaneously presenting adults who were either acting on the same object or a different one. It was reported that 9- to- 11-month old infants preferred to watch the video of the adult interacting with the object they had played with (Hauf, Aschersleben, & Prinz, 2007). Furthermore, follow up studies showed that it was interest in the actions with objects specifically that the agentic experience enhanced rather than simply watching objects or people per se. In addition, research conducted by Sommerville, Hildebrand, and Crane (2008) found that active training and practice facilitated 10 month old infants' ability to identify the goal of a tool-use event. Importantly, the researchers suggest that active experience using tools may help infants to build motor representations which subsequently guide their perception and support action understanding.

Taken together, these studies suggest that active experience effects both perceptions and understanding of what happens around them. However, in each of the studies described, infants were only required to observe and interpret. It is still unknown whether the benefit will still exist if a more demanding task is required.

Hypotheses

The primary goal of this study is to determine whether or not infants are able to solve a multi-step task using televised (video) information and whether this is a function of age. Given that infants are able to imitate actions from televised information very early on (Barr et al., 2007b), and by 10- to- 13-months of age they are able to solve analogical problems (Chen et al., 1997), it is expected that infants should be able to solve these types of problems using televised information as well. It is hypothesized that an improvement in performance over trials will result.

Furthermore, it is predicted that younger infants will be more successful in using televised information because they do not understand the difference between a symbol on a television screen and a real-life object and therefore do not treat them differently. Older infants, on the other hand, are beginning to develop dual representational understanding and will likely find it more difficult to apply televised information to a real object.

In addition to whether infants are able to apply knowledge learned during pre-test training to analogous problems during the test sessions, it hypothesized that type of training will be significantly different than another (i.e., live-active, live-passive or video training). That is, it is predicted that infants will display the most success in retrieving the toy in the active training condition given that this type of training should facilitate understanding (Sommerville et al., 2008).

Method

Participants

Participants were recruited from a variety of locations in the Toronto area. Brief presentations were given to parents during infant programs (i.e., library reading times) describing current lab projects and infant research in general. Interested parents provided their contact information and their infant's date of birth. This information was added to an on-going database. Eligible participants for this study were identified and were telephoned, given more details about this particular study and asked to participate. A total of 37 infants participated in this study. However, 5 infants were excluded from the analyses due to interference from the parent ($n = 1$), excessive fussiness ($n = 2$) or experimenter error ($n = 2$). In addition, 48 of 224 available trials were excluded because of lack of attention to the demonstration ($n = 33$) or equipment failure ($n = 15$). The rest of the data for these infants was included.

Thus, 32 infants were included in the final sample: 19 twelve-month olds ($M = 11$ months, 25 days; range = 11 months, 3 days to 13 months, 4 days; 11 male and 8 female infants) and 13 ten-month olds ($M = 10$ months, 1 days; range = 9 months, 15 days to 10 months, 30 days; 4 male and 9 female infants). These particular age groups were selected for several reasons. First, by using two age groups we may learn more about the developmental trajectory of analogical problem solving using televised information. Second, it has been established that 6 month olds do not demonstrate a video deficit when learning from video but the deficit is evident in research with 12 month olds (Barr et al., 2007b). However, what happens between the ages of 6-12 months is still unknown. Third, research has demonstrated that it is possible to ameliorate the video deficit with 12 month olds (Barr et al., 2007b). This is important given that one of the

main research questions is whether or not action experience can reduce the deficit effect.

Fourth, research has shown that infants start to benefit from active experience between the ages of 9 to 11 months (Hauf et al., 2007; Sommerville et al., 2008). All infants were healthy and full-term and born within 2 weeks of their expected due date.

Task Descriptions

The tasks used for this study involved solving a series of three similar problems. Each problem involved combining two sub-goals to reach an interesting toy. The methodology is similar to that used by Chen, Sanchez, and Campbell (1997) with several important modifications. In the original study, Chen et al. (1997) required infants to solve a series of problems. Infants saw two pieces of cloth, each of which had a string resting on it; a toy was attached to one string but not the other. To obtain the toy, the infant had to pull the target cloth, and then pull the target string to bring the toy within reach. The researchers also created multiple versions of the task to assess infants' learning and analogical reasoning skills. In all of them, the problems shared a common solution (all required pulling the target cloth and then the target string), and the arrangement of objects was similar across each trial. However, the problems differed in their surface characteristics. That is, the materials and colors of the strings and cloths, the side on which the target tools were located, and the goal toys were all different for each problem. In addition, the immediate contexts of the problems (the colors, height, shapes, and locations of the tables within the room) and the infants' posture when attempting to solve the problem (sitting on the floor, standing with parent support, or sitting on the parent's lap) were also changed. For the present study, the tasks differed from Chen et al. (1997)'s in the following ways:

1. Some of the materials used for each problem were slightly more distinctive. For the problems used by Chen et al. (1997), both elements of the problem were relatively similar (i.e., two brown cords and two white cloths with yellow and orange stripes for problem A; two white braided yarn strings and two tan cloths for problem B; two black braided yarn strings and two light blue cloths for problem C). For this study, the cloths, the first part of the task, were identical to those used by Chen et al. (1997). That is, the cloths were different colours and different sizes for each test. However, the second part of the task, the pulling object, had different properties for each test. For example, the pulling objects were approximately the same length but were made of rope for one test, ribbon for another, a hollow plastic tube for another, and a light plastic chain for another. The experimental argument for the above modification is that altering one element of the problem in a more distinctive way might require that the infants make more of an analogy between the problems in this case (compared to the analogy being made in the problems used in the Chen et al. study).

2. In the Chen et al (1997) study, the “training” for each infant was very similar (i.e., each infant was given the target toy and other items to examine while the experimenter set up the test. The infant was then encouraged to solve the problem on their own. If they were unable to do so, the parent was asked to demonstrate the sequence two times and the infant participant was then encouraged to imitate the actions). However, for the infants who saw the actions and imitated them, we don’t know if the improvement in performance was due to simply watching the solution or acting it out themselves. For this study, two separate training conditions were used, a *live-passive training* condition, and a *live-active training* condition were used to try to isolate the relative contributions of active and passive training. In addition, two *video training*

conditions were also included to test whether or not infants are able to use televised information to solve these types of problems (full descriptions follow below).

Design and Stimuli

As originally intended, infants would be required to complete all four training conditions (*live-active*, *live-passive*, *video-active*, and *video-passive*) in order to assess within-subjects differences. However, to avoid potential training effects across conditions, three new tasks had to be developed in addition to the original task used by Chen et al. (1997). The second task involved pushing a long handle to bring a box within reach and opening the box to retrieve a goal toy. The third task required the infant to remove a barrier and press a button to activate a rotating belt to bring a toy within reach. Finally, a fourth task required the infant to slide open a small door and slide a button from left to right. Sliding the button released a small ledge holding a toy in place and when released the toy slide down a ramp within reach of the infant. However, after pilot testing (see section below) it was decided that only the first three tasks would be used (see Figure 1 for images and Appendix C for detailed descriptions of each task version).

Task 1 Version A

Task 1 Version B

Task 1 Version C

Task 1 Version D

Task 2 Version A

Task 2 Version B

Task 2 Version C

Task 1 Version D

Task 3 Version A

Task 3 Version B

Task 3 Version C

Task 3 Version D

Figure 1. The stimuli used for the study.

Pilot Testing

Extensive pilot testing was conducted to ensure the level of difficulty of the new target actions was approximately the same across tasks, to determine a suitable length for the test trials and demonstrations, and also to determine an appropriate number of trials. This pilot testing revealed that infants seemed equally interested in all tasks but the fourth task seemed to be slightly more difficult. It was also determined that three trials seemed to be sufficient as

infants tended to become disinterested in the task with additional trials. As for the trials themselves, a duration of 100 seconds was found to be the most appropriate length. This time frame provided the infant ample time to solve the problem and longer durations also tended to lead to decreased interest. This trial length was approximately equal to that selected by Chen et al. (1997) and Barr et al. (2007b). Given the complexity of tasks and experimental procedure, pilot testing was also critical for establishing procedural timing parameters and experimenter coordination practice (this study required two experimenters).

Revised Design

Given that the cumulative amount of time that was allocated for the demonstrations and test trials was sufficiently long, piloting was also used to determine the maximum amount of time before infants became fussy and inattentive. It was critical that the experimenter move through the different tasks at efficient intervals as it was determined that infants would not maintain their attention levels for more than three demonstrations and nine test trials. Therefore, each infant was only required to complete three out of the four training conditions. It was also decided that the same three tasks would be used for each infant (the cloth task, the box task, and the belt task). For example, one infant would learn the cloth task (task 1) through live-active training, the box task (task 2) through live-passive training, and the belt task (task 3) through video-passive training (see Table 1). A second infant would learn the cloth task through live-passive training, the box task through live-active training, and the belt task through video-active training (see Table 1). Given that infants were only able to do three tasks, including the fourth would only have created an extra design complication. Thus, the fourth task was removed since it seemed, from initial observations, to be significantly more difficult than the other three

adding also to the total procedure time which was already precariously lengthy. Importantly, the three conditions and tasks were randomly assigned, the task paired with the training condition was randomly assigned, and the training condition order was counterbalanced.

