Acknowledgement: The version of record of this manuscript has been published and is available in MEDIA PSYCHOLOGY, accepted author version posted online: 13th of July 2016. http://www.tandfonline.com/doi/full/10.1080/15213269.2016.1202773.

Title:
The development of media sign literacy – a longitudinal study with 4-year-old children

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Abstract
In a longitudinal study, N = 137 children at the age of four years were tested for media sign literacy, intelligence and several precursors of academically relevant skills, such as phonological awareness and preschool quantity-number competencies. The children were tested four times over the following two years, measuring the development of these skills every six months. The purpose of the study was to explore whether children’s level of media sign literacy helps them acquire academically relevant symbolic skills like reading and mathematical competencies. The results indicate that media sign literacy as well as intelligence predict mathematical and linguistic competencies. Longitudinal findings indicate that children with higher levels of media sign literacy also achieve higher scores in precursors of mathematical and reading and writing skills, and structural equation modeling revealed a rich interconnectedness between media sign literacy and intelligence. Media sign literacy had a direct and significant effect on mathematical competencies at measurement point two and indirect effects on the precursors of reading and writing skills at measurement point four.

KEYWORDS: Children, development, media sign literacy, intelligence, phonological awareness, mathematical skills, longitudinal study
In their course of development, young children today remain in much closer and more intense contact than any previous generation, with diverse stationary and mobile media (Medienpädagogischer Forschungsverbund Südwest, 2013; Rideout, Foehr & Roberts, 2010; Rideout & Hamel, 2006). These media include film, television, and computer games as well as learning programs, audiobooks, comics, picture books, and smartphone apps. It seems necessary, then, to protect children from being cognitively and emotionally overwhelmed by media. For that reason, it is understandable that media literacy acquisition is now widely accepted in academic and political debate as an essential educational goal (Peréz Tornero & Varis, 2010).

However, in the absence of explicit attempts to encourage and promote it, it remains an open question how media literacy develops in childhood, and whether acquired media literacy has any impact on other relevant academic skills such as reading and mathematical skills.

**The Development of Media Literacy**

**What is Media Literacy?**

Among the many definitions of media literacy, it is generally agreed that it relates to specific knowledge and skills that enable (critical) understanding and use of media (e.g., Auferheide, 1993; Hobbs, 1997; Martens, 2010). Two types of abilities are of particular importance: first, the abilities necessary to understand media sign systems and second, the abilities that help us to use, analyze, evaluate, and communicate messages in various forms (Hobbs, 1997). According to Potter (2010), media literacy is a multidimensional concept that includes a range of cognitive, emotional, social, and aesthetic skills, which in turn form a continuum. At any time in their development, every individual occupies a specific position on the media literacy continuum. During the course of their development, people must continuously adapt to ongoing change in media technology and context.

Rather than addressing media literacy from an adult perspective (as is common to most such studies), Potter (1998) elaborated some theoretical assumptions about developmental aspects of media literacy. He described two sets of skills: “rudimentary skills,” which are acquired during childhood, and “advanced skills,” based on the rudimentary skills, which allow people to use various media in a critical and reflexive way. The present article will focus on the development of rudimentary skills in children between the ages of four and six years, entailing a strict focus on the understanding and correct use of symbol systems that organize different media rather than on competences required for critical analysis of media forms and content.

The components of rudimentary skills described by Potter are part of an ability, which we refer to as media sign literacy (Nieding & Ohler, 2008); this is probably the most important aspect of media literacy to be learned by children between two and six years of age. Following DeLoache’s (2004) definition, a symbol can be anything “that someone intends to represent...”
something other than itself” (p. 66). As well as being essential in the development of media literacy, the ability to understand and use symbols is an important milestone in children’s development. (Cassirer, 1944, p. 26) Symbols enable us to learn and understand without direct exposure to events and objects; in this way, they free us from the “here and now” (Sigel, 1970).

