Attention and Learning from Media during Infancy and Early Childhood

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Media products directed at very young children have exploded into the marketplace (Garrison & Christakis, 2005). At the same time, parent surveys reveal that very young children are being exposed to high levels of screen-based media (Rideout & Hamel, 2006; Rideout, Vandewater, & Wartella, 2003; Zimmerman, Christakis, & Meltzoff, 2007). Although the American Academy of Pediatrics (AAP) (1999) recommended no screen exposure before age 2, the empirical research about the effects of early media exposure on developmental outcomes is still in its infancy.

This chapter will focus on empirical studies that have measured the influence of media on attention, imitation, object search, and language learning. In a final section, these converging data will provide a conceptual framework to examine the potential impacts of early media exposure on cognitive and social development in the context of the AAP recommendation.

Very Early Media Exposure

US children are born into and develop in a world in which media pervade their daily experiences (for review, see Calvert, 2006). Recent nationally representative surveys of homes with children aged 6 months to 6 years found that 99 percent of homes contain a television set, 95 percent have a DVD player or videocassette recorder, 50 percent have three or more televisions, and 73 percent have a computer. Moreover, one third of these young children have televisions in their bedrooms (Rideout & Hamel, 2006; Rideout, Vandewater, & Wartella, 2003).

Access to media content directed at infants and young children is also changing, resulting in much earlier exposure to infant-directed programming. During the 1970s, children were first exposed to television on a regular basis at approximately 2.5 years of age (Anderson & Levin, 1976; Anderson et al., 1986). During the 1990s, television programs such as *Teletubbies* and videos/DVDs such as *Baby Einstein* started to be produced specifically for infants (Garrison & Christakis, 2005).

approximately $100 million in the US alone (Garrison & Christakis, 2005). Because there are media products designed just for them, many infants now begin consistently viewing videos and DVDs at 6 to 9 months of age; 74–90 percent are exposed to television before age 2 (Rideout, Vandewater, & Wartella, 2003; Zimmerman, Christakis, & Meltzoff, 2007).

Children below the age of 2 years spend approximately 1 to 2 hours per day with screen media, predominantly viewing television and prerecorded videos and DVDs, but only about 40 minutes reading books or being read to (Rideout & Hamel, 2006; Zimmerman, Christakis, & Meltzoff, 2007). Many parents view screen media favorably; for instance, 58 percent of parents in a nationally representative sample believe that early exposure to educational television programming is "very important" (Rideout, Vandewater, & Wartella, 2003). Computer experience and videogame play is still relatively rare prior to age two, but computers tend to be viewed very favorably by parents of preschool-aged children (Calvert et al., 2005) and that pattern may also hold true for those with even younger children as products become available that infants and toddlers can use.

Patterns of television use differ for children from different ethnic groups. In particular, African American and Latino children spend more time watching television than Caucasian children do (Rideout & Hamel, 2006). Similarly, patterns of viewing differ across socioeconomic groups. Families with lower incomes report higher levels of daily media use (Rideout & Hamel, 2006; Zimmerman, Christakis, & Meltzoff, 2007).

Availability also influences levels of television exposure. When children have television in their own rooms, they are exposed to higher levels of television content (Rideout & Hamel, 2006). When the television is on most or all of the time, children have higher levels of television exposure, they begin watching at an earlier age, are more likely to watch television every day, and watch it for longer periods of time (Vandewater et al., 2005). These children are also significantly less likely to be read to every day. Daily book reading is positively associated with language and cognitive development (Raikes et al., 2006). Birth order also impacts the amount of exposure and the type of exposure for children under 2. Specifically, infants with older siblings are exposed to more television and more non-educational content than first-born infants are (Zimmerman, Christakis, & Meltzoff, 2007).

In households with strict rules regarding the amount of television exposure, children watch less television (Vandewater et al., 2005). In households with strict rules about content, parents are significantly more likely to co-view with their children (Vandewater et al., 2005), which provides potential opportunities for parent-child interactions that can foster learning.

Taken together, the findings suggest that there is a complex interplay of factors involved surrounding household media patterns. These patterns are influenced by race and ethnicity, income, family composition, and parental beliefs about

whether media has the potential to be a positive or a negative influence on their child's development.

American Academy of Pediatrics Recommendation: No Screen Exposure before Age Two

Partly in response to rapid changes in the media landscape, the AAP (1999) recommended that parents should limit television exposure during early childhood. Specifically, children under the age of 2 should not be exposed to any type of screen media, and for children over 2, screen time (including television and computers) should be limited to 1 to 2 hours per day. This recommendation was based on two major concerns.