Table 1

Sample Participant Assignment of Experimental Training Conditions.

	Live-Active	Live-Passive	Video-Active	Video-Passive
Task 1	Infant A	Infant B	Infant C	Infant D
Task 2	Infant B	Infant A	Infant D	Infant C
Task 3	Infant C	Infant D	Infant B	Infant A

Additional Materials

Finally, pilot testing also suggested that moving the infant to a separate context—as done by Chen and colleagues—for each training condition was deemed too disruptive. To re-create the “changing environment” in another way, the tasks were presented at an experimental table designed and built specifically for this study. The table consisted of four platform legs, a testing platform where the task materials were presented to the infant, a curtain which covered the presentation area between trials, and two short walls enclosing the presentation area. The entire table was average size (93 x 63.5 x 46 cm). However, the presentation area that the tasks were arranged in was slightly smaller (79 x 63.5 x 46 cm). The table was painted white with brightly colored polka dots on the side; the curtain was also white with polka dots. Importantly,

the inside of the walls of the table were wired with coloured lights (red, blue, yellow, and green) and made of a transparent sheet which allowed the light to shine through onto the presentation area. The purpose of the lights was to increase the distinctiveness between each problem and essentially “change” (at the flick of a switch) the context similar to the method used by Borovsky and Rovee-Collier (1990). In that study, the researchers were able to create a distinctive test context by changing the crib liner between training and test trials.

Procedure

All infants were tested at the C.H.I.L.D. Lab at Ryerson University at a time of day when they were likely to be alert and playful (as indicated by their caregivers). Upon arrival to the lab, the infant and parent were invited to a waiting room. The study was described to the parent and they were given a pre-observation questionnaire (see Appendix A) and a consent form (see Appendix B) to complete. During this time, the experimenter played with the infant for approximately 10 minutes or until infant seemed to be comfortable with the experimenter (i.e., smiles and interacts with the experimenter) and their surroundings. Once the infant seemed comfortable and alert, the infant and parent were led into an adjacent testing room. The infant was seated on the parent’s lap in front of the experimental table (for detailed description see section above). The parent was asked to adjust their seat until the infant was high enough to comfortably reach for objects on the table. One observation camera was positioned directly across from the infant to capture the infant’s face. A second observation camera was positioned above and to the left of the infant to capture the entire surface of the table and the infant’s actions on the objects. The training and test session were videotaped for later analyses. After the parent and infant were situated in the appropriate positions, the curtain covering the

presentation area was opened to reveal the first set of task objects. The first training condition was pre-determined to be *live-active*, *live-passive*, *video-active* or *video-passive* (see below for description). Following the training session, the curtain was closed while the next test sessions were prepared. Infants were always given a toy to play with between trials to minimize fussiness. Time between trials was approximately 30 seconds. The training session was followed by three test trials (for detailed description see description below). This was followed by a second training session with a new task and three test trials. This sequence was repeated once more (a third training session with a new task and three test trials). Overall, each infant experienced a total of three training session and nine test trials (the upper limit determined during pilot testing). After the sessions were complete the experimenter thanked the parents and their infants for participating in the study. The infants were presented with an “Infant Scientist Award” recognizing their contribution to the advancement of science and parents were given a tote bag as a thank you gift for their volunteer time.

Training Sessions

For the *live-active* training session, the parent was asked to move the chair back slightly so the infant could not reach the objects. The experimenter then opened the curtain, knelt down next to the infant, waved her fingers back and forth to orient the infant’s attention to her hand, and then demonstrated the full sequence of three target actions for a specific task set (see Table 5). The target actions were not verbally described, but to maintain the infants’ attention to the demonstration, the experimenter used phrases such as “watch what I do next”, and “isn’t this fun”. The objects were then moved back to their original position (see Figure 1), the parent was asked to bring their infants forward so that they were seated at the table and the infant was

encouraged to explore the objects. The total duration of the session was approximately 60 seconds. Following this, the infant was given the goal toy to play with, if they had not already obtained it on their own, and the curtain was closed.

The beginning of the *live-passive* training session began the same way as the *live-active* session, however, after the first demonstration of the target actions, the objects were moved back to the starting position and the experimenter repeated the entire sequence twice more for a total of three demonstrations of the target actions. The toy was given to the infant to play with after the final demonstration. However, infants were not given an opportunity to interact with the rest of the task objects in any way. The entire session lasted approximately 60 seconds as well. It was important to keep the training session about the same length to ensure the infants had equal exposure to the objects.

When the curtain was opened for the *video-active* training sessions, the task objects were on the table and a 17" LCD monitor with the identical task objects on the screen was located just behind them. After the experimenter opened the curtain, she pointed to the screen to direct the infant's attention to the demonstration and said "watch this" at which point the research assistant started the pre-recorded video. During this session, the infant watched the experimenter perform the sequence of target actions on the pre-recorded videotape. The video was filmed from the infant's point of view in "real time" to make it look as natural as possible. However, only the experimenter's hands were visible on the screen. The parent was asked to keep their infant's attention on the screen as much as possible by pointing or saying neutral phrases such as "look at that" without describing the actions. The parent was also asked to move their seat so the objects were out of the infant's reach until the first demonstration was

over at which point the infant could explore and interact with the objects freely. The entire session lasted for approximately 60 seconds as well.

Similar to the *video-active* session, infants also saw the still image of the task objects on the LCD monitor when the curtain opened until the video began in the *video-passive* training session. The actions were demonstrated in a similar manner to the live demonstrations. The entire action sequence was demonstrated three times. This session also lasted approximately 60 seconds. Importantly, however, the real objects were not available to the infant at any point during the session (see Figure 2 for a schematic representation of the training conditions).

Figure 2. Schematic representation of the four training conditions.

Test Sessions

The test sessions involved a series of three trials and occurred immediately after each training session. During the test trials, the infant was seated at the table facing the task objects. The task objects were highly similar to those seen during the training sessions. Each version used

for testing had a common goal structure but different surface characteristics (see Figure 1 and Appendix C). The purpose of this was to assess analogical problem-solving skills across trials. Infants were given approximately 100 seconds to solve the problem and retrieve the toy. The trial ended when infants retrieved the toy. The parent and experimenter clapped for the infant if the infant did not retrieve the toy themselves, the experimenter gave them the toy directly. After the first trial was complete, the curtain was closed while the next trial was prepared (approximately 60 seconds). The second trial and third trials were then conducted in the same manner.

Dependent Measures and Coding

To assess potential differences in infants' attention during the *live-active*, *live-passive*, *video-active* and *video-passive* training sessions, the videotapes were scored to determine the percentage of time spent looking at the target actions and actively engaged with the task objects.

In addition, infants' performance during the test trials was assessed. Infants were assigned a "problem solving score" for each trial based on the number of actions they completed to retrieve the goal toy (see Table 2). A score of "0" was given if the infant completed no target actions, "1" if they completed one target action, "2" if they were able to complete two of the target actions, and "3" if they completed the entire action sequence and made contact with the toy (Note: during data analysis it was determined that infants fully retrieved the toy much more than expected and the coding scheme may have been too liberal. The data was re-coded using a more conservative coding scheme which stated that infants must fully retrieve the toy to obtain a score of three).

Table 2

Description of the Target Actions for Each Task.

Task	Target Action 1	Target Action 2	Target Action 3
Cloth Task	Cloth was pulled to bring pulling tool within reach	Pulling tool was used to bring toy within reach	Toy was retrieved
Box Task	Grip was pushed to bring transparent box within reach	Handle was pulled to open door and make toy accessible	Toy was retrieved
Belt Task	Barrier was removed to reveal push button	Button was pressed to activate belt and bring toy within reach	Toy was retrieved

Results

Overall, infants actively engaged and enjoyed the tasks while at the same time demonstrating an impressive ability to solve the novel means-ends problems. Unexpectedly, infants performed very well on the first trial and there were no differences across the three test trials. In addition, the expected age differences were not found. Furthermore, initial analyses revealed that there were no differences in performance between the live and video conditions. However, the results did suggest differences between the active and passive conditions. Additional analyses were conducted to explore these differences further and after careful consideration, it was determined that the coding scheme used for problem solving scores may have been too liberal. The data set was then re-coded using a more conservative approach. After descriptive statistics and data exploration, the remainder of the results section is divided into three subsections: preliminary analyses, primary analyses, and supplemental analyses.