There is some evidence that picture recognition is an innate function. For example, Hochberg and Brooks (1962) demonstrated that a 19-month-old boy, who had no previous exposure to any kind of pictures, was able to recognize and name familiar persons or objects in photographs. Subsequent research with infants has confirmed this finding (Daehler, Perlmutter, & Myers, 1976; DeLoache, Strauss, & Maynard, 1979; Dirks & Gibson, 1977). While picture recognition seems innate, the understanding and use of pictures as symbols is not, as young children treat pictures not as symbols but as objects in themselves. DeLoache and her colleagues (e.g. DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998; Pierroutsakos & DeLoache, 2003) noted that infants up to the age of 9 months rub the surface of the picture book as if trying to pluck the object from the page—in one case, trying even to put the nipple of a depicted baby bottle into their mouth. As children get older, this type of behavior decreases, to be replaced (at about 19 months of age) by pointing at and naming of objects. At that same age, children begin to understand the symbolic meaning of pictures. Around 18 months, children commonly understand that a new word (e.g., “whisk”) stands not only for the picture of an object but also for the object itself (Preissler & Carey, 2004). As described by Pierroutsakos and Troseth (2003), children’s understanding of objects in films seems to develop in a similar way, following identical age patterns. All these abilities essentially require an understanding that there is a relation between a pictorial representation and the represented object. This basic understanding is known as representational insight (DeLoache, 1995, 2000). It is commonly tested by means of the well-known object retrieval task (e.g., Deocampo & Hudson, 2005; Schmitt & Anderson, 2002; Troseth, Casey, Lawver, Walker, & Cole, 2007; Troseth, Pickard, & DeLoache, 2007), in which the experimenter shows the subject where a toy is hidden in a room as depicted in a picture, video, or scale model of that room. The child is then admitted to the real room and is asked to find the toy.

How are media literacy skills further developed?

According to Potter (2010), further fundamental skills include the ability to differentiate between program formats and between fiction and non-fiction, as well as a dawning skepticism—for example, with respect to advertisements. Recent research has confirmed this assumption; once children have grasped the representational properties of films, they become aware of different program formats.

At 4 years, children can already distinguish between advertising and other program formats (Diergarten, Nieding, & Ohler, 2014; Nieding, Ohler, Bodeck, & Werchan, 2006). Later, cartoons can be distinguished from formats such as Sesame Street, and eventually, news can be distinguished from children’s and adults’ shows (Wright, Huston, Reitz, & Piemyat, 1994). At preschool age, the distinction between reality and fiction in films seems initially to be based on the format (such as animation or film) rather than on the content (e.g., Downs, 1990). Subsequently, children develop a deeper understanding of fictional films. This requires, among other skills, an understanding of factuality—the ability to judge whether the events portrayed in
the movie are as true as those in the real world or whether the depicted scenes are merely constructed for television viewing (Wright et al., 1994). The results of one of our studies (Nieding & Ohler, 2012) confirm that even at 8 years, children’s factuality judgments are only 60% accurate (see also Harris, 2009).

When viewing film media, an understanding of the visual production and editing techniques characteristic of the symbol systems of films is essential to an understanding of content. As formal visual features of films (see Rice, Huston, & Wright, 1986) often compress time and space or emphasize certain information, comprehension of such features can be regarded as a crucial facet of film literacy.

Understanding of editing techniques increases significantly between 4 and 10 years of age. Techniques that make relatively low cognitive demands are the first to be understood because they correspond most closely to natural perception (Munk, Diergarten, Nieding, Ohler, & Schneider, 2012; Munk, Rey, Diergarten, Nieding, Schneider, & Ohler, 2012). One example of such a “first-order editing rule” (see d’Ydewalle & Vanderbeeken, 1990) is the close-up, in which a long shot is followed after a cut by a close-up. Children come to understand that the objects shown in close-up have not come closer but maintain their position while the shot changes.

Second-order editing rules, which organize spatial relations (e.g., in dialogue scenes), are acquired later. For example, the matched-looks rule states that actors who engage in a dialogue always look in opposite directions, if only one person is seen in the picture.

Even harder to understand are third-order editing rules, as these relate to the continuity of events. An example is the editing technique of cross-cutting, used in films to establish actions occurring at the same time in two different locations. To suggest simultaneity, the camera cuts away from one action to the other.

This pattern of results emerged from experiments in which children’s understanding of such techniques was investigated through measurements of eye movements after film cuts (Munk, Rey, et al., 2012) and by using Anderson & Smith’s (1984) method of reconstructing film scenes with Playmobil figures (Munk, Diergarten, et al., 2012). These results align with the findings of Smith, Anderson and Fischer (1985) that 4- and 7-year-olds differed less in correctly reconstructing space montages (a mixture of first- and second-order editing rules) than in reconstructing simultaneity montages (crosscutting).