First, numerous studies have shown negative effects of media on preschoolers' behavior, particularly in the arena of media violence (Paik & Comstock, 1994), and the AAP predicted that such negative effects would also occur when exposure occurred at a younger age. After the recommendation was released, reports have emerged that heavy exposure to television during early childhood is associated with poor school performance, increased bullying, attention problems, and sleep problems (Christakis et al., 2004; Thakkar, Garrison, & Christakis, 2006; Thompson & Christakis, 2005; Zimmerman et al., 2005). For example, in one study an association was found between heavy television exposure during the first three years of life and parental reports of attention problems in first graders, as indexed by the Behavior Problems Index (Christakis et al., 2004). The study included a large sample and statistically controlled for multiple potential risk factors including differences in socioeconomic status, maternal risk factors such as maternal depression, and child risk factors such as prematurity or prenatal drug exposure.

Although it is possible that early television viewing causes later attention disorders, it is also possible that children with attention disorders are motivated to watch more television and/or are encouraged to do so by parents who are finding it difficult to cope with young children who are hyperactive and have poor attentional control (Calvert, 2006). Furthermore, the data were collected when there was no infant-directed programming available, suggesting that these findings may largely be due to exposure to incomprehensible content that is designed for an older audience, known as *background television* (Calvert, 2006). In fact, two recent studies in which data were collected since 2000 have failed to replicate the findings (Acevedo-Polakovich et al., 2006; Stevens & Muslow, 2006).

A second concern of the AAP is that time spent with screen media may be displacing other activities that are more important for children's development, such as face-to-face time with parents and caregivers. The AAP reasoned that during television viewing, parental attention would be directed to program content, thereby

directed at the adult viewers (e.g., Kirkorian & Anderson, this volume, Chapter 9; Vandewater, Bickham, & Lee, 2006). In the study by Vandewater and colleagues (2006), television viewing also was negatively related to creative play among children under age 5. No relationship was found between time spent watching television and time spent reading (or being read to) or time spent in active play (Vandewater, Bickham, & Lee, 2006).

Despite the AAP concerns, other research has indicated that there are beneficial effects of screen media that is specifically designed for children who are ages 2 years and older. For example, exposure to high-quality children's educational programs such as *Sesame Street* and *Mister Rogers' Neighborhood* during the preschool years has enhanced cognitive development, language development, and prosocial skills and has a long-lasting positive impact on school readiness and academic performance (Anderson et al., 2001). In light of mixed findings of both positive and negative impacts of media content on behavior, current data on attention and learning from television during early childhood will be reviewed and implications for the AAP recommendation will be discussed.

Attention

It has been difficult to find the most appropriate means to index and quantify attention during early childhood. On the one hand, eye movements are one of the most practiced motor behaviors of infancy and also, with regard to any other system, most closely approximate that of adults (Haith, Hazan, & Goodman, 1988). On the other hand, although researchers using this measure often assume that attention implies encoding, it cannot be directly known what information the infant is encoding in the course of a visual fixation or the rate at which the infant is encoding it.

Media researchers have therefore adopted a number of different measures of attention, examining overall looking time and patterns of looking time, as well as verbal and non-verbal imitative behavior, pointing, vocalizations, and physiological correlates of heart rate and event-related potentials that take place during viewing (Anderson et al., 2001; Barr & Hayne, 1999; Carver, Meltzoff, & Dawson, 2006; Crawley et al., 1999; Richards & Casey, 1992; Richards & Turner, 2001; Rolandelli et al., 1991). The use of a variety of methods has resulted in the emergence of converging data and provides a more precise index of information processing of media during early childhood.

Selective attention

The grammar and syntax or "representational codes" of television that are thought to guide infant and young children's attention to and information processing of television are called formal features (Calvert & Scott, 1989; Huston & Wright, 1983; Rice, Huston, & Wright, 1982; Schmitt, Anderson, & Collins, 1999).

Formal features are the auditory and visual production and editing techniques characterizing the medium, such as action, sound effects, and pacing (the rate of scene and character changes). Some features, such as sound effects and rapid action are perceptually salient and likely to elicit attention and interest, whereas other features such as dialogue are not salient but important in processing the narrative (Huston & Wright, 1983).

There are a number of salient formal features that consistently increase toddlers' and preschoolers' selective attention to television content. In particular, attention to televised content increases and remains high in the presence of female adults, character action, children, puppets, animation, active movement (including dancing and repetition), singing and lively music, peculiar voices, and sound effects (Anderson & Levin, 1976; Calvert et al., 1982; Huston & Wright, 1983; Schmitt et al., 1999). Attention decreases as the length of a segment increases, during low-action sequences, and during periods of adult narration or abstract adult dialogue (Anderson & Levin, 1976; Calvert et al., 1982; Huston & Wright, 1983; Schmitt et al., 1999). Research has also shown that formal visual effects such as cuts, zooms, and pans, known as montage, enhance the attention of preschoolers (Calvert et al., 1982; Schmitt et al., 1999; Smith, Anderson, & Fischer, 1985) but not as effectively as formal auditory features, including sound effects (Huston-Stein & Wright, 1979; Rice, Huston, & Wright, 1982).

