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On-screen print: the role of captions as a supplemental literacy tool

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Children living in poverty are 1.3 times as likely as non-poor children to experience reading difficulties and lack key oral experiences that contribute to early literacy development. The purpose of this research was to study the effects of viewing commercially available educational television with closed captions. Seventy second- and third-grade economically disadvantaged children living in urban locations participated in this experimental research design. Children were randomly assigned to view videos with or without closed captions. Captions helped children recognise and read more words, identify the meaning of those words, generate inferences regarding programme content and transfer these skills to a normative code-related skill task. Risk status moderated word recognition performance: those at risk benefited from captions while those who were not at risk recognised more words when captions were absent.

The majority of children identified with learning disabilities have difficulties learning to read (Snow et al., 1998). At the fourth grade level, a higher percentage of Asian/Pacific Islander (i.e. 42%) and European American students (i.e. 41%) scored at or above *Proficient* on the National Assessment of Educational Progress reading assessment when compared with their American Indian/Alaska Native (i.e. 18%), Hispanic (i.e. 16%) and African American (i.e. 13%) peers (Lee, Grigg & Donahue, 2007). Moreover, children living in poverty are 1.3 times as likely as non-poor children to experience learning disabilities and developmental delays (Brooks-Gunn & Duncan, 1997). Poor children often have multiple risk factors that contribute to reading difficulties, most importantly, lack of appropriate home literacy experiences (i.e. opportunities for verbal interactions, storytelling and early book reading; Feitelson & Goldstein, 1986; Harris & Smith, 1987; Snow et al., 1998). In addition, children who come from non-English-speaking homes often with limited English proficiency are also at a disadvantage in learning to read English. Both children who are poor and children who are English language learners may also have poorly educated parents, little income, live in neighbourhoods where most families share similar characteristics and attend schools where the student body is

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predominantly low achieving (Brooks-Gunn & Duncan, 1997; Snow et al., 1998), placing them at greater risk for later reading difficulties. By virtue of these characteristics, poor children and children with limited English proficiency are more likely to experience reading failure and to be identified to receive special education services.

While it has been well documented that poor families lack educational resources at home (e.g. books and stimulating toys and materials; Zill, Moore, Smith, Stief & Coiro, 1995), over 98% of US homes have televisions (*Statistical Abstracts*, 2007) and 92% of these homes also have video cassette recorders or DVD players (*Statistical Abstracts*, 2007). Children whose parents have less than or equivalent to a high school diploma watch significantly more television than children whose parents have some college[1] (Roberts, Foehr & Rideout, 2005), spend less time with print materials than children in families where parents have more education (i.e. 36 vs 45 minutes) and perform better on early literacy tasks when they have a television in their bedroom (Linebarger & Wainwright, 2007). Given the extensive availability of this resource, one must ask how can it be harnessed to increase the number of home literacy experiences and, thereby, at-risk children's literacy outcomes?

Models of learning from television

Dual coding theory. Media stimuli are complementary, and, as such, the multiple modalities used in presenting these stimuli strengthen children's encoding and subsequent storage and retrieval of specific media content (Linebarger, 2001; Mayer & Anderson, 1991; Najjar, 1995; Neuman, 1995; Paivio & Csapo, 1973). When duplicative information is simultaneously presented via two modalities (i.e. audio and visual content), it can enhance young children's understanding of programme content by serving to increase the number of cognitive paths that can be followed to retrieve the information (Najjar, 1995; Paivio, 1975), leading to increased learning (e.g. Linebarger, Kosanic, Greenwood & Doku, 2004; Neuman, 1995). However, if information across modalities is dissimilar, then young children will engage in one of two behaviours: (1) switch between the two streams of information with subsequent reductions in acquisition of content in both modalities; or (2) choose one modality at the expense of the other. When programme content across modalities is dissimilar, young children tend to default to (i.e. recall more content) the visual channel of information at the expense of the auditory track, leading researchers to argue that young children privilege the visual domain (i.e. the visual superiority effect; Nelson, Reed & Walling, 1976; Paivio, Rogers & Smythe, 1968; Whitehouse, Maybery & Durkin, 2006). Without a formal content analysis, it is difficult to say exactly how much educational television content across audio and visual tracks is redundant. However, studies suggest that young children do not suffer comprehension decrements when content is presented both aurally and visually.

Travelling lens theory. As with print media, acquiring information from television is a complex process that involves both attention to and comprehension of programme stimuli. When interacting with televised stimuli, children must attend to important or interesting aspects of programme content as well as integrate this content into meaningful, comprehensible bits of information (Huston & Wright, 1989). Children develop cognitive skills to process information in one medium (e.g. television) and are able to use these skills when processing content found in other media forms (e.g. books; Linebarger, 2006; Neuman, 1995). Recently, researchers (e.g. Kendeou

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et al., 2005; Linebarger & Piotrowski, 2009) have begun to examine how skills developed in one medium transfer to and support processing in other media. For example, research has shown that comprehension of televised stories at age 6 predicts comprehension of print stories at age 8 (Kendeou et al., 2005). Similarly, television narratives have been found to support the development of preschoolers' story skills and subsequently aid in picture-book comprehension (Linebarger & Piotrowski, 2009).

Anderson and his colleagues (e.g. Anderson & Lorch, 1983; Anderson, Lorch, Field & Sanders, 1981) conducted a series of studies to understand how young children's attention is elicited during television viewing. The work resulted in a model of attention in which comprehension of the televised messages drives further attention. Huston and Wright (Huston & Wright, 1989; Rice, Huston & Wright, 1982) elaborated this model of attention, arguing that a child's attentional decisions when viewing a television programme are a function of stimulus features (i.e. formal features such as sounds and unusual visual effects; Calvert, Huston & Wright, 1987; Campbell, Wright & Huston, 1987); comprehensibility of the content; and viewer disposition (Huston and Wright labelled the model the 'travelling lens'). The model predicts that stimuli perceived as 'moderately novel, of intermediate complexity, integratable, somewhat regular, partially ordered, and recognizable' (Huston & Wright, 1989, p. 117) should elicit the greatest amounts of interest and attention. Similarly, familiarity and habituation as well as perceived incomprehensibility should lead to low interest and attention. With age and viewing experience, children will continually move towards more cognitively challenging television stimuli. Thus, those stimuli that were once considered incomprehensible will eventually move into the child's 'focal lens of maximum interest ... before they are habituated and become old hat' (Huston & Wright, 1989, p. 118).