Descriptive Statistics and Data Exploration

Descriptive statistics were calculated for each dependent variable in order to screen for the presence of outliers and to assess the normality of the distribution. Outliers more than 2 standard deviations from the mean were removed from the dataset before further analyses were conducted. The normality of the distribution was then examined for skewness and / or kurtosis. Because infants were able to solve most of the problems presented to them, the majority of their problem solving scores were clustered at the higher end of the distribution resulting in a negatively skewed distribution (Figure 3). Furthermore, most infants were able to complete the tasks much more quickly than expected resulting in a positively skewed distribution (Figure 2). Due to the presence of this significant level of skewness, square root and

log transformations were applied to the raw data. However, before deciding on the use of such transformations, the effect of the transformations on the data was carefully considered. First, the nature of the dependent variables was considered and it was determined that they were not likely to be normally distributed because of infants' high performance and the low frequency of several scores. Moreover, the degree to which the transformations corrected for the level of skewness and kurtosis was also taken into account. Although both the square root and log transformations were able to reduce the skewness and kurtosis levels slightly, neither was able to completely eliminate it entirely. In addition, research on the question of whether or not to transform data has suggested that when using a robust test (such as the *F*-test in analysis of variance) the statistical model remains accurate even when the assumption of normality is violated (Glass, Peckham, & Sanders, 1972). Therefore, since most of the research questions would be addressed using the robust analysis of variance (ANOVA) test, the main dependent variables were not likely to be normally distributed, and both transformations were not able to correct the level of skewness and kurtosis, it was decided not to apply the transformations and the data was kept in its original state.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS, version 17). An alpha level of $p < 0.05$ was selected as the critical cut-off for significant results and Bonferroni corrections were performed to reduce the rate of Type I errors in post-hoc tests.

Figure 3. Histograms demonstrating infants' mean problem solving scores and mean task completion time across the three test trials. Mean problem solving scores were negatively skewed and mean task completion time was positively skewed.

Preliminary Analyses

Following descriptive analysis and data exploration, preliminary analyses were conducted to determine if there were differences across gender, task, and condition order. If no significant differences were found, the data were collapsed for all subsequent analyses. The results are described below.

Problem solving scores. Initial t-tests revealed no significant differences in mean problem solving scores across gender, $t(73) = 0.70, p = 0.64, ns$. In addition, infants performed equally well whether they were given a live or video training condition first, $t(69) = 0.62, p = 0.53, ns$. Finally, an ANOVA revealed no significant differences across the three problem-solving tasks, $F(2, 41) = 1.19, p = 0.32, ns$. Infants performed equally well on the cloth task, box task, and belt task. The data are presented in Table 3 below.

Table 3

Mean Problem Solving Scores and Standard Deviations for Gender, Task and Condition Order.

	Gender		Task			Condition Order	
	Male	Female	Cloth	Box	Belt	Video First	Live First
<i>M</i>	2.67	2.64	2.73	2.59	2.66	2.62	2.68
<i>SD</i>	0.39	0.41	0.32	0.39	0.47	0.44	0.38

Task completion times. Initial t-tests revealed no significant differences in task completion time across gender, $t(74) = 0.70, p = 0.64, ns$. Infants also performed equally well whether they were given a live or video training condition first, $t(71) = 0.77, p = 0.44, ns$. However, an ANOVA showed significant differences across the three problem-solving tasks, $F(2, 42) = 12.36, p = 0.00$. Because there were significant differences, the data are divided by task for subsequent analyses involving task completion times. The data are presented in Table 4.

Table 4

Mean Task Completion Times and Standard Deviations for Gender, Task and Condition Order.

	Gender		Task			Condition Order	
	Male	Female	Cloth	Box	Belt	Video First	Live First
<i>M</i>	39.32	43.64	30.92	46.38	48.41	43.64	39.89
<i>SD</i>	19.77	20.86	16.53	18.70	21.88	20.65	20.78

Primary Analyses

Primary analyses were conducted to address each of the three main objectives of the study. To address the first objective, correlations and t-tests were performed to determine differences between older and younger infants on performance. The second and third objectives of the study were addressed using analysis of variance to determine differences across the demonstration and training conditions. Finally, the last objective of the study was to determine whether infants were able to use analogical problem solving to apply their knowledge from the demonstration and training sessions to the test trials; this objective was addressed using analysis of variance as well. Results are described below.

Age differences. To address the first objective of the study, separate analyses were conducted to determine if there were age differences across both problem solving scores and task completion times. Initially, the infants were grouped into two categories, younger infants (9-10 months) and older infants (11-12 months) and ANOVAs were conducted to determine if

there were age differences. No significant differences between older and younger infants were found; however, this outcome may have been due to the small number in each group.

Therefore, correlations were conducted using the actual age of each infant.

Problem solving scores. Overall, problem solving scores were fairly high. No infant received a score of zero and very few received scores of one. Older infants received scores of three on the majority of their trials. Younger infants were more likely to receive a score of two. The data are presented in Figure 4. Although the mean problem solving scores of older infants ($M = 2.69, SD = 0.37$) was slightly higher than that of younger infants ($M = 2.62, SD = 0.43$), a t-test indicated that the difference was not significant, $t(73) = 0.70, p = 0.48, ns$. In addition, there was no significant correlation between age and mean problem solving scores, $r = 0.05, p = 0.64, ns$.

Figure 4. Frequency of each problem solving score as a function of age.

Task completion times. Because significant differences were found across task in the preliminary analyses, the data for task completion times were analyzed separately for each task. For the most part, older infants tended to complete the tasks more quickly than younger infants. This pattern was found for both the cloth task and the belt task. For the box task, the opposite pattern was found. Younger infants completed the task slightly more quickly. However, because of the small sample size, it was not possible to test whether these differences were statistically significant. The data are shown in Table 5.

Table 5

Mean Task Completion Times and Standard Deviations for Older and Younger Infants.

	Cloth Task		Box Task		Belt Task	
	Older	Younger	Older	Younger	Older	Younger
<i>M</i>	26.57	37.19	47.50	44.14	44.53	52.83
<i>SD</i>	13.28	19.44	19.88	16.97	21.51	22.35

Differences across demonstration and training type. To address the second and third objectives of the study, ANOVAs were conducted to determine if there were differences in performance according to the type of demonstration and type of training. Separate analyses were completed using mean problem solving scores and task completion time as dependent variables. The results are reported below.

Problem solving scores. A 2 (demonstration type: live, video) X 2 (training type: active, passive) within-subjects ANOVA was conducted on the mean problem solving scores. No significant differences were found between the live ($M = 2.63$, $SD = 0.44$) and video conditions ($M = 2.70$, $SD = 0.33$), $F(1, 16) = 0.01$, $p = 0.93$, *ns*. However, there was a statistically significant effect of training type, $F(1, 15) = 9.58$, $p = 0.01$. Active training ($M = 2.73$, $SD = 0.42$) resulted in higher problem solving scores than passive training ($M = 2.60$, $SD = 0.37$). Post-hoc tests revealed that there were differences depending on the type of training across both the live and video demonstrations. The difference between problem solving scores for the video-active ($M = 2.76$, $SD = 0.31$) and video-passive ($M = 2.61$, $SD = 0.34$) conditions approached statistical significance ($p = 0.07$) but did not surpass the critical cut-off. However, the difference between the live-active ($M = 2.70$, $SD = 0.48$) and live-passive condition ($M = 2.51$, $SD = 0.42$) was statistically different ($p = 0.03$). The data are presented in Figure 5.

Figure 5. Mean problem solving scores as a function of demonstration type and training type. An asterisk indicates that infants performed better in one experimental condition than the other. Significant differences were found between the live-active and live-passive conditions.

Task completion times. Separate analyses were executed for each task since preliminary ANOVAs revealed significant differences across task. Infants tended to complete the task in the least amount of time during the video-active conditions followed by the live-active conditions, live-passive conditions, and finally, infants took the most amount of time for video-passive conditions. The same pattern was revealed for both the cloth task and the box task. For the belt task, however, infants completed the task most quickly during the live-passive conditions, followed by the video-passive, video-active, and live-active conditions, respectively. Because of the small number of infants in each condition, the statistical significance of these differences could not be tested. The means and standard deviations are presented in Table 6 and depicted in Figure 6.

Table 6

Mean Task Completion Times (in seconds) and Standard Deviations for Each Task.

	Cloth Task		Box Task		Belt Task	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Live-Active	29.34	8.27	46.29	24.77	57.13	20.49
Live-Passive	31.13	15.88	47.00	12.70	44.83	31.23
Video-Active	18.08	7.13	43.88	21.85	45.37	13.23
Video-Passive	38.44	21.88	48.53	17.40	45.25	22.58

Figure 6. Mean task completion time as a function of task and experimental condition.

Analogical problem solving and learning across trials. To address the fourth objective of the study, a variety of analyses were conducted to determine if infants were able to use the information provided to them during training and apply that knowledge during test trials. Separate analyses were conducted for both problem solving scores and task completion times. The results are presented below.

Problem solving scores. Overall, infants' problem solving scores were quite high across all trials. Furthermore, there was very little difference across the first ($M = 2.47, SD = 0.58$), second ($M = 2.39, SD = 0.64$) and third trials ($M = 2.44, SD = 0.57$). An ANOVA was conducted to determine if these differences were significant and revealed that they were not, $F(2, 62) = 0.43, p = 0.65, ns$.

The differences across trial were also examined across experimental conditions. In all conditions, no infants received a score of zero and very few infants received a score of one. The majority of scores achieved were either two or three. However, the distribution of these scores differed considerably across conditions. In the video-active condition, infants received scores of three across all trials. In contrast, in the live-passive and video-passive conditions, infants were more likely to receive scores of two on the first and second trials and scores of three on the third trial. In addition, although there were relatively few scores of one, there were more scores of one on the passive conditions in comparison to the active conditions. These results could not be tested statistically due to the small sample size. The histograms are presented in Figure 7.