Development of sustained attention to comprehensible media content

Studies examining children aged 2 months to 5 years (e.g., Alwitt et al., 1980; Crawley et al., 1999; Richards & Cronise, 2000; Richards & Gibson, 1997) and even adults (Anderson & Burns, 1991) show similar looking patterns, suggesting that an attentional mechanism for processing dynamic media content emerges very early in development. The looking patterns are characterized by large numbers of 2 to 3 second looks but fewer looks of longer duration (Richards & Anderson, 2004). Rapid looks toward and away from the screen indicate that participants are responding to the formal features. The looks that last longer than 15 seconds are termed *sustained attention*. During periods of sustained attention active cognitive processing of material is occurring. While looking patterns to media are similar across development, sustained attention to media increases systematically as a function of age (Anderson & Levin, 1976; Anderson et al., 1986; Lemish, 1987).

Measuring sustained attention Studies have demonstrated that during periods of sustained attention to television presentations, infants and toddlers are less distractible than they are during periods when attention is more variable (for review, see Lorch, 1994). Richards and Turner (2001), for example, showed 6- to 24-month-olds a *Sesame Street* movie. At random intervals, 5 second distracters of another *Sesame Street* movie were presented on a second television monitor.

looks. These findings imply that sustained attention involves focused information processing such that other stimuli are less likely to distract selective attention to media content. Sustained attention in turn allows the media content to be processed.

Sustained attention is typically accompanied by heart rate (HR) deceleration. Sustained lowered HR, in turn, is thought to allow for optimal and active information processing as HR variability, respiration, body movement, and distractibility decrease (Clifton & Nelson, 1976). During sustained attention, HR decelerates as the duration of the look continues and accelerates back to baseline levels immediately before the offset of the look (Richards & Cronise, 2000). In contrast, HR acceleration is thought to reflect a rejecting or defensive response (Clifton & Nelson, 1976). HR patterns have been used to index 2- to 24-month-olds sustained attention during media presentations and correlate strongly with looking patterns (Richards & Anderson, 2004).

Age-related changes in sustained attention Both the amount of sustained attention and when sustained attention is allocated changes as a function of age. The amount of sustained attention gradually increases during infancy (Richards & Gibson, 1997; Richards & Chronise, 2000) and continues to increase through the preschool years and into adulthood (Richards & Anderson, 2004).

Infants do not begin to discriminate between content until late in the first year of life. During the first year of life infants allocate the same amount of sustained attention to a comprehensible narrative sequence and to incomprehensible sequences of randomly generated patterns. In contrast, older 18- and 24-month-olds differentiate between comprehensible and incomprehensible sequences, allocating more sustained attention to comprehensible sequences (Richards & Chronise, 2000). Taken together, these findings indicate that information processing of media content changes gradually across infancy and toddlerhood because of an increasing ability to understand the content.

Processing two-dimensional stimuli during early childhood

Very early in development, both the auditory and the visual components of television are processed in a rudimentary way (see also Hollenbeck & Slaby, 1979; Lemish, 1987). Four-month-olds, for example, will preferentially attend to audiovisual tracks where the speech matches the visual track over comparable mismatched auditory and visual tracks (Kuhl & Meltzoff, 1982).

Processing of televised information is, however, cognitively demanding. Recently researchers using event-related potentials (ERPs), that provide a precise measure of the speed of processing of information, have shown that 18-month-old infants require more time to process two-dimensional (2D) images than they require to process real three-dimensional (3D) objects. To document

this, Carver, Meltzoff, and Dawson (2006) paired the infants' favorite familiar toy with an unfamiliar toy matched on shape, color, and size. For the 3D condition, toys were placed in a display box. For the 2D condition, digital photos of the familiar and unfamiliar toys were presented on a computer monitor. Although ERPs showed that 18-month-olds differentiated between familiar and novel toys in both the 2D and 3D conditions, toddlers were much slower at differentiating the 2D pictures of novel and familiar objects than the real 3D objects.

The relationship between attention, media content, and comprehension

Both overall duration of looking and looking at specific times predict children's comprehension of content during early childhood. Perceptually salient production techniques such as sound effects can facilitate attention to specific program points, thereby increasing young children's processing of the content that immediately follows that feature (Calvert et al., 1982; Rice, Huston, & Wright, 1982). The sound effect initially creates an attentional orienting response, which later becomes a learned signal or marker that important content will follow, thereby disrupting any habituation process (Calvert et al., 1982). Through this process, children learn to use sound effects as guides for their selective attention to important plot-relevant content.