Application to literacy

Dual coding theory and the 'travelling lens' model predict that children with few print experiences and poor reading skills may find on-screen print overly challenging and thus not attend to it, whereas fluent readers may ignore on-screen print because they have habituated to it (Linebarger et al., 2004). Although it is possible that through repetition poor readers will gain enough familiarity with on-screen print to benefit from such exposure (i.e. the combination of print and television provides an opportunity for media synergy to occur), initially such benefits are unlikely. Similarly, fluent readers are unlikely to experience much benefit from on-screen print as they are already progressing on a positive literacy trajectory. It is the group in the middle, emerging readers who are not yet fluent, who should evidence the greatest literacy gains from exposure to on-screen print because the content will be perceived as both interesting and cognitively challenging and thus within their 'travelling lens' (Huston & Wright, 1989; Linebarger et al., 2004). There is preliminary evidence supporting these predictions; emerging readers were found to benefit the most from on-screen print when compared with both poor readers and fluent readers (Linebarger et al., 2004).

On-screen print

Televised on-screen print can take different forms including: (1) print placed on-screen as part of a curriculum strategy in educational television (e.g. *Between the Lions*); (2) captions; and (3) subtitling. Captioning and subtitling are superficially similar in that both add words to a picture. Captions are intended for deaf or hard-of-hearing viewers, are

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usually broadcast in closed form (i.e. to see the captions, a viewer needs to activate the closed caption option found in the television menu) and match the language featured in the audio. Captions are usually placed in different areas of the screen to reflect the position of the speaker and they use symbols that indicate the presence of sound effects (e.g. ♫). Subtitles are meant for hearing viewers; are usually positioned in the bottom centre of the screen; are 'open' (always visible to all viewers); ignore sound effects; and are a translation of the audio using a different language. Although the two terms are used interchangeably in the United Kingdom, the present study, conducted in the United States, is based on captions as defined above.

Impact of captions on word recognition abilities

When visible on-screen, captions provide an opportunity for children to read while they view their favourite programmes. While viewing, children see words combined with visual information and hear accompanying audio content that can help them match the printed word form to its on-screen aural and visual referent. Koskinen and her colleagues (Koskinen, Bowen, Gambrell, Jensema & Kane, 1997; Koskinen, Wilson, Gambrell & Jensema, 1986; Neuman & Koskinen, 1992) proposed that adding captions to programmes children already watch may subtly influence children's knowledge and understanding of print. In a longitudinal study of continuous caption use in the home, children who viewed with captions scored significantly higher on normative tests of word identification and passage comprehension when compared with non-caption viewers (Koskinen et al., 1997). Linebarger (2001), using carefully controlled scripts written at a reading level below the average child in the study (i.e. first-grade level), found that second-grade children who viewed short clips with verbatim captions read words found in the scripts more accurately when compared with children who viewed the same clips without captions. In that study, the verbal narration was slower than verbal narration typically found in commercial educational programming (i.e. 90 words per minute [wpm] compared with a more typical 122 wpm in commercial educational programming; Jensema, McCann & Ramsey, 1996). A number of other studies examined whether educational television that uses on-screen print as part of a larger curricular strategy (e.g. *Between the Lions*; not captions) could help children develop literacy skills. In these studies, literacy skills' improvements were found for children in preschool through third grade (Linebarger et al., 2004; Linebarger & Wainwright, 2007; Prince, Grace, Linebarger, Atkinson & Huffman, 2002; Uchikoshi, 2006). These studies suggest that educational programmes with captions will support children's recognition of words used in these programmes.

Impact of closed captions on comprehension abilities

To comprehend televised texts effectively, children need to allocate a portion of their cognitive capacity to actively distinguish, review and, in some cases, construct the organising features (Baker & Brown, 1984). Shea (2000) argued that presenting content via two modalities (i.e. aural and visual) helps children comprehend that content. Adding a third modality (i.e. print), if it reinforces content found in the first two domains, has the potential to further enhance comprehension. Alternatively, this additional content may overwhelm children's cognitive capacities, resulting in comprehension decrements. Whether the third modality enhances or overwhelms cognitive processing depends on the viewer, the viewer's current skill set (e.g. can the viewer read and decode words?) and general cognitive capacity available to simultaneously process this third stream of stimuli

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as well as the nature of the tasks to be completed after viewing. Moreover, programme comprehension requires that children retain relevant programme content (e.g. plot, setting, characters, actions, goals) across programme segments, a skill significantly more challenging than matching print with aural and visual stimuli.

In earlier research, the presence of on-screen print was associated with reductions in young children's comprehension of the televised content (Linebarger, 2001). Identifying literal story elements involves summarising crucial story events as they occurred in a televised text (i.e. when 'X' happened, what happened next) while distinguishing inferential story elements involves identifying the organising features or main idea of the story. Both types of comprehension are challenging for young children in traditional contexts (i.e. book reading). Inferential identification usually appears in the upper elementary grades (Baker & Brown, 1984; Ezell, Kohler, Jarzynka & Strain, 1992). Linebarger (2001) hypothesised that, because children were still struggling with the mechanics of reading (i.e. they were beginning readers), the on-screen print demanded and captured their attention, causing them to shift back and forth between the storyline and the captioned text. Only one task could be done efficiently at a time leaving children with fewer cognitive resources available to process the meaning of the text both at a literal and an inferential level. Evidence that comprehension improves in the presence of closed captions exists for children who are proficient readers (Griffin & Dumestre, 1993). The research evidence suggests that children who view educational television without captions will outperform their caption-viewing peers on comprehension tasks.