Examples of other media frequently used by children at preschool age with special symbol systems include comic books, audiobooks, and computer games. With regard to comic books, it has been shown that preschoolers are acquainted with fundamental conventions such as speech bubbles and are aware of how comics reflect emotions (Yannicopoulou, 2004). Numerous studies have centered on the popular Japanese manga comics, in which emotions are expressed by characters’ eyes rather than by their mouths (as in Western comics) (see Nakazawa, 2005).
Children of pre-school age also enjoy listening to audiobooks. Indeed, studies suggest a positive influence of audio media on language development (Ritterfeld, Niebuhr, Klimmt, & Vorderer, 2006).

Another medium in everyday use is the video game, played by 91% of children in the United States between the ages of 2 and 17 (NPD Group, 2011). While video game research has traditionally focused on negative effects, a body of research has begun to emerge that views video games from a different perspective regarding their benefits (see Granic, Lobel, & Engel, 2014). This research is based in part on the assumption that video game environments promote a new kind of interactive media literacy (Gee, 2003; Kress, 2003; Leu, 2001).

Another important aspect of children’s use of media—both computer and video games and books and movies—is the understanding of geographical maps, as many such media use maps that are of relevance to the narrative structure. Some understanding of simple maps emerges early in life (Spelke, Gilmore, & McCarthy, 2011); for example, children as young as 3 to 4 years of age can find a location in a sandbox as indicated on a small rectangular map (Huttenlocher, Newcombe, & Vasilyeva, 1999) or place an object into a container based on a map that shows an arrangement of three containers (Shusterman, Lee, & Spelke, 2008). By the age of 6, children can use maps of six small rooms to navigate through an unfamiliar laboratory setting (Uttal & Wellman, 1989).

### Purpose and Design of the Present Research

In the present study, we explored the course of children’s media literacy development from four years on in order to investigate whether the ability to understand media symbols helps children to acquire academically relevant symbolic skills such as reading, writing, and mathematical competencies.

All of the cognitive functions and processes explicated above—representational insight, genre discrimination, understanding of editing techniques and symbol systems in video games, and awareness of the conventions in comic books and maps—involves an interplay between mental (internal) and external representations. A shared characteristic of all these cognitions is that they do not refer primarily to features of the environment but to features of external representations of the environment—in other words, to symbolically organized media.

Against our general assumption of the importance of media sign literacy, one might argue that this capability can be reduced to other cognitive functions such as logical reasoning, understanding spatial relations, and narrative comprehension. In contrast, our theoretical framework assumes that cognitions dealing with symbol systems of external representations are based on a bundle of interrelated and multidimensional symbolic skills (e.g., Kirkham, Stewart, & Kidd, 2013). The first perspective focuses on underlying cognitive processes, while our perspective engages with the logic of cognitions that are confronted with the symbolic organization of media.

Both of these theoretical positions are in accordance with the fact that different symbolic domains exist and that they are related with one another. Despite that, little research has
considered the development of children’s understanding of the relationship among different symbolic domains. The concept of symbolic sensitivity, which describes the further development of representational insight (DeLoache, 2000), depends on divergent experiences with symbols—not only with the specific type of symbols required in a specific task but also with different symbol types. According to the common source hypothesis, different symbolic skills are correlated because they stem from a general symbolic skill that operates in similar ways across different areas (Namy & Waxman, 1998; Cambell & Namy, 2003). There is some empirical evidence in support of this assumption, for example, in relation to graphic symbolism, written words, pictures, and gestural symbols (e.g., Kirkham et al., 2013; Callaghan & Rankin, 2002; Allen, Mattock, & Silva, 2014). However, it remains unclear whether such early symbolic skills also predict later acquisition of academic skills. Taken together, the results support the assumption that early acquisition of media-related symbolic skills may foster children’s later acquisition of academic skills such as reading, writing, and mathematics, as these skills also depend on an understanding of the underlying symbol systems and of the operations that are possible within these systems. This in turn depends on the possibility of transfer of these skills from one symbol domain to another.

To answer this question, a second examination of the object retrieval task seems promising. In her “model model,” DeLoache (1995) described the factors that influence whether a child will successfully complete the task—that is, whether he or she will search in the correct place (DeLoache, 1995). One of the factors internal to the child is their symbolic sensitivity, which is the “general expectation or readiness to look for and detect the presence of symbolic relations between entities” (DeLoache, 1995, p. 112). Training studies have shown that one cannot teach a child to solve the object retrieval task using a symbol system for which they have not achieved representational insight (DeLoache & Burns, 1994; Troseth & DeLoache, 1998; vgl. Deocampo & Hudson, 2005). However, the task can be performed within a symbol system in which the child has representational insight, followed by transfer of the acquired skill to a different symbol system (Troseth & DeLoache, 1998).