The comprehensibility of the content also leads to increased attentional interest by young children (Anderson et al., 1981; Field & Anderson, 1985; Lorch, Anderson, & Levin, 1979; Lorch & Castle, 1997). Anderson and colleagues (1981), for example, found that 3- and 5-year-olds attended significantly more to the correctly sequenced version of a *Sesame Street* episode than to any distorted versions, such as foreign or backwards dialogue or randomly ordered shots. Using the same kind of methodology, Anderson and colleagues presented 6- to 24-month-olds with either correct or distorted versions of *Teletubbies*, a program that is designed for 1-year-olds (Anderson & Pempek, 2005; Kirkorian et al., 2005). The 18- and 24-month-olds paid significantly less attention to the distorted sequences of the program (either random sequence or backwards dialogue) than the correctly sequenced program. However, the 6- and 12-month-olds in the study paid equal amounts of attention to the correct and distorted versions of the program. These findings suggest that children begin to understand very simple television programs sometime between 12 and 18 months of age.

Repeated presentations of the same television program also help to maintain attention, in part because comprehension increases across exposures until it finally reaches ceiling levels (Anderson & Levin, 1976; Anderson et al., 1981; Barr et al., 2007; Crawley et al., 1999). Crawley and colleagues (1999), for example, showed 3-, 4-, and 5-year-olds an episode of *Blues Clues*, once per day for five days. Although there were significant age-related differences in comprehension scores, comprehension at all ages increased with repeated exposure to the program.

verbal and non-verbal imitative behavior, pointing, and vocalizations during viewing have all been associated with increased comprehension. For example, levels of verbal responding increased across five successive exposures to an episode of *Blues Clues* (Crawley et al., 1999).

Individual differences in attention to media Habituation is the ability to attenuate looking at familiar stimuli after repeated presentations. It is thought to reflect the speed of encoding; the more rapidly habituation occurs, the more rapidly the information is processed (Thompson & Spencer, 1966). Individual differences in infants' visual attention during habituation studies are reliable; for instance, infants with shorter looking times typically habituate faster than infants with longer looking times and subsequently have higher IQs (e.g., Colombo et al., 1991).

Similarly, during the processing of dynamic media, there are individual differences in discriminating non-meaningful screensavers and more meaningful content (Courage, Reynolds, & Richards, 2006; Richards & Casey, 1992). For example, Courage and colleagues (2006) measured HR variability and looking time to complex stimuli (faces and Sesame Street vignettes) and simple stimuli (geometric patterns) in 3- to 12-month-olds. HR variability reflects the ability to rapidly adapt to and process novel information and higher HR variability is associated with higher IQ. Older infants with higher HR variability were increasingly likely to attend to more complex stimuli and less to random geometric patterns. That is, infants who are better information processors are faster at deriving meaningful content from media.

Attention seems to be consistent across various tasks, including television viewing. Ruff, Capozzoli, and Weissberg (1998), for instance, observed 2.5-, 3.5-, and 4.5-year-old children as they viewed television, played with toys, and participated in structured repetitive tasks. Those children who were classified as attentive demonstrated that same pattern across all tasks. Thus, attentional patterns seem to be an individual style that children bring to many different tasks, and television viewing is subject to that same general style.

Role of co-viewing Attention to television also reflects joint attention patterns between the child and the parent (for review, see Butterworth, 2001), which provide a platform for learning. Both book-reading and television studies have shown differences in the ways that parents provide scaffolds, i.e., links between what the child knows and the content to be learned (Barr et al., in press; DeLoache & DeMendoza, 1987; Fletcher & Reese, 2005; Lemish & Rice, 1986).

In a recent semi-naturalistic study conducted in infants' homes, we examined 120 parents' and their 12-, 15-, or 18-month-olds' viewing of one of two popular infant-directed programs, *Baby Mozart* and *Kids Favorite Songs 2* (Barr et al., in press). Half of the infants in our sample had prior exposure to the video content, half did not. Infants who had previously seen the content looked for

significantly longer periods of time. Infant's looking times and interactions were also influenced by parental scaffolding. In particular, the more questions, descriptions, and labels about program content that parents provided, the more infants looked at and interacted with the infant-directed program content. These findings suggest that both prior experience and parent-child interactions during early viewing experiences influence how well the infant will understand the content.

The role of background television Children are often inadvertently exposed to programming designed for adults simply because they are in a particular room when the television is on. This "background television" is typically incomprehensible to younger ages (Anderson & Pempek, 2005). Because play is critical for subsequent social and cognitive development (Singer & Singer, this volume, Chapter 13), Evans-Schmidt, Pempek, Kirkorian, Frankenfield, and Anderson (submitted) have recently examined the impact of background television on children's play behavior. Children aged 1, 2, and 3 years were observed during a 1 hour play session in a laboratory playroom. For 30 minutes an adult television show played in the background; for the other half of the time, no television show played. Although parents were in the room, they were asked to complete study forms and to limit interaction with their children. Children only attended to the background television 5 percent of the time, but play episodes were shorter, less complex, and included less focused attention than when the television was not on.