Impact of captions on phonological and phonemic awareness

Code-related literacy skills (i.e. phonological awareness, phonemic awareness) have been linked to vocabulary size, narrative skill and print knowledge both in print contexts (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg & Poe, 2003) and televised contexts (Linebarger & Piotrowski, 2006). The relationship between code-related literacy skills and vocabulary is derived from the development of children's phonemic awareness. That is, as children add more word forms to their lexicon, greater sensitivity to the subtle phonemic variations in word forms (e.g. map vs mop) and how these variations are related to different semantic representations is needed (Ouellette, 2006). As such, code-related skills can be enhanced indirectly via contributions to general vocabulary knowledge. Captions also directly impact code skills by providing the child with the opportunity to see the printed form of a word, hear the aural representation and contextualise the meaning of the word based on its televised representation (Sadoski & Paivio, 2001). These effects should be strengthened with increased exposure. Furthermore, children who most benefit tend to be those with various risk factors and, subsequently, difficulty acquiring literacy skills (Anderson, Huston, Schmitt, Linebarger & Wright, 2001; Kulik & Kulik, 1991; Linebarger et al., 2004). Thus, viewing educational television with captions should support children's phonological and phonemic awareness skills.

In summary, viewing television programmes with on-screen captions offers a supplemental literacy tool that is both feasible and scalable. There is limited research on the use of captions with beginning readers, particularly using commercially available educational programming. The Linebarger (2001) study used carefully developed scripts written at a first-grade level with more difficult words inserted. The current study represents an important contribution to the literature, combining commercially available

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educational television and on-screen print especially as it relates to two under-served populations: economically disadvantaged African American children and economically disadvantaged Hispanic children who spoke Spanish as a first language (i.e. English language learners). Acquisition of programme-specific vocabulary, improvements in programme-specific comprehension and generalising these improvements to normative measures of word recognition and phonemic awareness were tested. A child's initial reading ability was also tested to determine whether initial ability, used as an indicator of risk status, moderated any of these results.

Method

Participants

Seventy second- and third-grade children attending four Title 1 public schools in two large Midwestern cities in the United States whose participation was approved by their parents were included. Forty-two were girls ($M = 7.5$ years) and 28 were boys ($M = 7.8$ years). Eighty-two per cent of the families reported incomes below US$30,000; 57% were reading below a first-grade level and 79% of the children were reading below a second-grade level as measured by their oral reading rates ($M = 24.4$ wpm; Oral Reading Fluency Task; Good, Simmons, Kame'enui, Kaminski & Wallin, 2002); and five of the children had an identified reading or learning disability as reported by their parents. Children were recruited from a population of economically disadvantaged families. Fifty-six per cent were African American children who spoke English as their first language and 44% were Hispanic children learning English as a second language (i.e. English language learners).

Design and intervention conditions

To address the hypotheses, an experimental design was used (Shadish, Cook & Campbell, 2001). Children were randomised into one of two conditions: intervention ($n = 35$) versus control ($n = 35$). In the intervention group, children watched six videos with captions. The control group watched the same set of six videos (in the same order) without captions. See Table 1 for descriptive information by condition.

For those in the intervention condition, the on-screen closed captions were the original captions created for each video by professional captioning agencies using parameters established by the Media Access Group at WGBH (i.e. the Boston, Massachusetts public television station) and the Federal Communication Commission (1999). These parameters resulted in near-verbatim captions with a maximum presentation rate of 120–130 wpm.[2] When captions were edited to reduce the presentation rate, substitute words or phrases were not more complicated than the original wording. With these guidelines, captions for children's programmes match the spoken narration or dialogue about 84% of the time. We purposely used the original, commercially created captions to examine whether commercially available captions could have the same impact as carefully designed, researcher-derived captions could (e.g. Linebarger, 2001).

Setting and apparatus

Video episodes were presented to children using a 13″ TV/VCR combination unit. Children were seated in groups of two to three, approximately 1–2 feet away from the screen and the

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Table 1. Demographic characteristics, frequency of reading and writing, and pre-test standardised reading scores across all children and within group.

	All	No captions	Captions	$F(1, 69)$ or $\chi^2(70)$[a]
Child's age (in years) (*SD*s)	7.63	7.57 (0.79)	7.70 (1.02)	.38
Race/ethnicity				$\chi^2 = .06$
African American	39	20	19	
Hispanic[b]	31	15	16	
Gender				$\chi^2 = .00$
Male	28	14	14	
Female	42	21	21	
Risk status				$\chi^2 = .42$
At risk	14	6	8	
Moderately at risk	26	13	13	
Not at risk	30	16	14	
Maternal education (*SD*s)	11.50 (2.14)	11.51 (1.72)	11.49 (2.52)	.00
Child's reading/writing frequency (%)				.52
Rarely	31.4	25.7	37.1	
Sometimes	31.5	37.2	25.8	
Frequently	17.2	17.2	17.2	
Daily	19.9	19.9	19.9	
Normative pre-test literacy scores				
Dolch words (*SD*s)	169.80 (46.49)	169.13 (48.76)	170.47 (44.80)	.01
Decontextualised target words (*SD*s)	33.50 (30.02)	36.97 (31.36)	30.03 (28.64)	.94
Oral reading fluency (*SD*s)	48.27 (32.72)	47.97 (35.01)	48.57 (30.76)	.01
Nonsense word fluency (*SD*s)	53.55 (30.04)	57.06 (31.65)	50.04 (28.35)	.96

Notes: Ranges for each variable: age = 6–10 years; maternal education in years = 7–16 years. Book reading and writing frequency: rarely = never to once a month; sometimes = two times per month to once a week; frequently = three to four times per week; daily. Dolch words (out of 220) = 9–219. Decontextualised target words (out of 120) = 0–112. Oral reading fluency = 4–155 words per minute. Nonsense word fluency pre-test score = 8–141 letter–sounds per minute.