These findings support our assumption that it may be possible to prepare children for the acquisition of such skills before they enter school by teaching them other symbol systems. In the present study, we assessed the relative importance of media sign literacy at the age of 4 as a predictor of precursors of reading, writing, and mathematical competencies two years later, when students are close to entering school.

With respect to the precursors of reading and spelling, there is substantial evidence that children’s early progress depends on their phonological awareness (Bus & van IJzendoorn, 1999; Ennemoser, Marx, Weber, & Schneider, 2012; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Schneider, & Näslund, 1993), involving the detection and manipulation of syllables and phonemes and the ability to detect rhymes. In addition to phonological awareness, grammatical skills are also important prerequisites for learning to read, and especially for reading comprehension (Muter, Hulme, Snowling, & Stevenson, 2004).

In addition to verbal skills, mathematical competencies play a major role in school achievement. Specific predictors at kindergarten age include early understanding of quantities, numbers, and
the relation between quantities and number words (Geary, 2011; Krajewski, Nieding, & Schneider, 2008; Krajewski & Schneider, 2009).

Given that a nonspecific important predictor of academic achievement is intelligence (Koponen, Aunola, Ahonen, & Nurmi, 2007; Niklas, 2011; Schneider & Näslund, 1993), nonverbal IQ was included as a control variable.

The aim of the present study, then, was to test our assumption that media sign literacy predicts both reading and writing literacies on the one hand and mathematics on the other—that is, children with higher media sign literacy should achieve greater linguistic and mathematical performance. A second assumption was that this should remain the case even after the relevant intelligence factor has been controlled. In our longitudinal study we tested children’s media sign literacy and intelligence three times (every six months), beginning at the age of 4 years. At 5 to 6 years we tested phonological awareness and preschool quantity-number competencies as precursors of academic skills.

**Method**

**Design and Sample**

At the outset, the study sample comprised 137 children (69 boys and 68 girls), recruited from two German cities. To recruit the participants, we contacted kindergartens and organized information sessions with parents to obtain their written consent to participation. There were four measurement points (MPs) in total, at 6-month intervals. Mean age at MP 1 was 4;3 (years; months; SD = 3.5 months); at MP 2, mean age was 4;9; at MP 3, mean age was 5;3; and at MP 4, mean age was 5;9. Total dropout (unavailability for all MPs) was N = 12 subjects, due to parents relocating to different cities or for other reasons. The results reported here are therefore based on data for N = 125 children (60 boys, 65 girls) who completed all four MPs.