Subsequently, Kirkorian and colleagues (2005) conducted the same experiment but asked parents to interact with their children. Parents engaged in significantly less toy play, and were less actively involved with their young children when the adult television program was on than when it was off. Overall, the authors argue that background television may be acting as a distracter and may have long-term negative consequences for social and cognitive development. Specifically, it may interfere with learning on two fronts: by decreasing parent-child interaction and by disrupting the focus on play via incidental sounds that attract infant attention to the television. Reorienting to play is difficult, and it is more difficult because there is no parental support to do so.

Summary and theoretical implications Overall, studies of attentional processing of television during early childhood have demonstrated a number of important principles. First, the similarity of looking patterns of 2- to 24-month-olds suggests that an attentional mechanism for processing 2D dynamic stimuli emerges very early in development. Second, processing of televised information is cognitively demanding. Physiological measures indicate that sustained attention increases across infancy, and that infants require additional time to process 2D images relative to processing real 3D objects. Third, although the underlying

during viewing. When parents and their young children attend to the television together and parents make direct reference to the television content, looking time increases. Similarly, when adult-directed television is on in the background, parents interact less with their young children and do not actively engage their babies and toddlers with program content, and thus looking time decreases.

There are competing theories of the development of attention to television during early childhood. Aspects of each of these theories account for some but not all of the findings described above. According to the comprehensibility theory, attention to media is guided by the comprehensibility of the content and by similar principles to those that guide selective attention more generally. Consistent with this theory, comprehensibility begins to guide attention to media during early infancy and attentional mechanisms, such as sustained attention, develop gradually across early childhood (Richards & Anderson, 2004).

As proposed in the "sampling model of attention," toddlers and preschoolers begin to decide when to view and when to play with toys based on their knowledge of formal features (Huston & Wright, 1983). That is, attention can be divided between toy play and television viewing because children learn that formal features signal and mark specific media content. There is also a developmental component to this theory. In terms of television specific features, attention to television is initially directed by perceptually driven processes, but with development and experience, children come to learn that different perceptually salient features serve to mark content for further processing as well as provide visual and verbal modes that children can use to represent content (Anderson et al., 1981; Calvert et al., 1982; Huston & Wright, 1983).

Mediation of viewing by adults is a third perspective that influences attention and learning. According to Vygotskian theory, all cognitive functions develop through social experiences (Vygotsky, 1978). Specifically, once a child has mastered a skill in a supportive social context, the skill will be internalized which enables the child to apply this skill in new contexts. Consistent with Vygotskian theory, parents mediate looking patterns toward television stimuli during infancy, either positively by directing their child's attention to programs made for babies during co-viewing, or negatively by reducing interaction patterns with their infant when absorbed in watching an adult program (Barr et al., in press).

The theories share two important principles: (1) that attention to media content follows a gradual developmental trajectory, and (2) that attention is mediated. The theories differ, however, in the ways in which attention is mediated. Based on the current literature, a comprehensive theory of the development of attention to 2D dynamic stimuli during early childhood will have to consider how the processes interact. In particular, a comprehensive theory must take into consideration features unique to television, the content of the program, and the role of parent mediation.

Imitation

Historically, researchers chose imitation to investigate the potential impact of television exposure. At the time, policy makers were concerned about the impact of violent media content on children's aggressive behavior outside of the media context. As such, imitation provided a direct measure of information transfer from the media context to the real world (Bandura, 1965; Bandura, Ross, & Ross, 1963). While the initial focus was on the imitation of aggressive actions (for review, see Paik & Comstock, 1994), subsequent research focused on imitation of prosocial behavior (Stein & Friedrich, 1972).

The fact that imitation paradigms are non-verbal, a characteristic of very early development, allows researchers to directly examine learning from media by the youngest audiences. For these reasons, the ability of infants and toddlers to learn from televised presentations has also been examined using imitation paradigms (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003; Huang & Charman, 2005; Hudson & Sheffield, 1999; McCall, Parke, & Kavanaugh, 1977; Meltzoff, 1988).

Imitation paradigms allow the manipulation of a number of important media variables. First, people do not typically encounter actual television actors. In imitation studies, this can be simulated by having one experimenter demonstrate the target actions on television and another experimenter interact with the child in the real world. Second, infants would only infrequently have immediate access to what they see on television. To more closely simulate these real-world conditions, researchers therefore use a deferred imitation procedure. The experimenter demonstrates the target actions on television, and infants are tested after a delay. From a theoretical perspective, deferred imitation from television is a complex representational task (e.g., Barr & Hayne, 2000; Meltzoff, 1988). Successful completion of the imitation task from a videotaped model requires participants to form a memory of the event on television, and, only after a delay, participants must transfer that memory to 3D objects in the real world and reproduce the target actions. That is, examining deferred imitation from television also examines memory development, a key component of cognitive development.