[a]The chi-square tests and all *F*-tests were non-significant.

[b]All children of Hispanic origin spoke Spanish as their first language and were categorised as English language learners by their schools.

experimenter sat to the right and slightly behind the children. The viewing took place in empty classrooms during the after-school programme hours at each of the schools.

Stimuli

Six 30-minute programmes airing during spring 1999 on the public broadcasting service were chosen as stimuli. Curriculum documents and promotional materials developed by each of the programmes indicated that these programmes had been designed for children in our age group (i.e. second- and third-grade children). Programmes were viewed in the following order: *Arthur & Friends*, *Magic School Bus*, *Reading Rainbow*, *Wishbone*, *Zoom* and *Kratts' Creatures*.

Procedures

After parental consent was received, all children were pre-tested using the researcher-developed and standardised instruments described below. Once completed, all children began viewing stimuli associated with their assigned condition (i.e. with or without captions) in small groups of two to three children. After viewing each video, all

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children's video-specific knowledge was tested, one-on-one, via a series of brief, video-specific indices including: (1) word recognition of target words (i.e. words featured in the video using criteria described below); (2) definition of target words; (3) one literal comprehension question that required the child to identify the climax of the video; and (4) one inferential comprehension question that required the child to describe the main idea of the video. After all episodes were viewed, all children were again tested using the original set of measures (or an alternate form, where available). All viewing and testing sessions took place during the children's after-school child care programme housed at each of the schools involved ($n = 4$ schools).

Measures

The measurement strategy selected was based on several considerations including the collection of information to describe the participants, sensitivity to immediate effects of the intervention, the ability to detect change using standardised measures and robustness to implementation quality.

Parent demographic and media access/use questionnaire. Parents were asked to provide both demographic and media access/use information about their families and children. Data used in these analyses included birth dates, gender, family size, income, ethnicity/race, primary language in the home, whether or not the target child had an identified disability, children's use of media (i.e. computers, TV, print) in the home and the number of books the child had available to him/her.

Video-specific literacy measures

Word recognition. All children were asked to read five words used in each video after viewing the video. These words (i.e. target words) were selected based on the following criteria. Each word needed to be: (1) a 'content' word (i.e. important to the video story and not an incidental word like 'because', 'through' or 'actually'); (2) repeated at least four or five times in the video; (3) explained in the video either through a verbal definition/description, through a visual demonstration or both (e.g. 'humpback' was presented and defined by a scientist through a voice-over while viewers saw a swimming and leaping humpback whale); and (4) at a second- to fourth-grade level. In our initial selection of words, we used a book for authors to determine at what grade and in what aspect of the curriculum a word was introduced (Mogilner, 1992). However, on closer examination using another basic vocabulary text (i.e. the EDL Core Vocabularies in Reading, Mathematics, Science, and Social Studies; Taylor et al., 1989), we determined that our selected target words actually ranged in difficulty between first and seventh grade. Because of the range of word grade levels, we weighted the words in the analyses based on grade (e.g. Grade 2 word scores multiplied by 2, Grade 3 word scores multiplied by 3 and Grade 4 word scores multiplied by 4). Project staff scored children's pronunciation of words for fluency (i.e. target word recognition; 4-point scale: 0 = *inaccurate*; 1 = *read with difficulty*; 2 = *sounded out*; 3 = *fluent; read with no difficulty*). Examiners were trained and practised until inter-examiner agreement on fluency scores equalled 90% or higher.

Comprehension. Three different measures of video-specific comprehension were administered to all children: target word comprehension, literal comprehension and

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inferential comprehension. Given the number of videos each child needed to see, the number of children involved in the study and the limited amount of time each child was available to participate in this study, the comprehension questions needed to be brief. After completing the word recognition task described above, children were asked to provide a definition for each of the words (i.e. target word comprehension). In the event that the child was unable to read the target word fluently, a clear pronunciation of the word was provided before asking for the definition. Literal comprehension involved identifying a critical or main story event that was visually and/or verbally described (e.g. when x happened what happened next) while inferential comprehension required the children to give the main idea of the programme.

Comprehension questions and definitions were both scored using a 3-point scale (0 = *no response*; 1 = *partially correct answer*; 2 = *accurate and complete answer*). Two independent raters scored 11% of the definitions. Krippendorff's αs (Hayes & Krippendorff, 2007) were acceptable for target word comprehension (= .95), literal comprehension (= .91) and inferential comprehension (= .86).

Normative literacy measures

Normative literacy measures were administered at both the pre-test and the post-test to all participants.

General word recognition. First, children were asked to read a list containing 220 high-frequency words (i.e. Dolch words) compiled by E. W. Dolch (1948). This list comprises 50–75% of the reading material encountered by American students, especially in Kindergarten through third grade (Frey, Kress & Fountoukidis, 2000; May, 1998). We included this list of words because all words except 'upon' were found multiple times across the video stimuli. Next, children were asked to read a decontextualised target word list that contained all 30 target words (i.e. five words from each of the six videos that were selected based on the four considerations detailed above). As with the target word video-specific assessments, children's ability to read each word fluently was examined (i.e. 4-point scale: 0 = *inaccurate*; 1 = *read with difficulty*; 2 = *sounded out*; 3 = *fluent; read with no difficulty*).