Task completion times. There were some moderate differences in task completion time across trials. Infants tended to take the most time to complete the task on the first trial and reduce the time by several seconds on the second trial. This pattern was found for both the

cloth and box task. For the belt task, the task completion time was similar for trial 1 and 2 and decreased on trial 3. The differences could not be tested because of the small sample size.

The differences across trial were also examined across experimental condition with similar results reported. The time to complete the task was reduced from trial 1 to trial 2 for most tasks across experimental conditions. The data are presented in Figure 8.

Figure 7. Frequency of each problem solving score as a function of trial and experimental condition (top left, live-active; top right, live-passive; bottom left, video-active; bottom right, video-passive).

Figure 8. Task completion time as a function of task, trial and experimental condition (top left, live-active; top right, live-passive; bottom left, video-active; bottom right, video-active).

Supplemental Analyses

Follow-up ANOVAs were conducted to take the results of the earlier analyses one step further. More specifically, these analyses were conducted to address issues that may have had an influence on the results of the primary analyses. For example, differential levels of attention during demonstrations and training, data coding and within-subjects training effects. Thus, supplemental analyses were completed to ensure a thorough accounting of how attention and training might have altered infants' learning in this study.

Attention during demonstrations and training. The percent of attention (looking time and active engagement with task objects) during the demonstration and training sessions is shown in Figure 9. Overall, the percentage was consistently high for all conditions. The live conditions showed slightly higher attention (live-active, $M = 86.81$, $SD = 9.72$, live-passive, $M = 86.70$, $SD = 10.51$) compared to the video condition (video-active, $M = 80.06$, $SD = 9.89$; video-passive, $M = 77.78$, $SD = 11.71$). A 2 (demonstration type: live, video) X 2 (training type: active, passive) within-subjects ANOVA across percentage of attention during demonstration and training sessions yielded no main effect of demonstration type (live or video), $F(1, 16) = 3.25$, $p = 0.09$, or training condition (active or passive), $F(1, 17) = 0.01$, $p = 0.90$. The fact that there were no differences in the percentage of time that infants looked at the demonstrations or were actively engaged with the task objects during training means that subsequent differences in performance on the tasks could not be attributed to differences in attention during learning time.

Toy retrieval information. Infants were very interested in the tasks presented to them and demonstrated an impressive ability to solve the multi-step means end problems. Infants made contact with the task objects on virtually every trial (there were only two exceptions where infants made no contact with any object) and succeeded in bringing the toy within reach on most trials (94%). Of those trials, contact was made with the goal toy on 81% of the trials, and the goal toy was fully retrieved on 62% of the trials. Infants did not make contact with the goal toy on 19% of the trials and did not bring the toy within reach on 6%.

Figure 9. Percentage of attention (looking time during demonstrations and active engagement with task objects during training) as a function of experimental condition.

Primary analyses using re-coded data. Because infants fully retrieved the toy much more than expected, it was determined that the coding scheme may have been too liberal. Initially, infants were given a problem solving score of three if they made contact with the goal toy. In comparison, the new conservative coding scheme stated that infants must fully retrieve the toy to obtain a score of three. This change to the coding scheme changed the distribution of scores considerably (see Figure 10). Therefore, the primary analyses were conducted a second time using the new data set and the results are presented below.

Figure 10. Distribution of problem solving scores (left original data set; right, re-coded data set).

Age differences using re-coded data. Overall, the same pattern of results was found for the re-coded data set. No infant received a score of zero and very few received scores of one. Older infants tended to achieve slightly higher problem solving scores and received scores of three on the majority of their trials. Younger infants were more likely to receive a score of two. The mean problem solving scores of older infants ($M = 2.47$, $SD = 0.47$) was slightly higher than that of younger infants ($M = 2.35$, $SD = 0.42$) but a t-test showed that the difference was not

significant, $t(81) = 1.53$, $p = 0.13$, *ns*. In addition, there was no significant correlation between age and mean problem solving scores, $r = 0.15$, $p = 0.18$, *ns*.

Differences across demonstration and training conditions using re-coded data. A 2 (demonstration type: live, video) X 2 (training type: active, passive) within-subjects ANOVA was conducted on the re-coded problem solving scores. The data are shown in Figure 11. Similar to original data set, there was a main effect of active or passive training, $F(1, 17) = 9.79$, $p = 0.01$, but no main effect of demonstration type (live or video), $F(1, 19) = 0.03$, $p = 0.86$. Post-hoc analyses showed that problem solving scores were considerably higher in the live-active training condition ($M = 2.52$, $SD = 0.44$) compared to the live-passive training condition ($M = 2.18$, $SD = 0.52$) and this difference was statistically significant ($p = 0.01$). In addition, problem solving scores were higher in the video-active condition ($M = 2.67$, $SD = 0.31$) compared to the video-passive condition ($M = 2.32$, $SD = 0.34$) and this difference was also statistically significant ($p = 0.01$). In comparison, only the difference between the live-active and live-passive conditions was significant in the original data set.

Figure 11. Average problem solving score as a function of experimental condition. An asterisk indicates that infants performed better in one experimental condition than the other.

Significant differences were found between the live-active and live-passive conditions. The same pattern was found between the video-active and video-passive conditions.

Analogical problem solving using re-coded data. Overall, infants' problem solving scores were still quite high across all trials after re-coding the data. Furthermore, there was still very little difference across the first ($M = 2.46$, $SD = 0.57$), second ($M = 2.43$, $SD = 0.62$) and third trials ($M = 2.47$, $SD = 0.55$). An ANOVA was conducted to determine if these differences were significant and revealed that they were not, $F(2, 62) = 0.02$, $p = 0.98$, *ns*.

The differences across trial were also examined across experimental conditions. For the most part, re-coding the data did not alter the results for the live-active, live-passive or video-active conditions. However, re-coding the data appeared to have a significant impact on the video-passive condition. In the original data set, infants received more scores of one and two on the first two trials and received a greater proportion of scores of three on the third trial. However, after re-coding the data, infants were more likely to receive scores of two on all trials.

These results could not be tested statistically due to the small sample size. The histograms are presented in Figure 12.

Figure 12. Frequency of each problem solving score as a function of trial and experimental condition (top left, live-active; top right, live-passive; bottom left, video-active; bottom right, video-passive).

Between-subjects analysis. Finally, because this was the first study to examine the video deficit effect using a within-subjects design, it is possible that the results described above were influenced by training effects. To ensure that this was not the case, the data from each participant was divided according to condition order and only the data from the first condition were entered into the analyses and the data from the second and third condition were deleted. The results are presented below.

Problem solving scores. A 2 (demonstration type: live, video) X 2 (training type: active, passive) between-subjects ANOVA was conducted on the problem solving scores obtained for each infant on their first condition. There was no main effect of demonstration type (live or video), $F(1, 24) = 0.31, p = 0.58$, and although the difference between active and passive training approached significance, $F(1, 24) = 3.92, p = 0.06$, it did not surpass the critical cut-off.

Problem solving scores using re-coded data. A 2 (demonstration type: live, video) X 2 (training type: active, passive) between-subjects ANOVA was also conducted on the re-coded problem solving scores obtained for each infant on their first condition. Similarly, there was no main effect of demonstration type (live or video), $F(1, 24) = 0.31, p = 0.58$. However, there was a main effect of training type (active or passive) $F(1, 24) = 3.92, p = 0.06$.

Discussion

The present study had four main objectives. The first was to examine the video deficit effect in the context of multi-step means-end problems. That is, to investigate whether infants were able to use live and televised information to guide their behaviour and whether this varied as a function of condition. The second objective was to determine if there were other ways to increase performance on the video conditions and reduce the video deficit in a new way (using active experience). The third objective was to provide support for the perceptual impoverishment theory or dual representation hypothesis. Finally, the fourth objective was to assess analogical problem solving across the test sessions. The findings, as related to the four objectives of the present study, are discussed in greater detail below followed by a description of the implications, limitations, future directions and conclusions of the present study.

Live versus Video

The primary objective of the present study was to determine if infants were able to use televised information through video to solve a series of means-end problems and whether performance was inferior in comparison to a live demonstration. In the present study, infants aged 9- to 12 months were able to solve means-end problems using information obtained from both a live and televised model. This finding corroborates previous developmental science that has shown that infants are able to use televised information to guide their own behaviour in imitation tasks (e.g. Barr et al., 2007), object search tasks (e.g. Schmitt & Anderson, 2002), emotion processing tasks (e.g. Mumme & Fernald, 2003), and language tasks (e.g. Kuhl, Tsao, & Liu, 2003). However, the majority of these studies have also reported that while infants are able to learn from the televised information, their performance is almost *always* inferior in

comparison to performance after learning from a live demonstration. In contrast to these findings, the present study did not reveal a difference in performance across the live and video demonstrations. Interestingly, performance was considerably better for the video conditions. There are several possible explanations for why this finding is inconsistent with other reports in the literature: first, the first-person perspective used to demonstrate the target actions rather than the more commonly used third-person perspective; second, the steady close-up shot used for the video demonstrations, and finally, the nature of the task itself.