Studies have shown that infants as young as 6 months can imitate limited actions demonstrated by videotaped models after a 24-hour delay (Barr, Garcia, & Muentener, in press). A videotaped demonstration has also been shown to be an effective reminder for 18-month-olds for events they learned 10 weeks earlier. In a study by Hudson and Sheffield (1999), infants learned 6 or 8 novel event sequences in a laboratory playroom. After a 10-week delay, 18-month-olds were presented with a videotaped demonstration of the activities that they had previously learned. Infants who watched the video performed significantly more target actions than did infants who did not see the video.

Infants learn better from a live adult than they do from a video presentation, a phenomenon known as the video deficit effect (Anderson & Pempek, 2005; Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003; Hudson & Sheffield, 1999). In Barr and Hayne (1999), for example, infants were shown a demonstration either live or on video. On one imitation task the 12-, 15-, and 18-month-olds imitated the live model after a 24-hour delay. In contrast, only 18-month-olds imitated the televised model, and their performance was inferior to that of the group who had seen the live model. On a different imitation task, 15-, 18-, 24-, and 30-month-old infants who saw a video model imitated significantly fewer actions than did infants who saw a live model when tested either immediately or after a 24-hour delay (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003). Imitation tasks reveal evidence of the video deficit until children are 3 years of age (Hayne, Herbert, & Simcock, 2003; Hudson & Sheffield, 1999; McCall, Parke, & Kavanaugh, 1977).

The *video deficit effect* is not task specific. The video deficit effect is also seen during emotion processing tasks. In a study by Mumme and Fernald (2003), infants were given unfamiliar objects (e.g., plastic valve) to explore. Next, they watched a videotape in which an actor responded in either a positive or negative manner to each of these objects. When given a second opportunity to play with the object, 12-month-olds avoided the object if they had seen the televised adult react negatively, and they showed increased exploration if they had seen the televised adult react positively. In contrast, 10-month-olds' behavior showed no impact of the televised adult's emotional reaction. The authors concluded that babies as young as 12 months old are capable of responding to emotional cues shown on television but 10-month-olds are not. It is important to note that 10-months-olds can use emotional cues from analogous live demonstrations.

The video deficit is also exhibited when children search for objects (Deocampo & Hudson, 2005; Schmitt & Anderson, 2002; Troseth, 2003; Troseth & DeLoache, 1998; Troseth, Pierroutsakos, & Deloache, 2004). Using a standardized paradigm, children are given an extensive orientation where they are shown the correspondence between a video representation of a room and an actual room. Then the experimenter goes into the room and hides a toy. The child views the toy being hidden on a television monitor in an adjacent room. Immediately after the toy is hidden, the child goes into the room and is asked to retrieve the hidden toy. Two-year-olds are unable to find the hidden toy, but 2.5-year-olds are successful (Troseth & DeLoache, 1998).

One explanation for these findings is that the sheer magnitude of change in size between the television monitor and the room where the object was hidden as well as the change in dimension from a 2D screen to a 3D real-world experience might be causing the poor performance. To test this hypothesis, Evans, Crawley,

and Anderson (submitted) built a felt-board that was the same size as the television screen. Two-year-olds saw either a live model hide a sticker behind a felt object on the felt-board or saw a video model hide the same object on a television screen. Toddlers who viewed the live model found the sticker behind the felt object, but toddlers who saw the video model did not find the sticker.

Overall, the video deficit effect is exhibited across multiple different experimental paradigms by infants ranging from one year to three years of age. The ability of infants and toddlers to learn from media is reduced by the video deficit. Recently, however, researchers have investigated whether the video deficit effect can be ameliorated, and in so doing have uncovered potential mechanisms to explain the effect.

Reducing memory demands

Infants often see material repeatedly because of television programming content and video technology. Indeed, parents report that preschoolers frequently ask to view the same program repeatedly (Mares, 1998). Because comprehension of television content is cognitively demanding during early childhood, repetition allows for additional processing time which enhances comprehension of material. More specifically, repeated presentation of the same television episode maintains attention and increases comprehension of television content by preschoolers (Abelman, 1990; Anderson et al., 1981; Crawley et al., 1999; Sell, Ray, & Lovelace, 1995). For this reason, the same episodes of programs such as *Blues Clues* are aired multiple times per week.

Similar beneficial effects of repetition take place for infants. For example, vocabulary gains occur when infants repeatedly viewed *Sesame Street* videos or educational DVDs, but not when they viewed television programs only once (Linebarger, 2005). Barr and her colleagues (2007) found that repetition enhanced deferred imitation for 12- to 21-month-olds. In this study, infants exhibited the same level of deferred imitation after observing a live and a televised model if the number of demonstrations of the target actions presented on television was doubled. If the number of demonstrations of the target actions presented on video was not doubled, however, 21-month-olds continued to exhibit a video deficit effect (Barr et al., 2007).