Normative code-related literacy skills. Two of five individually administered and timed subtests from the *Dynamic Indicators of Basic Early Literacy Skills* (Good & Kaminski, 2002; Kaminski & Good, 1996) were used to measure children's phonemic awareness and fluency skills. Children were given a set of instructions, a practice item and then asked to do as many of the particular subtest as they could for 1 minute. Each subtest had 20 equivalent forms available. Nonsense word fluency (NWF) consisted of made-up words that follow the rules of English syllable structures and the alphabetic principle. In every language there are restrictions about the patterning of phonemes (or sound combinations) in words. Children were given a sheet of paper with nonsense words printed across the page and were instructed to read each word or say as many of the sounds as they could in 1 minute. The examiner gave credit for any correctly said sounds. For example, a child would see 'rij' and say '/r/ /i/ /j/' and receive 3 points or say '/r/' and receive 1 point. Oral reading fluency (ORF) consisted of children reading passages that measure the child's skill at recognising and reading words rapidly and accurately. Interviewers recorded the number of words read accurately in 1 minute to determine the child's oral reading rate.

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Assignment to risk status

We used initial reading ability, identified by scores on the pre-test NWF assessment (discussed above), as a marker of the child's reading risk status. This score was used to form three categories: at risk for poor reading outcomes in fourth grade, moderately at risk and not at risk for reading difficulties in fourth grade using national benchmarks empirically established by the creators of the measure (Good et al., 2002). Achieving 50 letter–sound correspondences by winter of second grade has been set as the benchmark for prediction of successful later reading achievement while reading <30 letter–sounds per minute is predictive of poor reading outcomes in fourth grade. At-risk performers were those not making satisfactory progress towards learning to read at the start of the investigation. Based on benchmarks for children this age, these children were in need of intensive instructional support if they were to achieve desired reading outcomes in fourth grade. Those whose scores reached the established benchmark were considered not at risk. According to Good et al. (2002), parents and teachers can be confident that these children are making adequate progress towards reading outcomes. The group of children who were classified as moderately at risk had not achieved the benchmark indicating adequate reading progress, yet they were not below the at-risk benchmark. No clear prediction is available for these students; however, they may be moving off track in their reading development (Good et al., 2002). Other research using a similar risk status classification has resulted in more clearly distinguishing results of an on-screen print intervention (Linebarger et al., 2004).

Results

Analysis of covariance (ANCOVA) models were used to evaluate group differences on the post-test video-specific and normative measures. Between-subjects factors included group (two levels: captions and non-captions), child's risk status (three levels: at risk, moderately at risk, not at risk) and child's gender (two levels). Preliminary ANOVAs examining each factor indicated that child's gender was unrelated to any of the child outcomes and was, therefore, dropped from the final models. We also examined whether the children's background (i.e. African American English-speaking or Hispanic English language learners) impacted our results. Across the outcomes, the findings were either that English language learners benefited from the caption intervention and English speakers' performance did not differ (i.e. target word, literal and inferential comprehension); that both benefited from the intervention, but the effects were larger for ELL children (i.e. target word recognition, Dolch words and NWF); or that there were no benefits of the intervention for either group (i.e. ORF, decontextualised target word recognition). Because our hypotheses were related to the efficacy of the delivered intervention and the role that risk status played in that effectiveness, we controlled for the child's background in our analyses.

Several other covariates were used or constructed to control for potential third variables. All analyses controlled for children's scores on a particular outcome at pre-test (e.g. pre-test NWF scores were controlled for when analysing post-NWF outcomes). For analyses related to specific programme content, the pre-test target word recognition score was used as a covariate. For analyses related to normative assessments, pre-test scores for each normative measure were controlled. Finally, in all analyses, maternal and child composites were used as covariates. The maternal composite, focusing on maternal

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education, was constructed by *z*-score transforming and then summing reported maternal years of education and mother's highest degree. Mother's education is a commonly used covariate that has been found to relate to both child media use and literacy or academic achievement outcomes (Anderson et al., 2001; Linebarger et al., 2004; Wright et al., 2001). The child composite, focusing on frequency of child's literacy-related behaviours, was formed by *z*-score transforming and summing how often a child read books alone or wrote letters, stories and other print-related activities.

The computed ANCOVA models allowed us to examine an overall or omnibus *F*-test for the significance of the risk by group interaction effects. We also executed planned comparisons examining group differences within each level of risk to determine which, if any, of the comparisons were most involved with a significant omnibus interaction effect, or, alternatively, if the omnibus was not significant, to evaluate whether any of the simple main effects were significant. Corrections for experiment-wise error were performed using modified Bonferroni adjustments of the α level (i.e. reducing Type 1 error rates or finding a significant difference when one does not exist; Jaccard, 1998). To estimate the practical significance of the outcomes, effects sizes were computed (i.e. Cohen's *d*; Cohen, 1988). Table 2 reports all findings from the final ANCOVA analyses.

Impact of captions and video-specific content

Video-specific word recognition. We expected that children in the captions condition would outperform children in the non-captions condition on the target word recognition task and that these results would be moderated by risk status. Our results showed that children who viewed programming with captions did not perform significantly differently from their non-caption viewing peers on the target word recognition measure, although trends were in favour of the captions group (no captions: $M = 150.64$, $SD = 59.93$; captions: $M = 165.25$, $SD = 56.85$; $d = 0.20$). As predicted, we did find that risk status moderated word recognition outcomes. Specifically, a significant two-way interaction between group and risk status was present, $F(2, 69) = 4.327$, $p = .018$, indicating that at-risk ($d = 0.61$) and moderately at-risk ($d = 0.84$) children who viewed programmes with captions did benefit from the intervention when compared with their counterparts who viewed without captions while not-at-risk children who viewed without captions outperformed their peers who viewed with captions ($d = -0.45$; see Figure 1). There were no significant univariate tests indicating that all simple main effects of group were contributing equally to the pattern of relationships identified in the interaction.