The effect of the visual perspective of the model on imitation has not been well investigated. Despite various definitions of imitation, most researchers agree that it involves mapping your own behaviour onto the behaviour observed in another individual. A crucial aspect of this skill would therefore be the ability to spatially transform viewed actions. When a model faces the viewer (the third-person perspective), the viewer is required to spatially reverse the actions he or she is seeing. In contrast, the first-person perspective does not require any transformation because the model is already presented from the viewer's point of view. In an experiment conducted by Jackson, Meltzoff, and Decety (2006), participants watched video-clips depicting simple hand and foot actions filmed from the first- and third-person perspectives and were then required to imitate the actions. Results showed that participants were significantly faster in imitating the actions of a model seen from the first-person perspective and also seemed to generate fewer errors. Therefore, demonstrating the target actions from the first-person perspective in the present study (compared to the third-person perspective typically used in these types of studies) may have somehow enhanced infants' ability to learn from video.

Along the same lines of argument, a second possible explanation for the difference in performance may have been related to the angle chosen to film the video demonstrations. In order to keep the visual perspective consistent, a camera was set up in place of where the infant would be sitting during the test sessions to film the video demonstration clips; in effect, a more natural “infant perspective” was created in the present study. This resulted in a “close-up” effect in which the task objects and only part of the experimenter were visible on the video. This is in contrast to video clips used in other studies where the video typically shows much more of the experimenter. For example, Barr and Hayne (1999) describe the experimenter’s face and torso being shown in the videos used for their experiments. Usually, an effort is made to keep the video clips and the live demonstrations as similar as possible. However, in an attempt to investigate whether more complex viewing conditions affected infants’ tendency to imitate, at least one previous study has attempted to use close-up shots (Barr & Hayne, 1999, experiment 1C and 3). In the video clips used for experiment 1C, the demonstration began with a wide-angle shot of the experimenter and task objects. At the beginning of the demonstration of the target actions, the camera zoomed in to create a close-up shot of the actions before zooming out again at the end of the demonstrations. For experiment 3, the demonstration alternated between a wide-angle shot of the experimenter and task objects and a close-up shot of the experimenter’s hands during each demonstration of the target actions. Overall, the results of these experiments showed that both 15 month olds and 18 month olds still did not perform as well in the video conditions with close-ups in comparison to their performance in the live conditions. Arguably the close-ups should have helped infants focus their attention. However, it should be noted that in the video clips just described, there seems to be a considerable amount of

zooming in and zooming out. Rather than helping the infants focus their limited attentional resources on the target actions, the movement from the camera likely increased the level of distraction. In contrast, the video clips used in the present study remained steady and maintained the close-ups shot throughout the entire clip. This methodological component may have helped infants focus their attention on the target actions without the distraction of the camera moving.

Finally, one other possible explanation for the difference may have been the task used in the present study. Although the video deficit effect is a commonly reported finding in the infant learning literature, several studies have reported equal learning from live and televised information. For example, Meltzoff (1988) did not find a video deficit effect in 14 month olds who were shown how to pull apart a dumbbell-shaped object. Initially, researchers criticized the task and suggested that the one-step sequence was not affected and only more complicated multi-step sequences resulted in a video deficit. However, other research has shown that a variety of multi-step sequences can be learned equally well from live and video demonstrations and do not show a video deficit. For example, when 15-month-old infants were shown how to “build a rattle” (by placing a block in a jar, putting a velcro lid on the jar, and shaking the handle attached to the lid to make a sound) they imitated the actions whether they were modeled live or on television and importantly, the infants in the live and video conditions performed equivalently. Furthermore, 9- to- 12-month-old infants performed equally well across live and video conditions for the three tasks used in the present study (which were all similar to the rattle task in that each task involved multiple steps and each step must be completed in the proper order). Interestingly, there seems to be a distinctive difference between the *types* of

tasks that result in a video deficit and those that do not. For example, tasks in which infants have shown differential learning across live and video conditions appear to have redundant requirements. That is, the actions required don't necessarily seem purposeful in comparison to the tasks that do not show the deficit. For example, in the object search tasks, the toddler is being asked to retrieve a toy that has essentially already been "retrieved" by the model when she has demonstrated where the toy is hiding or in the puppet task when the infant is asked to remove a mitten from the puppet to shake a bell and is then required to put it back. There are several possible interpretations for why we see differential learning across these tasks. The first may be that infants are able to solve means-end problems relatively easily on their own without any demonstrations. The ability to execute a sequence of planned steps to achieve a goal (means-end problem solving) develops rapidly after 6 months of age. By 7 months, infants begin to solve simple one-step problems such as searching under a cover for a toy (Willatts, 1984) or pulling a cloth to retrieve an out of reach toy (Willatts, 1999). At 9 months they can solve problems requiring two intermediate steps and by 10 months, infants can solve problems requiring three intermediate steps (Willatts, 1992). Given that these young infants are such "expert" problem-solvers, it may be the case that infants are not necessarily using the live or televised information provided to them to complete the means-end tasks but rather, are completing the tasks themselves through trial and error. While a control group of infants was not included in the present study, Barr and Hayne (1999, experiment 2) did include a group of baseline infants who were exposed to the test objects but did not receive any kind of demonstration. The authors reported that while no differences were found in the performance of infants in the live and video conditions, both groups performed significantly better than the

infants in the control group. Given the similarity between the rattle task and the tasks used in the present study, it seems unlikely that infants would be able to complete the task without previously being given information regarding the goal of the task. Beyond this speculation, however, a control group should be included in future studies using these tasks in order to systematically rule out this possibility.

Secondly, another possible elucidation for these task differences may be related to infants' ability to understand others' intentions. In a much cited study by Gergely, Bekkering, and Kiraly (2002), 14-month-old infants watched an adult use an unusual action to illuminate a light box; she pressed the box with her forehead rather than her hands. In one condition, the experimenter's hands were simply placed on table next to the light box. When infants in this condition were given the light box themselves, the majority of them also used their forehead to illuminate the light. In another condition, the experimenter pretended to be cold and held a blanket around her shoulders therefore making her hands "unavailable" before pressing the light box with her forehead. In this case, when infants were given the light box themselves, most of them used the simpler (yet undemonstrated) method of pressing the light with their hands. In the "hands-occupied" condition infants may have assumed that the adult used her hand because she had to (she could not use her hands). Because this constraint did not apply to the infants themselves, they used their hands. However, in the "hands-free" condition, on the other hand, infants likely assumed that the adult could have used her hands (they were free) and that there must have been some reason for this choice and therefore copied the unusual action. Similarly, Bruggar, Adams, Mumme, & Bushnell (2007) reported that infants imitate only those actions deemed *necessary* to create an effect. Furthermore, research has also shown that infants are

able to infer and imitate the intended goal of a model's actions even if the model fails to actually achieve (demonstrate) this goal (Meltzoff, 1995). Infants can also distinguish between a model's intentional and accidental behaviours and are more likely to imitate intentional acts (Carpenter, Akhtar, & Tomasello, 1998). While infants seem to be able to demonstrate their knowledge of another's goals for live models, this skill for televised models is not yet clear. Guided by these important developmental findings, one could suggest that while infants are able to understand a live model's goals and a televised model's goals equally well for certain tasks (resulting in no video deficit effect) this may be more difficult when the goals of the task are not as clear. That is, when the model's goals are ambiguous, infants may not readily apply the knowledge gained from a televised model as easily as that obtained from the live model. This observation and account is consistent with previous work conducted by Wenner and Bauer (1999) who found that "enabling events" that must be assembled in the correct order to achieve the goal (such as the rattle task) are learned earlier than "arbitrary events" that can be assembled in any order (such as the puppet task). Therefore, infants are first able to complete orderly tasks and show no video deficit while it may take slightly longer for the arbitrary tasks to be fully understood resulting in a video deficit effect initially.

Finally, another possibility for these task differences may involve the age of the infants being tested. When a skill first develops, it does take some time before infants settle in to one particular pattern of use. For example, it has been reported that infants are able to imitate actions with objects from approximately 6 months of age (Collie & Hayne, 1999). While at least one study has found that 6-month-old infants learn equally well from live and video demonstrations (Barr et al., 2007b) another has reported a video deficit effect using the same

imitation task with 12-month-olds (Barr & Hayne, 1999). Similarly, in the present study, 9- to-12-month old infants were required to complete a multi-step means-end task. Previously, it has been reported that this skill emerges between 7 and 10 months of age. While the video deficit is not evident in this study, perhaps it would be with older infants. That is, it may be the case that a newly acquired skill is very flexible in its early stages and can be used in a variety of ways (i.e., using information from live or video sources to use the skill) but becomes more rigid with time and experience.

Active versus Passive

Another key objective of the present study was related to whether providing infants with active experience could ameliorate the video deficit effect. While no video deficit effect was found in the current study, active experience did significantly increase performance, as hypothesized. Furthermore, this pattern was shown across both live and video conditions.