**Tasks and Test Instruments**

**Media literacy.** Media literacy was assessed at each MP by means of a test designed by the authors with ten subscales; nine of these subscales were derived from the computer-based online test for media sign literacy (Domaratius & Ohler, 2006; media sign literacy of children). In a pilot study, N = 130 children between 4 and 8 years were tested with the complete measure including 27 subscales. Task difficulty and item selectivity were used as criteria for choosing the 10 subscales included in the present study. These subscales measured ability to recognize and assimilate symbols and figures in various kinds of media, including films, educational computer games, comics, radio plays, and picture books. Subscales included a number of items varying from two to eight, valued at one point for each correct answer. Each item was introduced by an electronic animated tutor (an animated comic ape), who explained the new task. Participants were asked to use the computer mouse to indicate their chosen option within a multiple-choice format. As every child had previous training on handling the mouse, they were able to do so effectively.
The first subscale assessed the child’s ability to differentiate between reality (or non-fiction) and fiction on TV. Two short film sequences, both live-action with similar content—one fictional and the other one documentary—were shown simultaneously, using a split-screen technique and ending with a freeze frame. After each showing, the child had to indicate which story had happened in reality by clicking on one of the two freeze frames. The second subscale measured whether children could yet differentiate between several film genres (such as commercials, fairy tales, cartoons, news, and children’s films) by showing prototypical pictures from each category. In this case, an oddity detection method (Nieding et al., 2006) was used, asking the child to click on one of three pictures that differed from the other two. The third subscale used radio plays to assess whether a child could match a presented voice to its corresponding character. Assuming that children are able to distinguish the typical voices of fairytale characters, we analyzed voices of dwarfs, fairys, giants, wolfs and bears in audio dramas and produced resembling versions in voice pitch, volume, and speech rhythm. In each trial the children had to match the voice to one of three visually presented characters. Subscale 4 measured the child’s ability to detect emotions in faces in comics. For each item, three faces were shown, and the child had to choose the face that corresponded with a requested emotion. Subscale 5 focused on the visual portrayal of different characters’ visual perspectives. The vertical perspective of views is used in various media to support intended effects like the dominance of one character. A perspective from above can, for example, stress the fact that someone’s counterpart is in an inferior position. The child’s ability to understand vertical perspectives was assessed by showing three characters of different sizes (elephant, tiger, and ant) and several pictures involving different vertical angles. The child then had to indicate which of the three animals had seen the scene from a certain perspective (e.g., a worm on the ground or a giraffe eating a tree’s leaves). Subscale 6 measured a child’s ability to understand the narrative continuity of animated film stories. After watching a short film sequence, the child had to predict how the story was going to continue by choosing one of three pictures that matched the progress of action in relation to the narrative content. Subscale 7 dealt with symbolic understanding in everyday use, which assessed the limitations of our concept of media literacy by exploring children’s knowledge of the symbolic use of colors in daily circumstances, such as the correct colors of traffic lights or water taps. Subscale 8 measured the child’s symbolic understanding of maps, in which the child had to indicate the meaning by clicking on symbols for towns, mountains, and rivers. The ninth subscale involved other computer-based items to measure knowledge of user interfaces. Educational computer games often present available functions symbolically by using intuitive pictograms (e.g., an owl as a wise character to represent the help function), and confident navigation of such programs therefore requires some level of metaphoric knowledge. To measure this kind of symbolic understanding, a fictional computer game setting was devised for subscale 9, in which the child had to click on one of several icons to perform a certain function. Half of the items were quite concrete (e.g., a door icon symbolizing the end of the game) while the others were more abstract (e.g., an x-like cross symbolizing the exit function). The final subscale (which was not part of the computer-based online test) measured comprehension of film montage by asking children to reconstruct animated films using dolls (Anderson & Smith, 1984; Smith, Anderson, & Fischer, 1985). The children were shown five stop-action trick film sequences produced by the authors involving a range of montage techniques, such as flashbacks, point-of-view shots, or simultaneous actions presented as a crosscutting sequence. Pilot studies identified the five selected films as optimal for differentiating montage comprehension among children of between 5 and 8 years (Munk, Diergarten, Nieding, Ohler, & Schneider, 2012). After watching the film,
the child’s task was to re-enact it, using all the characters and content as shown. Adequacy of reconstruction was rated as an indicator of montage comprehension.

Raw scores on each subscale were divided by the number of the subscale’s items, and a total score was calculated by adding these quotients. The sum was then divided by 10, resulting in a mean score that ranged from 0 to 1. Internal consistency (indicated by Cronbach’s alpha) for all items ranged from .76 to .77 across the four MPs. For the subscales across all four MPs, Cronbach’s alpha ranged from .58 to .64.1

**Intelligence.** Children’s nonverbal intelligence was measured using the two subscales “Classification” and “Matrices” from a shortened version of the Cultural Fair Intelligence Test (CFT; Cattell, Weiß, & Osterland, 1997). The first subscale was used to assess ability to classify figural objects. For each of the 12 items, the child was given 5 similar objects and was asked to identify the one that did not match the others. The child was allocated 5 minutes to complete this subscale. The “Matrices” subscale also consisted of 12 items. For each item, an incomplete pattern was depicted, and the child had to choose one of five pictures that would complete this pattern. Completion of this subscale required the ability to recognize rules and patterns. The allocated time for completion was limited to 7.5 minutes. Psychometric properties of the two subtests were sufficient, with split-half reliability coefficients for preschool children of .79 and .78 for “Classification” and “Matrices,” respectively. The intercorrelation between the two subtests was .39 for this age group (Cattell et al., 1997). The total score of the two subscales was divided by 24 (the maximum available score), resulting in a score ranging from 0 to 1.

**Precursors of linguistic competencies.** Precursors of reading and spelling were measured by two subscales. One of these, measuring grammatical skills, was derived from the “Heidelberger Sprachentwicklungstest” (HSET), a language development test by Grimm and Schöler (1998) that measures the language abilities of children aged three to nine. In the chosen subtest, “Grammatical Structures,” children were asked to act out a given sentence using small dolls. The sentences ranged from relatively simple grammatical structures (e.g., “the elephant jumps”) to more complex ones (e.g., “Waldi permits Molli to lie down” and “The mother pets the cat that is being carried by the boy”), with a maximum possible score of 21. The other subtest was part of a measure of phonological awareness used by Weber, Marx, and Schneider (2007), measuring children’s ability to detect the initial sounds of words, which is an important component of phonological awareness. There were 10 items, with a maximum score of 10 points. The total scores obtained in the two subsets were divided by the respective maximum subtest scores of 21 and 10. The two resulting scores were added, and the sum was divided by 2, resulting in a score between 0 and 1. The internal consistency of these subscales is .85 (Cronbach’s alpha).