Video-specific comprehension. We hypothesised that children in the non-captions group would outperform their peers in the captions group on the comprehension tasks and that risk status would moderate these findings. Unexpectedly, we found that target word comprehension and inferential comprehension scores were higher after viewing programmes with captions versus viewing programmes without captions while literal comprehension scores were unaffected by viewing condition. Further, risk status did not moderate these findings.

Children who viewed with captions knew the meaning of more target words ($M = 136.72$, $SD = 47.09$) when compared with children who viewed without captions ($M = 113.22$, $SD = 49.64$), $F(2, 69) = 4.157$, $p = .046$, $d = 0.49$. There were no significant main effects or interactions for literal comprehension. Means for both groups were nearly identical (captions: $M = 9.46$, $SD = 2.19$; no captions: $M = 9.77$, $SD = 2.13$;

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Table 2. Means, standard errors and ANCOVA results for group by risk status across all outcomes.

Outcome	Non-captions		Captions		ANCOVA F and (partial η^2)		
	M	*SE*	*M*	*SE*	Group (G)	Risk (R)	G × R
Target word recognition					1.101 (.018)	0.671 (.022)	4.327* (.126)
At risk	128.18	23.94	159.28	20.34			
Moderately at risk	140.54	15.11	187.89	15.72			
Not at risk	183.21[a]	14.76	148.56[a]	15.44			
Group means	150.64	10.13	165.25	9.61			
Target word comprehension					4.157* (.065)	0.408 (.013)	0.868 (.028)
At risk	109.88[b]	19.84	157.89[b]	26.85			
Moderately at risk	115.36	12.52	124.81	13.02			
Not at risk	114.41	12.22	127.47	12.79			
Group means	110.69	9.43	131.26	8.85			
Literal comprehension					0.352 (.006)	1.369 (.044)	1.006 (.032)
At risk	9.59	0.89	10.73	0.75			
Moderately at risk	9.42	0.56	8.72	0.58			
Not at risk	9.39	0.55	9.86	0.57			
Group means	9.46	0.37	9.77	0.36			
Inferential comprehension					4.023* (.063)	0.698 (.023)	0.805 (.026)
At risk	9.90[a]	1.08	12.25[a]	0.92			
Moderately at risk	10.03	0.68	10.25	0.71			
Not at risk	9.46	0.66	10.65	0.70			
Group means	9.79	0.46	11.05	0.43			
Dolch words					5.160* (.080)	0.017 (.001)	2.97+ (.091)
At risk	164.98	8.80	178.98	8.84			
Moderately at risk	160.70[b]	5.80	185.91[b]	6.28			
Not at risk	174.43	5.51	172.38	5.86			
Group means	166.70	3.87	179.09	3.87			
Decontextualised word recognition					1.651 (.027)	0.052 (.002)	1.035 (.034)
At risk	34.72[a]	5.49	45.26[a]	5.02			
Moderately at risk	39.32	3.49	42.82	3.79			
Not at risk	40.70	3.50	39.34	3.55			
Group means	38.25	2.33	42.47	2.35			
Nonsense word fluency					4.83* (.076)	2.851+ (.088)	0.263 (.009)
At risk	64.47	12.49	77.04	12.32			
Moderately at risk	66.27	7.82	87.54	8.22			
Not at risk	45.72	9.22	57.09	8.41			
Group means	58.82	4.91	73.89	5.14			
Oral reading fluency					0.190 (.003)	0.853 (.028)	0.104 (.004)
At risk	59.22	8.56	59.37	7.94			
Moderately at risk	58.04	5.52	52.66	5.86			
Not at risk	63.86	5.38	62.36	5.50			
Group means	60.37	3.68	58.13	3.64			

Notes: Group by risk status mean differences (i.e. means in each row) sharing the same superscript are either marginally significant ([a]) or significantly different ([b]).
$^{+}p < .100$; $^{*}p < .05$.

$d = -0.14$), suggesting that all children were able to adequately identify the critical story event in each video. Finally, for inferential comprehension, there was a significant main effect of group, $F(1, 69) = 4.023$, $p = .049$, $d = 0.48$. Children who viewed with captions were better able to provide the main idea of each programme ($M = 11.05$, $SD = 2.54$) compared with children who viewed without captions ($M = 9.79$, $SD = 2.72$).

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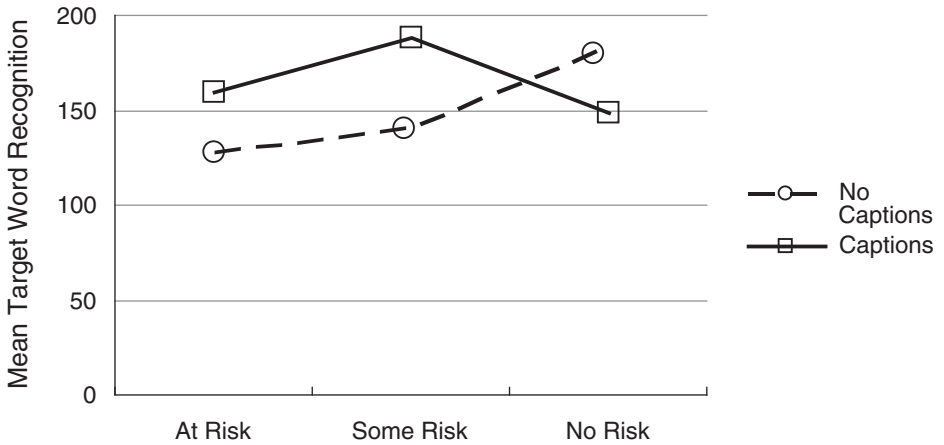

Figure 1. Two-way interaction between risk status and group for target word recognition.

Transfer of video-specific content to normative literacy outcomes

General word recognition. We expected that viewing captions over time would support children's ability to transfer video-specific recognition of target words to decontextualised word recognition tasks at the conclusion of the intervention when compared with children watching the same programmes without captions. Further, we expected that risk status would moderate these findings.