Jean Piaget, one of the most influential developmental theorists, believed that the developing child is an active thinker who is constantly trying to construct more advanced understandings of the world through trial and error experimentation (Piaget, 1952). As an alternative to the “action-discovery” approach, researchers have suggested that it is more beneficial for infants to learn by watching others. Support for this position comes from research conducted by Provasi, Dubon, & Bloch (2001), and others, who reported that infants were more successful in manipulating a knob (in a simple manipulation task) after having watched a model perform the same task than after free play with the knob. Similarly, we know that infants readily learn to use tools by watching others (Barrett, Davis, & Needham, 2007). The debate between the importance of self performed and observed actions has continued for several decades and

while there seems to be sufficient evidence to argue that infants can learn by watching others, the role of active experience should not be discounted. Compelling findings from work conducted by Munakata, McClelland, Johnson, and Siegler (1997) revealed that 6- to-7-month old infants could be trained to use an intermediary object as a means to a desired end (pulling a towel to retrieve a distant toy) simply by instructing the parent to put their hands over their infant's hands and guide the infant through the proper motions. This skill likely would not have developed until several weeks later, but by receiving active training, infants were able to demonstrate competence much earlier than would be expected. In a similar spirit, Needham, Barrett, & Peterman (2002) provided young infants with the ability to pick up toys using "sticky" mittens (mittens with the palm covered in soft velcro that can pick up toys that have hard velcro on them) weeks before they would have been able to do so without the help of the mittens. Just by placing their hand near the toy, they were able to gain control over the toy and move it around. In comparison to infants who did not receive training with the mittens, trained infants look at objects more frequently, engaged in more exploratory mouthing behaviours with the objects, and also attempted to intentionally retrieve more toys whether or not they were still wearing the mittens. Additional research has shown that active experience augments infants' ability to understand the actions of others as well. For example, hands-on training was found to provide greater understanding of another person's goals compared to an observation alone condition (Sommerville, Hildebrand, & Crane, 2008). Similarly, other research conducted by Hauf, Aschersleben, and Prinz (2007) also found that agentic experiences influenced infants' perceptions of actions performed by others. That is, infants' acting on objects themselves increased their interest in the actions of other people with the same object.

As hypothesized, and in line with previous findings, active experience substantially increased infants' performance on the problem solving tasks. Even with only one complete demonstration initially and a short amount of time exploring the object themselves, infants received significantly higher problem solving scores than in the passive conditions where they witnessed three complete demonstrations revealing how to solve the multi-step task. In addition, infants solved the problems in less time in the active conditions. Because infants were given time to explore the objects themselves during the training session in the active conditions (before the test sessions) it seems likely that they did not need as much time during the first trial to explore the objects as infants who had only passively seen the objects and did not have an opportunity to interact with them during training. This explanation may account for the variation in task completion times.

Theoretical Considerations

The third objective of the present study was to contribute to the discussion in the literature related to the perceptual encoding impoverishment theory and the dual representation hypothesis. Even though a video deficit effect was not found in the present study, the current findings do suggest support for several features of each of these theories and perspectives. According to the dual representation hypothesis, it is not until the second year of life that infants are able to truly differentiate between 2D images and 3D objects resulting in a decrease in learning from television (DeLoache, Pierroutsakos, & Troseth, 1996). Before this time, infants treat images and objects in very similar ways and do not show a video deficit. Compatible with this argument, findings from the present study found no significant differences between the live and video conditions for infants under the age one year.

However, the data from the present study may also provide support for the perceptual impoverishment theory. According to this theory, infants do not perform as well in video conditions because of poor perceptual encoding (Barr & Hayne, 1999). That is, the 2D input is impoverished in comparison to the 3D input in terms of size, colour, depth cues, shadows, etc. making it difficult to visually process. Similarly, Johnson (1997) has argued that more streams of information are required before a 2D image can match its 3D counterpart. In the present study, infants in the passive condition simply looked at a video screen and observed an experimenter demonstrating the target actions several times. However, in the active condition, infant viewed the same demonstration on the screen but *also* had the same objects in front of them. It is likely that having the objects in front of them may have reduced the attentional requirements associated with processing and encoding information from the television screen. Rather than having to form a representation of the task objects from the 2D video display and transfer the perceptual attributes to the 3D object during the test sessions, infants in the active conditions presumably would have been able to encode the 3D attributes of the test objects directly. The fact that infants performed so much better when they were given an opportunity to encode the 3D attributes of the test objects directly is consistent with the perceptual impoverishment theory.

Overall, the current findings provide some contributory evidence in support of each of these two primary theories. Consistent with the perceptual impoverishment theory, adding the additional streams of information to encode information increased performance when infants were observing target actions from a 2D source and were required to transfer that information to a 3D source. Furthermore, the data are also in keeping with the dual representation

hypothesis indicating that infants under one year of age interact with 2D images and 3D objects similarly. Because they do not understand the critical differences between them, information is transferring easily and no deficit occurs. Neither theory is able to conclusively explain the findings as there is a dynamic interplay of perceptual processing, encoding, retrieval, and representational factors involved.

Analogical Problem Solving

The final objective of the present study was to determine if infants were able to use information obtained during the demonstration and training sessions and apply that knowledge to different problems in the test session: analogical problem solving. This paradigm was modeled after that used by Chen et al. (1997) in which the researchers changed the colour and size of the task objects but the underlying structure of the problem remained the same. For the present study, in addition to altering the colour and size of the task objects used for the first step of each problem, special design attention was given to the properties of the objects used for the second step (for example, using a string, a hollow plastic tube, and a ribbon). The reasoning in the current study was that this new design may present a more difficult analogy for the infants to make thereby improving the robustness of the previous finding. However, it should also be noted that much more systematic research is needed to determine whether or not this analogy is in fact more difficult. Furthermore, it is also important to note that while these analogical problems may look very similar to adults and the common structure seems obvious, this is not the case for infants (Chen et al., 1997). In the current study, infants in both age groups performed reasonably well even from the first trial and there were no significant differences across trials. This is somewhat surprising given that there were age differences

reported in the Chen et al. (1997) study and the task used in the current study was believed to be slightly more difficult. According to Chen et al. (1997), 13-month-old infants were able to transfer the solution across tasks quite readily. However, 10-month-olds were only able to transfer the solution to problems with a high degree of perceptual similarity (for example, different task objects but the same goal toy for each problem). Several key factors may have been related to this discrepancy. In the current study, it was determined during pilot testing that moving infants for each task was quite disruptive. Therefore, infants remained seated on their parent's lap for each problem. Thelen (2000) suggested that when infants remain in the same position, the memory of actions that are built up over the course of the trials include both visually stored information as well as a memory for the feeling of the specific postures involved with completing the task—all of which are integrated into the next plan for action. For example, in a study conducted by Smith, Thelen, Titzer, and McLin (1999), the authors found that after hiding a toy in one location consistently, infants would continually reach to the first location even after they had seen the toy placed at another location. On the other hand, when parents are asked to change the infants' postures by standing them up on their laps (rather than remaining in a seated position) just before the toy moves to the second location, infants are able to resist the urge to reach to the first location and correctly reach to the second location. These findings suggest that by keeping infants in the same position for each trial, the present study may have inadvertently "helped" infants perform better since they had to complete the same actions on each test trial. However, it should be noted here that in the present study, several efforts were made to create "unique separation" between trials: the curtain was closed in between each problem; the parents were asked turn their chair away from the presentation

area; and the lights illuminating the presentation area for the task objects were changed between each problem in an attempt to replicate the changing environment in another way. This manipulation was modeled after previous research conducted by Borovsky and Rovee-Collier (1990) which found that changing the crib liners between the training and test trials was sufficient to create a distinctive test context. In this case, because we did not report a significant difference across trials, it may be that the lights did not make *enough* of a difference to “trick” the infant into thinking they were in a new place. Alternatively, the lights may not have had as much context influence on the 9- to- 12-month olds used in the present study. Although the lights appeared to have an impact during pilot testing, more systematic research is needed to determine whether or not changing the lighting context has a major influence on subsequent learning.

In addition to the changing contexts, another procedural difference may have affected the results. In the present study, all infants were given at least one demonstration of the target actions before the test sessions. In contrast, infants in the Chen et al. (1997) study were first given an opportunity to interact with the objects themselves and if they were unable to solve the problem, the parent was asked to demonstrate the correct solutions. Therefore, infants in the Chen et al. (1997) study were only encouraged to actively explore the objects *before* seeing a demonstration whereas infants in the present study were always given a demonstration of the target actions before being given active experience (in the active condition; infants in the passive condition were not given any active experience but were still shown how to solve the problems). Interestingly, results from the Chen et al. (1997) study indicated that the greatest improvement in performance occurred between the first and second test trial (during which

infants would have been given active experience) and there were no differences in performance between the second and third trials. In the current study, performance was high from the first trial and there were no significant differences between the first, second, or third trials. Thus, the timing of the demonstrations and / or the timing of the active experience may have played a more significant role in infants' ability to solve problems than assumed at the outset of this study. Similarly, recent work conducted by Sommerville, Woodward and Needham (2005) has reported that the order of active experience does in fact make a difference in terms of learning. In their study, the researchers found that when infants were given active experience with a test object prior to or after watching another person use the object only infants with active experience focused on the relationship between the actor and her goal whereas infants who watched first did not. Thus, active experience facilitated the infants' perception of another's actions.