When memory demands are decreased, 2-year-olds are also often successful in searching for objects. For example, if 2-year-olds thought that they were viewing the event through a window rather than on a television screen, the cognitive demands of transferring information from a 2D image to a 3D object were reduced and they were able to find a hidden toy (Troseth & DeLoache, 1998). If given extensive experience of seeing themselves on television, toddlers were able to find a hidden toy; presumably seeing themselves on a screen increased their understanding

ing location, but when they return to the room they perseverate and look again in the original hiding place because the memory representation formed from finding a real object is stronger than that formed when viewing a 2D hiding demonstration. They fail to update their memory representations. Suddendorf (2003) tested this working memory hypothesis. He predicted that if the memory demands were reduced such that memory updating was not necessary, then 2-year-olds would be able to find a toy after viewing it hidden on television. Consistent with his hypothesis, performance remained high if toddlers were tested in four different rooms rather than being tested repeatedly in the same room (Suddendorf, 2003).

Formal features

During early childhood, attention increases in the presence of a perceptually salient formal feature such as a sound effect because it elicits a primitive orienting response, thereby improving comprehension of contiguously presented content (Calvert, et al., 1982; Huston & Wright, 1983). Such formal features could be used to provide an entry point for very young children's viewing. That is, features like sound effects could be used to assist very young children's attention to, and imitation of, targeted content.

Initial studies of imitation from television (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003; Hudson & Sheffield, 1999; McCall, Parke, & Kavanaugh, 1977; Meltzoff, 1988) failed to incorporate common attention-capturing features into their televised segments. Recently, however, Somanader, Garcia, Miller, and Barr (2005) examined whether adding sound effects would enhance imitation from television by 6- and 12-month-old infants. Infants were assigned to one of three conditions: matched sound effects (salient sound effects timed to each target action), mismatched sound effects (deliberately mismatched to the target actions), or no salient formal features. We hypothesized that infants may initially orient to salient formal features but with experience may learn to use these features as markers of important content (Calvert et al., 1982; Huston & Wright, 1983). Consistent with this prediction, young 6-month-olds exhibited deferred imitation of the target actions regardless of whether the sound effects were matched or mismatched to the target actions. In contrast, 1-year-olds imitated target actions from television when the sound effects were matched to the target actions but performed at baseline when the target actions and sound effects were deliberately out of synch with the target actions. That is, mismatching sound effects that commonly convey informational content interfered with performance by 12-month-olds, presumably because they expected the sound to match up with an important visual event; such expectations did not seem to exist for the younger 6-month-old infants. There are a number of formal features, including zooms, cuts, music, and pacing, that are part of infant-directed programming that have received no empirical research at this point.

Social contingency

During live interactions, social partners engage in contingent ongoing behaviors with one another. For example, when one partner asks a question, he/she pauses and waits until the other social partner responds. It has been argued that the lack of such social contingency is the critical factor missing from televised information. Consistent with that argument, research with older toddlers and preschoolers has demonstrated that the lack of contingency and control reduces interactivity and comprehension of video material (Calvert, Strong, & Gallagher, 2005; Crawley et al., 1999; Troseth, 2003; Troseth, Saylor, & Archer, 2006).

Troseth and colleagues (2006) hypothesized that increasing social contingency would improve learning from television. Toddlers in a contingent condition interacted with an experimenter across a close-circuit television screen for 5 minutes. At the end of the interaction, the experimenter told children where they could find the hidden toy in the room next door and asked them to go and find it. Toddlers in the non-contingent control group watched pre-taped social interactions that were not contingent upon their behavior. The 2-year-olds who received contingent feedback were significantly more likely to find the hidden toy than were the toddlers who had seen a pre-taped non-contingent interaction. Troseth, Saylor, and Archer (2006) concluded that during the second year of life, toddlers increasingly expect to obtain relevant information from a contingent social partner. Lack of contingency during the televised demonstration disrupts the transfer of information from television to real-life activities.

Language: grammar and vocabulary

Live social interaction is necessary for processing complex grammatical structures of a language (Kuhl, Tsao, & Liu, 2003; Naigles & Mayeux, 2001). Kuhl and colleagues (2003) tested 9-month-olds for learning of a phonetic discrimination present only in Mandarin after the infants had interacted with a native Mandarin speaker for a total of 4 hours over 12 sessions. Typically native English speakers at 9 months of age and even as adults cannot make the distinction between the two sounds, but native Mandarin speakers at both ages can. After brief exposure to live interactions, the 9-month-olds were able to make the distinction, but if the information was presented on television, they were not.