For the Dolch words tasks, we found a significant main effect of group, $F(1, 69) = 5.160$, $p = .027$, $d = 0.54$. Caption viewers were able to accurately and fluently read more Dolch words ($M = 179.09$, $SD = 22.90$) when compared with non-caption viewers ($M = 166.70$, $SD = 22.90$). There was also a marginally significant two-way interaction between group and risk status, $F(2, 69) = 2.97$, $p = .059$. At-risk ($d = 0.74$) and moderately at-risk ($d = 1.06$) children who viewed programmes with captions outperformed their counterparts who viewed without captions while not-at-risk children who viewed without captions outperformed their peers who viewed with captions ($d = -0.06$; see Figure 2). Univariate tests indicated that moderately at-risk children were most involved in the significant result, $F(1, 60) = 7.43$, $p = .008$. There were no significant main effects or interactions for decontextualised target word recognition, although the trend favoured caption viewers over non-caption viewers (captions: $M = 42.47$, $SD = 13.90$; no captions: $M = 38.25$, $SD = 13.78$; $d = 0.30$).

Normative code-related skills. In line with the extant literature, we expected children in the captions viewing condition to outperform their non-captions viewing peers on normative code-related skill assessments, and for risk status to moderate this relationship.

For the NWF task, there was a significant main effect of group, $F(1, 69) = 4.830$, $p = .032$, $d = 0.52$. Caption viewers were able to read more nonsense words in 1 minute ($M = 73.89$, $SD = 29.05$) when compared with non-caption viewers ($M = 58.82$, $SD = 29.05$). There was also a marginally significant main effect of risk status, $F(1, 69) = 2.851$, $p = .066$. Moderately at-risk viewers ($M = 76.91$, $SD = 31.05$) outperformed at-risk viewers ($M = 70.76$, $SD = 55.05$; $d = 0.14$) who, in turn, outperformed not-at-risk viewers ($M = 51.41$, $SD = 40.37$; $d = 0.40$). There were no significant main

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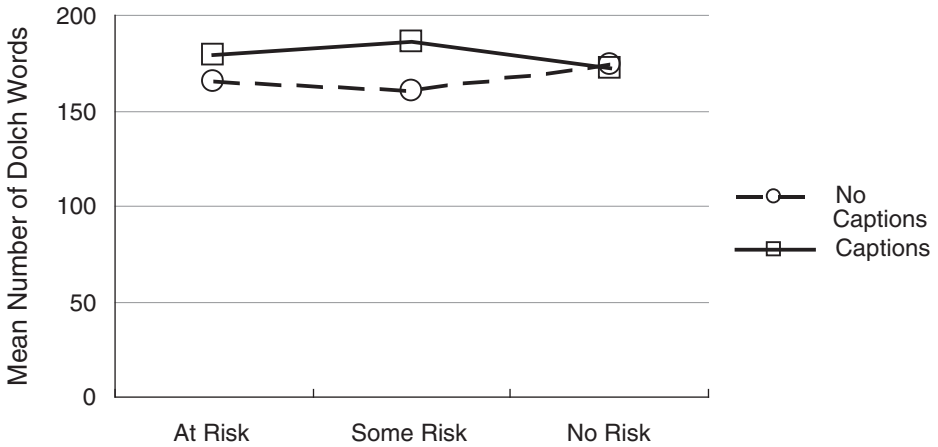

Figure 2. Two-way interaction between risk status and group for mean number of Dolch words.

effects or interactions for ORF. Means for both groups were nearly identical (captions: $M = 58.13$ wpm, $SD = 21.53$; no captions: $M = 60.37$, $SD = 21.77$; $d = -0.10$).

Discussion

The majority of outcomes examined indicated that children who viewed with captions outperformed their counterparts who viewed without captions. Risk status moderated the relationship for target word recognition as well as Dolch words.

Impact of captions on word recognition

Dual coding theory predicts that the information delivered via more than one modality (e.g. aural, video, print) should be better learned than information delivered via one modality (Paivio & Csapo, 1973). We did find that word recognition scores for both programme-specific content (i.e. target word recognition) and more generic content (i.e. Dolch words) were higher for caption viewers when compared with non-caption viewers. Programme-specific performance was moderated by risk status, indicating that effects were limited to only at-risk and moderately at-risk children. This finding is explained by the 'travelling lens' model. Specifically, children who have at least some familiarity with print, but not so much that reading print is automatic or easy, would be most likely to attend to the print due to its novelty and challenge. Earlier research found that children most at risk and those not at risk did not benefit from educational television containing on-screen print (Linebarger et al., 2004); however, the stimuli used in this earlier study displayed only selected content in a print format and the children were younger (i.e. Kindergarten and first grade). It is likely that by second and third grade, the children still struggling with reading had enough print familiarity to find the presented content moderately novel and challenging and thereby worthwhile to attend to. Conversely, those children who had learned to read either found the content too easy and tuned it out (i.e. not at risk) or they already possessed the skills measured in this study. Although

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decontextualised target word recognition mean scores were higher for caption viewers at the post-test, this difference was not significant.

In addition to displaying on-screen print tied to the aural narration, repetition of target words probably played a role in learning to read these words. Target words repeated, on average, 25 times per video and, when originally selected for this study, did not repeat in any of the other videos children would see. This level of exposure was enough to help children identify and read the words immediately after viewing, but not to retain or transfer their knowledge of that word to a decontextualised reading task after a period of 10 days to 2 weeks. The improved performance for Dolch words, which did repeat in each video (i.e. 48.3% of the words, on average, in each video were comprised of Dolch words), suggests that repeat exposure to on-screen print paired with visual and auditory inputs does help children learn, retain and transfer knowledge of these words to a delayed reading task.