Finally, one other possible explanation for the difference in performance found between infants in the current study and infants in Chen et al. (1997)'s study may have been the nature of the coding scheme used to evaluate performance. In the Chen et al. (1997) study, infants were given a score ranging from 0-2 depending on how efficiently they solved the problem. Infants were given a score of 0 if they were unable to solve the problem, a score of 1 if they solved the problem with a trial and error approach and a score of 2 if they solved the problem with a goal-oriented approach. For the current study, infants were given a score from 0-3 depending on the number of target actions they completed. This particular coding scheme was selected for the present study because this type of coding scheme gave infants credit for each section of the task they completed rather than overall performance which is important when trying to determine

exactly where performance differences exist. Moreover, because it was believed that altering the second step of the task in a more distinctive way may have increased the overall complexity of the task, the second set of distracter items used in the Chen et al. (1997) study were not included in the current study making trial and error more difficult to assess. In addition, this coding scheme fits more closely with the majority of coding schemes used in the imitation literature (e.g. Barr et al., 2007b) and it was important to keep this consistent given that this is the area in which the current findings would be more directly compared to.

Implications, Limitations, and Future Directions

Acknowledging the important differences between dynamic television (in the home) and controlled televised video (in the lab), the connections and extensions between the two are significant with laboratory research in this area can provide critical insights into how children learn from television. With the tremendous rise in the development of television programs and videos directed specifically at infants and subsequent television viewing by these young viewers, there is also a growing body of research investigating whether infants are actually able to effectively learn from these types of media. While the AAP recommends (2001 report) restricting the amount of exposure to television for children under the age of 2, recent reports estimate that by the age of 24 months, approximately 90% of infants engage in television viewing on a regular basis (Zimmerman et al., 2007). In a relatively short amount of time, infant television viewing has become an enormous industry. This may be in part due to the educational claims made by these products either indirectly or directly. For example, many of the titles themselves are highly suggestive of cognitive benefits (e.g. Baby Einstein, Brainy Baby). Moreover, testimonials on packages and websites take the message that much further

exclaiming to “teach your child about language, colours, shapes, and patterns”. Most importantly, this type of marketing appears to be highly effective; indeed, a survey conducted with over 1000 families reported that 29% of parents cited the most common reason for allowing their infant to watch TV is that it is “good for the brain” (Zimmerman et al., 2007). Shockingly, the same survey found that only 6% of the parents interviewed were even aware that the AAP had guidelines discouraging parents from allowing their infant to watch television.

One of the main criticisms of television viewing is that for the most part, it is a passive activity, and it takes time away from other more interactive activities between infants and parents that have been shown to be vitally important for development. However, newer DVD programs, such as that developed by DVD MAGIQ, have created companion toys that respond to the onscreen content to go along with the DVDs. The creators’ argue that this provides the infant with a more enriching learning experience. Along similar lines, the present study investigated whether providing infants with active experience with the task objects along with televised demonstrations of how to solve the tasks in an experimental setting would show higher levels of problem solving. Results indicated that infants were in fact able to solve means-end problems using information from a televised model. These results are consistent with a variety of studies showing infant learning from television (e.g. Barr et al., 2007b; Schmitt & Anderson, 2002; Kuhl et al., 2003; Mumme & Fernald, 2003). While there were no significant differences between the live and video conditions, there were differences between the active and passive conditions, as expected. Still, future studies are needed to determine the robustness of this finding. That is, determining whether active experience is able to enhance performance in imitation and object search tasks and possibly ameliorate the video deficit

previously reported using these tasks (e.g. Barr et al., 2007b; Schmitt & Anderson, 2002).

Moreover, it is important to maintain a developmental perspective when considering these issues. Conclusions drawn from a single task have the potential to be misleading given that we do not know specific details regarding the age at which infants can use specific types of televised information or whether there are other differences between tasks across different ages.

Additionally, this area of developmental science is still relatively new and extending and implementing the “home television” to the “laboratory television” is not without complexity—

there are a myriad of key variables to monitor and control for. While the televised demonstrations in this study were made to be as consistent with the live demonstrations as much as possible, they did not include many of the typical features seen in commercially available infant programs. For example, the visual and auditory effects, camera angles, etc.

Future research is called for to systematically examine the effects of these features on learning from television. On a final but related point, to keep the demonstrations as consistent as possible across participants, parents were asked refrain from describing the target actions as they were being demonstrated. Only the experimenter spoke and said relatively neutral comments such as “watch what I do next”. However, researchers investigating parent and infant behaviours while engaged in television viewing have recently reported that most parents tend to narrate during a video presentation of commercially available programming (Barr, Zack, Garcia, & Muentener, 2008). Experimentally manipulating the level of narration is another possible avenue for future research. Ultimately, it will be crucial to understand infants’ learning from more naturalistic—and parent sensitive—conditions before we are able to draw unequivocal conclusions from the lab to real life

An additional line of future research involves analogical problem solving. When adults are confronted with a new problem to solve, it is generally assumed that their problem solving behaviour is guided by previous experience with a similar problem. However, according to Chen et al. (1997) there continues to be a debate in terms of children's problem solving ability. On the one hand, researchers have argued that early experiences are critical for later development (implying that infants are capable to transferring what they've learned from one situation to the next). On the other hand, young children are believed to be inflexible learners who cannot transfer knowledge. This particular area has not been well investigated in years, but given the importance of such a skill, it is worth pursuing.

Conclusions

Several important conclusions can be drawn from the present study. First, infants are able to use televised information to solve multi-step means-end problems. Second, even when the surface characteristics of the task are changed, 9- to- 12-month olds infants are able to transfer the solution presented to them during the demonstration to the new problems. Third, infants performed equally well when the information was presented to them through a live or televised demonstration. Fourth, a single complete demonstration (either live or on video) followed by a small amount of active exploration time with the task objects resulted in significantly higher problem solving scores compared to three demonstrations (either live or on video) with no active experience. Collectively, the findings from the current study highlight the importance of active experience and provide a foundation for future research on infant learning. This research ultimately adds to the growing body of developmental science that aims to

address socially-relevant questions which hold enormous implications for the healthy cognitive and social-emotional development of infants in the first years of life.

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Appendix A:

Pre-Observation Questionnaire

Cognition • Health • Infancy
Learning • Development

Study Name: _____
Researcher: _____
Participant Number: _____
Date: _____

PRE-OBSERVATION QUESTIONNAIRE

Welcome to the CHILD Lab! Before we begin our session, we ask that you complete this simple questionnaire regarding your child's early development. We will use your responses in addition information we will gather from the observation session and this will help us to better answer our research questions. Please answer the following questions as accurately as possible. You are not obligated to answer any of the questions you do not wish to and may stop participating at any time without penalty. All questionnaire responses will be entered into a secure database and will be kept confidential by the researcher. If you have any questions, please contact Danielle Labine (416-979-5000 ext. 4859 or danielle.labine@psych.ryerson.ca). Thank you!

I. PERSONAL INFORMATION

Parent's Name: _____

Address: _____

Telephone: _____

☐ I would like to receive your newsletter featuring updates about the lab and results from previous studies

☐ Please contact me if my son/daughter is eligible to participate in future studies

May we contact you by email? ☐ Yes ☐ No Email address: _____

How did you hear about our lab? _____

☐ Brochure / Poster ☐ Website ☐ Friend ☐ Resource Centre ☐ Other: _____

II. INFORMATION ABOUT YOUR INFANT

Name: _____ Gender: ☐ Male ☐ Female

Date of Birth (dd/mm/yy): _____ Expected Date of Birth: _____

Were there any complications during pregnancy or delivery? ☐ Yes ☐ No

If yes, please explain: _____

Ethnicity: ☐ African American ☐ Asian ☐ Caucasian ☐ Hispanic ☐ Other: _____

Birth Order: _____

Age of siblings: _____

(Please continue on the following page...)

III. CURRENT ABILITIES OF YOUR SON/DAUGHTER

1. Is your child able to reach for objects?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
2. Is your child able to hold objects without dropping them?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
3. Is your child able to pick up very small object (example: Cheerios) with their fingers?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
4. Does your child use his/her hands and mouth to explore objects?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
5. Is your child able to roll over (from back to stomach <u>or</u> stomach to back)	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
6. Is your child able to sit up independently?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
7. Is your child able to crawl?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
8. Is your child able to pull themselves up to a standing position using furniture?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
9. Is your child able to walk using support (example: furniture or help from a parent)?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____
10. Is your child able to walk independently?	☐ Yes ☐ No	If yes, at what age (in months) did this ability emerge? _____

11. Do you have any concerns or comments regarding your child's development?

(Please continue on the following page...)

IV. VIDEO VIEWING HABITS

12. How many hours per day is a television in use in your household? _____

13. When other members of the household are watching television, is your infant interested in the screen?

☐ Yes ☐ No ☐ It depends on the program

14. Please describe the type of programming that interests your child:

☐ Programming geared for adults ☐ Cartoons ☐ Educational programs for children

☐ Infant Development (Baby Einstein) ☐ Children's movies ☐ Other: _____

15. Does your child actively engage in viewing television or movies alone? ☐ Yes ☐ No

If yes, please state how many minutes per day: _____

16. Do you and your child actively engage in viewing television or movies together? ☐ Yes ☐ No

If yes, please state how many minutes per day: _____

If you answered yes to question 15 or 16, please list the titles of the television shows or DVDs:

_____	_____
_____	_____
_____	_____

17. Do you have any concerns or comments regarding your child's vision?

Thank you! The next session will begin shortly...