Vocabulary learning is also more effective from a live interaction than from a video demonstration for 15- to 24-month-olds (Grela, Krcmar, & Lin, 2004). Other language studies have indicated, however, that vocabulary learning can be facilitated by specific content during infancy and preschool (Barr, 2006; Linebarger & Walker, 2005; Rice et al., 1990). Linebarger and Walker (2005) followed infants longitudinally from 6 to 30 months and recorded television

presented on television or if they were presented by parents. Two-year-olds were randomly assigned to a voiceover video group, a parent-mediated video group, a parent-mediated live group, or a baseline condition. Infants in all three experimental conditions imitated significantly more target actions than did those in the baseline control condition and there were no differences between the experimental conditions. That is, 2-year-olds were able to apply novel labels regardless of whether the television or a parent provided the label. Whether such labeling is similarly effective at younger ages is not known (Hayne & Herbert, 2004).

Theoretical explanations

There are two primary, but not mutually exclusive, theories to account for the video deficit effect. The first is termed the perceptual impoverishment hypothesis, and the second is the dual representation hypothesis. The perceptual impoverishment hypothesis accounts for the video deficit in the following way: because the 2D perceptual input is impoverished relative to a real 3D presentation, learning is impaired (Barr & Hayne, 1999; Schmitt & Anderson, 2002; Suddendorf, 2003). Johnson (e.g., Johnson & Aslin, 1996; Johnson, 1997) has proposed that the perceptual system requires a minimum amount of information for perception regardless of its source (e.g., 2D or 3D stimuli). Studies using 2D stimuli have demonstrated that younger infants require information from more sources to form an object percept than older infants do (Johnson, 1997, 2000). Similarly, a 2D presentation may not match its 3D counterpart until a sufficient number of attributes are available to match from 2D to 3D (see Smith, 2000, for a similar argument regarding language acquisition).

Data collected from imitation studies is consistent with the perceptual impoverishment hypothesis. Between 1 and 2.5 years of age, infants exhibit a video deficit effect, but by 3 years it disappears. Furthermore, some situations can increase performance; these include additional information provided by repetition (Barr et al., 2007), the signaling of crucial information through formal features (Somander et al., 2005), a change in rooms to reduce memory load (Suddendorf, 2003), the inclusion of social contingency (Troseth, Saylor, & Archer, 2006) and the addition of language cues (Barr, 2006).

According to the dual representation hypothesis, the video deficit effect may be due to an emerging ability to use symbols and to treat televised images differently than real objects (Barr & Hayne, 1999; DeLoache, 1995; Pierroutsakos & Troseth, 2003; Troseth, Pierroutsakos, & DeLoache, 2004). DeLoache and colleagues have investigated children's ability to perceive and understand the nature of pictures (both moving and static images) and to act upon that knowledge by exploring infants' manual responses to 2D images (for review, see Troseth, Pierroutsakos, & DeLoache, 2004). Pierroutsakos and Troseth (2003) found that 9-month-olds treated the high-resolution video images as if they were real

objects, manually exploring the toys presented on video, rubbing them and attempting to pick them up. By 19 months of age, the reaching behavior had been replaced by pointing; 15-month-olds were intermediate between the two.

DeLoache and colleagues argue that the change between 9- and 19-months is due to experience exploring 2D and 3D objects. Beginning around 5 months of age, when reaching develops and independent manual exploration begins, infants treat images and objects in very similar ways, attempting to explore both as physical objects to determine their properties. Over time, infants come to recognize the different functional properties of 2D and 3D objects. For example, a ball can bounce but a picture of a ball does not. Based on this acquired knowledge, 1- to 2.5-year-olds fail to use 2D information presented by the image to inform behavior in the 3D world. In other words, children learn to disregard the possible informational content of pictures and television. Some time during the third year of life, children master dual representation and can understand that a picture provides meaningful information that can be acted upon in the real world. The video deficit effect disappears. At this stage, children can represent the image of the picture both as an object and as a symbol for the real object and thus transfer of information can occur.

Taken together, these findings suggest that understanding the symbolic nature of media develops slowly across early childhood. Clearly perceptual processing and memory demands, as well as social contingency and symbolic processing limitations, contribute to reduced ability to learn from television during early childhood. Neither perceptual impoverishment theory nor dual representation theory accounts for all the current findings, suggesting a need for the integration of the two major competing theories.

Conclusions and Implications: The AAP Recommendation

The long-term effects of early media exposure on social and cognitive development are largely unknown. Although the American Academy of Pediatrics recommended that infants and toddlers have limited exposure to television, the amount of programming targeted to very young children has increased dramatically, and television exposure during infancy has increased accordingly. As parents are being told to avoid exposing their infants to screen media, they may also feel pressures to ensure that their children are media literate.

The negative effects of background television exposure on play and the fact that infants learn less from television than from live demonstrations underscore the limitations on what infants can gain from media exposure. Even so, the fact that repeated exposure to televised segments enhances imitation and language

children under 2 remains premature. Yet there is no doubt that infant development now occurs, in part, in the company of screen media. The types of early screen exposure that are potentially beneficial or harmful remain important questions to be unraveled by future research.

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