Impact of captions on comprehension scores

As with word recognition, dual coding theory predicts that comprehension of programme content would be enhanced when that content was delivered in two modalities; however, the effects of content delivered in three modalities is unclear. Linebarger (2001) found that aural narration coupled with visual information supported children's incidental and inferential comprehension abilities (just two modalities) while on-screen print when coupled with both aural narration and visual information (three modalities) supported literal comprehension (i.e. when 'x' happened, what happened next). Given that Linebarger's (2001) sample was most similar to our sample, we hypothesised that comprehension scores would be the highest for children viewing without captions because only two modalities would be involved in the delivery of content and would, therefore, not overload children's limited cognitive resources. Despite these concerns, we found that comprehension scores on two of the three comprehension tasks favoured caption viewers over non-caption viewers (i.e. target word comprehension, inferential comprehension). Further, the remaining outcome, literal comprehension scores, was unaffected by the presence or absence of captions. Rather than overloading the child's cognitive capacity, it appears that the delivery of information via three modalities helped the viewer focus on the episode content.

It may also be the case that children spent little time fixating on the on-screen print (although word recognition scores would suggest that at least some attention was paid to the print). In eye-tracking work with younger children, there were very few fixations to print in both traditional stories (i.e. books; 4.5% of fixations to print; Evans & Saint-Aubin, 2005; Justice, Skibbe, Canning & Lankford, 2005) and televised stories (Vaala, Lapierre & Linebarger, 2009). By adulthood, 84% of fixations were to on-screen print (Jensema, El Sharkawy, Danturthi, Burch & Hsu, 2000). Although not an exact comparison, interpolating from these studies suggests that children in our sample likely paid more attention than the younger children in Linebarger's (2001) study but not so much that they were unable to comprehend word meanings and content.

Impact of captions on code-related skills

Identification of nonsense words measured children's knowledge of the alphabetic principle and their understanding of English orthographic structure and was improved in the presence of captions. The triple modality inputs for words (i.e. auditory, visual, linguistic) that the captions-viewing group experienced helped children increase their

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stores of semantic and syntactic abilities, making them more fluent on this task (i.e. their ability to identify sounds increased from 50 spm before the intervention to 66 spm after the intervention). However, transferring this sound-specific fluency to more fluent reading of generalised English-reading passages (i.e. ORF) did not occur. This is very close to our findings reported here. Linebarger (2001) also found no impacts of captions on children's ORF scores. As with the decontextualised target word recognition task described above, it is likely that viewing six different educational television programmes was not sufficient to move the child's general reading fluency abilities.

Although captions were not found to enhance children's reading fluency, the findings in favour of captions for supporting nonsense word identification are important. Fisch (2000, 2004) discusses the importance of transfer of learning, or the ability to take programme-specific content, mentally encode that content and then use it appropriately in novel situations. These normative reading assessments measure children's ability to transfer the specific literacy content featured in the videos into more generalised literacy skills. One of the most important educational goals for children is learning to transfer specific skills to generalised contexts. Fisch (2004) suggested that this goal is best supported through varied practice, or exposure to multiple examples in a variety of formats. Educational television coupled with captions provided multiple and varied formats that helped young children in this study begin to make this transfer.

Implications for intervention

Using captions for young at-risk readers can be an effective supplemental literacy tool in supporting word recognition, content comprehension and code-related literacy skills after viewing just six different educational TV programmes one time. Linebarger (2001) found this to be true with carefully constructed scripts written with maximal reading supports embedded. The stimuli used in this study generalise Linebarger's (2001) findings to commercially available, high-quality educational programming and the feasibility of captions as an easy-to-use, pervasive and scalable intervention. Coupling our findings with Koskinen et al.'s (1997) study of continuous caption use across many types of programming in the home provides compelling evidence for the power of this nearly universal resource available on every television set manufactured in the United States since July 1993.

Limitations

Several limitations must be considered when interpreting these findings. First, the small sample size warrants caution in the generalisability of the findings beyond these populations. However, because these children are generally at higher risk for delays in literacy skills, the current positive findings contribute additional support for the benefits of captions and, more generally, on-screen print to the extant literature featuring hearing-impaired, learning-disabled and English language learners (e.g. Adler, 1985; Koskinen et al., 1986; Linebarger, 2001; Linebarger et al., 2004; Neuman & Koskinen, 1992; Parks, 1994). In these populations, using captions and on-screen text was related to improvements in various reading abilities as well as an increased desire to use television as a literacy tool. Second, it is important to remember that the viewing environment of the study (i.e. small groups in empty classrooms) may have somehow altered how the children experienced the medium. Although all children viewed in the same environment, it is possible that these findings would not translate in the same manner in a more

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common viewing environment such as the child's home. Koskinen et al.'s (1997) home study suggests that it would.

Conclusion

Overall, these results support the developing body of evidence that early readers can learn to read and gain a clearer understanding of new words while viewing existing children's educational programming with print on-screen (Linebarger, 2001; Linebarger et al., 2004; Prince et al., 2002). Interestingly, these results also suggest that television captioning increases attention to and subsequent comprehension of television content. If the goal is to help children learn to recognise and subsequently understand the meaning of new words as well as transfer specific literacy content into more generalised literacy skills, then turning the closed captions option on while children are watching television at home or in school is a good starting point.

Notes

1. Researchers found a curvilinear relationship between parents' education and child screen media use (i.e. television, videos/DVDs and movies); that is, children whose parents either had equivalent to or less than a high school diploma or at least a college degree watched the most television while those whose parents had some college watched the least (i.e. high school diploma or less – 4 hours 23 minutes; some college – 3 hours 46 minutes; college or greater – 4 hours 20 minutes; Roberts et al., 2005).
2. Captions for children's programmes are not verbatim; rather, they are edited, typically for beginning or easy readers (Media Access Group/WGBH, http://main.wgbh.org/wgbh/pages/mag/services/captioning/faq/sugg-styles-conv-faq.html).

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