Appendix B:
Consent Form

PARTICIPANT CONSENT FORM

RESEARCH PROJECT TITLE: Infant Learning from Television: Beyond Imitation in 9- and 12-month old Infants

PURPOSE: The purpose of the study is to help us understand what young infants are able to learn from video.

This consent form, a copy of which will be left with you for your reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

PROCEDURE: After the Pre-Observation Questionnaire has been completed and your baby seems comfortable, the two of you will be led to an adjacent testing room. Your baby will sit on your lap at a table. A brief video demonstrating a sequence of actions will be shown on a television screen and your baby will then have an opportunity to interact with the toys shown in the video. We are interested in measuring your child's ability to apply televised information to objects in real life. There are no right or wrong answers. Sometimes babies are very interested in the task and are successful in solving the problem using the televised information and sometimes they are not interested or successful. Both of these are normal responses and do not say anything about your child's development. We ask that you sit quietly while your baby is trying to solve the problem themselves. However, after each attempt, we encourage you to interact with your baby and provide social reward. The entire experimental session should last approximately 30 minutes and will be video-taped for analysis purposes at a later date.

POTENTIAL RISKS AND BENEFITS: The only potential risk for participation in either of these studies is that the infant may become disinterested in the task and display fussiness. However, you are free to take a break to address any needs of their infant or to discontinue the session at any time. The researcher will also closely monitor the infant's readiness to continue.

As for the potential benefits, you have the opportunity to learn more about infant development. In addition, the procedure is designed to be engaging for infants of this age group and they typically enjoy the many trials presented to them in this "game-like" fashion. Importantly, although not a direct benefit to participants, the findings from this study have the potential to extend previous research and contribute to the question concerning what young infants can learn from video. This work could have a key impact on parents' choices for healthy learning and development.

CONFIDENTIALITY: Any information that is obtained in connection with this study, including the information you provide in the questionnaire, will remain strictly confidential. Your privacy and that of your infant will be respected. All records will be referred to in the study using pseudonyms and study codes which will be securely stored on password-protected media. The questionnaires and any other hard copy information pertaining to this study will be stored in a separate locked filing cabinet from the consent forms in the laboratory. Sessions are video-taped in order to allow the researcher to examine the records of observations at a future date. All video-recordings will be used strictly for research purposes and can only be accessed by those directly involved in the study. These images, like the rest of your child's information, are stored separately from information identifying your child. Should you at any time wish not to be contacted for future studies, please tell a member of the lab, and we will be happy to remove your name from contact list.

PARTICIPATION: Your participation is voluntary. You are not under any obligation to answer any questions. If at any time you wish to withdraw from this study and session, you may do so without any consequences by simply notifying the researcher. You also have the option of removing your infant's records of observation from the study or requesting that the session not be video-taped.

ADDITIONAL INFORMATION: Because of the unique needs of infants, a variety of special procedures are in place to ensure your baby is safe and comfortable during each component of the study. In the waiting area, the toys provided for the infants to play with are age-appropriate. All of the materials used during the experiment are designed and built to be safe for babies with smooth rounded edges and the use of non-toxic paint. All toys are sterilized with a baby-safe cleaning agent after each session with an individual infant. In addition, the tasks are designed to be very engaging for infants at this age. The trials are conducted in a “game-like” fashion which infants typically enjoy. Infants will remain with their caregiver at all times. The caregiver and researcher will continually monitor the baby’s emotional state and readiness to continue. The sessions can also be paused to address any feeding or changing issues that arise and a clean and private area of the lab is provided for these purposes.

FEEDBACK: We hope that you are interested in the research and we will be happy to answer any further questions you might have about it at any time. If you wish to be informed about the results of this study, please leave your phone number and/or e-mail address and you will be contacted upon the completion of this project. If you do not wish to be contacted and are still interested in the results of the study then you may obtain information about the results by contacting us.

COMPENSATION: As a token of our appreciation for taking part in our study, you and your child will receive a small gift bag containing a small children’s book or toy to take home with them for their efforts. You and your child will receive this complimentary gift regardless of whether your child completes the study.

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Dr. Jean-Paul Boudreau
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This research has been approved by the Ryerson Research Ethics Board (REB). If you have any concerns about this project you may contact the Research Ethics Board Chair (Nancy Walton, 416-979-5000 or rebchair@ryerson.ca) and Alex Karabanow (416-979-5000 ext. 7112 or alex.karabanow@ryerson.ca)

CONSENT: I agree to have my son/daughter, _____, participate in the study described above. I have read the description of the study and I understand the details of the procedure. As part of my consent, I agree to be videotaped during the experimental session. I realize that I may withdraw my child from the study at any time if I wish to do so.

Name of Parent/Guardian

Signature of Parent/Guardian

Signature of Researcher

Date

Appendix C:

Detailed Task Descriptions

Task 1 Description

Task 1 required two sub-goals (pulling a cloth and pulling another object) to retrieve a toy. The first sub-goal, pulling the cloth, brought the second object within reach. The infant could then pull the second object (the second sub-goal) to bring the goal toy within reach and retrieve it.

Task 1, Version A

Task items included a hollow plastic blue stick (33.02 cm) and a red cloth (23 x 15 cm) as the task items. One end of the stick rested on the cloth and the other was attached to the goal toy.

Task 1, Version B

Task items included a thick green rope (33.02 cm) and an orange cloth (25 x 13 cm) as the task items. One end of the rope rested on the cloth and the other was attached to the goal toy.

Task 1, Version C

Task items included a thick red ribbon (33.02 cm) and a blue cloth (29 x 7.5 cm) as the task items. One end of the ribbon rested on the cloth and the other was attached to the goal toy.

Task 1, Version D

Task items included a white plastic chain (33.02 cm) and a green cloth (18 x 18 cm) as the task items. One end of the chain rested on the cloth and the other was attached to the goal toy.

Task 2 Description

Task 2 required two sub-goals (pushing a handle and opening a transparent box) to retrieve a toy. The first sub-goal, pushing the handle (long wooden dowel), brought the transparent box within the infant's reach. The infant could then use the handle attached to the box to open it (the second sub-goal) and retrieve the goal toy.

Task 2 Version A

Task items included a long wooden dowel and weight colored red (33 cm) with a red circle shape on the end (4 cm) and a transparent box (10 x 10 x 10 cm) with a black knob handle attached to it (2.5 cm). The wooden dowel was attached to the transparent box. The center of the dowel had a small hole in the middle which was placed on a support riser and secured to the base to allow the system to glide freely from side to side. The goal toy was placed inside of the transparent box.

Task 2 Version B

Task items included a long wooden dowel and weight colored yellow (33 cm) with a yellow triangle shape on the end (4 cm) and a transparent box (10 x 10 x 10 cm) with a thick white handle (7.5 cm) attached to it. The wooden dowel was attached to the transparent box. The goal toy was placed inside of the transparent box.

Task 2 Version C

Task items included a long wooden dowel and weight colored blue (33 cm) with a purple cross shape on the end (5 cm) and a transparent box (10 x 10 x 10 cm) with a handle made of a piece of blue ribbon (6 cm) attached to it. The wooden dowel was attached to the transparent box. The goal toy was placed inside of the transparent box.

Task 2 Version D

Task items included a long wooden dowel and weight colored green (33 cm) with a green square shape on the end (4 cm) and a transparent box (10 x 10 x 10 cm) with a handle made of thin green string (7.5 cm) attached to it. The wooden dowel was attached to the transparent box. The goal toy was placed inside of the transparent box.

Task 3 Description Task 3 required two sub-goals (removing a barrier and pushing a button) to retrieve a toy. The first sub-goal, removing the barrier, revealed a button. When the infant pressed the button (the second sub-goal), the experimenter activated a circling belt on which the goal toy was located at the end. Activating the belt brought the goal toy within reach for the infant to retrieve it

Task 3 Version A

Task items included a red cardboard barrier (18 x 18 x 10 cm) with a red foam handle (7.5 x 4 x 2.5 cm) in the shape of an oversized Lego block and a blue push button with a smiling cartoon face on a green base (10 x 13 x 7.5 cm). The goal toy was located at the end of a small rotating belt (52 x 25 x 2.5 cm).

Task 3 Version B

Task items included a yellow cardboard barrier (15 x 13 x 13 cm) with a yellow foam handle (7.5 x 4 x 2.5 cm) in the shape of an oversized Lego block and red push button with a smiling cartoon face on an orange base (10 x 13 x 7.5 cm). The goal toy was located at the end of a small rotating belt (52 x 25 x 2.5 cm).

Task 3 Version C

Task items included a purple cardboard barrier (23 x 15 x 10 cm) with a blue foam handle (7.5 x 4 x 2.5 cm) in the shape of an oversized Lego block and a yellow push button with a neutral cartoon face on a green base (10 x 13 x 7.5 cm). The goal toy was located at the end of a small rotating belt (52 x 25 x 2.5 cm).

Task 3 Version D

Task items included a green cardboard barrier (19 x 15 x 13 cm) with a green foam handle (7.5 x 4 x 2.5 cm) in the shape of an oversized Lego block and a red push button with a neutral cartoon face on a blue base (10 x 13 x 7.5 cm). The goal toy was located at the end of a small rotating belt (52 x 25 x 2.5 cm).