**Precursors of mathematical competencies.** Quantity-number competencies during the preschool years are an important precursor of mathematical competencies in early school years (Krajewski & Schneider, 2009) (Krajewski & Schneider, 2006, 2009a, 2009b). These core abilities were assessed using a test for young children developed by Krajewski (2003). A short version of this test was applied at MP 4, using subscales that measured knowledge of numbers and ability to count, mainly because these dimensions have proved to be the core preschool

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1 Further detail regarding this scale can be obtained from the authors.
precursors of mathematical achievement in elementary school. For the subscale relating to numbers, the numbers 1 to 20 were presented in large digits in random order, and the children were asked to name these numbers. For every correct answer, 0.5 points were awarded, resulting in a total of 10 points. There were 8 items in the subscale used to test counting ability. Children were asked to count forward as far as they could, gaining up to 4 points, depending on how far they could count without making a mistake. Another item asked them to count backwards from 5. Other items asked questions like “What number comes before/after 5?” The maximum possible score for this subtest was 12. The sum of both subtests was divided by 22, resulting in a total score ranging from 0 to 1. The internal consistency of these subscales was high (Cronbach’s alpha = .92).

**Parent questionnaire.**

*Duration and variety of media use.* Parents were asked to fill out a questionnaire regarding the children’s media experience. As well as general questions (child’s name, age, etc.), the questionnaire asked questions about the different types of media the child was exposed to in their daily environment (TV, cinema, computers, books, comics, newspapers, magazines, radioplays, radio) and about duration of daily media use (in hours, to include all media as mentioned). From these data, we calculated one score for variety and one for duration of the child’s media use.

*Socioeconomic status (SES).* The questionnaire also asked for the parents’ profession, which we used to estimate the family’s socioeconomic status. Studies of competencies acquisition in young children often reveal an influence of parents’ SES. For this reason, we assessed this variable at MP 1. We did not ask for this information directly (such as yearly income), however, because of prior experience that many parents would refuse to answer this question. Instead, both parents were asked in the questionnaire to state their profession. The SES of the family was then estimated using the Magnitude-Prestige Scale (Wegener, 1985; Wegener, 1988), a validated measure that is highly correlated with actual SES (Hadjar, 2004).

**Procedure**

At each MP, the participants were examined in individual sessions in the laboratory. Because the participants were so young and were not familiar with the laboratory situation, one parent was allowed to accompany them into the room. Before testing began, there was a warm-up session in which the experimenter introduced herself and tried to make the child comfortable with the situation. Once the child had settled in, the parents were asked to have a seat in the back of the laboratory and not to help the child with any answers. They were handed the questionnaire and asked to fill it out during the testing session.

Testing at MP 1 lasted approximately 50 minutes. During this time, the two subscales of the Cultural Fair Intelligence Test (Cattell et al., 1997) were completed first. After a break, during which the children were invited to eat, drink, and move around, participants were presented with the online media sign literacy test. To begin, the children received a short training session with the computer mouse. The online tutor explained how to use the mouse and invited the children to complete several tasks, such as moving the mouse to certain places and clicking on pictures. Once the child had become accustomed to using the mouse, the online portion of the media sign
literacy test was administered, including the first nine subscales. The online tutor explained each task and praised the children for their effort. Unlike the mouse training session, the tutor praised the child regardless of the correctness of their responses in the actual test.

The tenth and final subscale was administered offline. The child was first introduced to several Playmobil dolls and materials. They were then shown one practice item—a short film clip that featured some of the Playmobil dolls. The experimenter explained that they should re-enact the film they had just seen and then handed out all the dolls and materials that featured in the film. Once the child understood the task, the first test trial commenced. The experimenter rated the correctness of the re-enactment according to previously defined criteria.

At MP 4, precursors of linguistic and mathematical competencies were tested in addition to intelligence and media literacy. This final test session therefore included one extra break and lasted approximately 20 minutes longer than the previous three sessions.

**Results**

We first assessed the development of media sign literacy and intelligence over all MPs by conducting two analyses of variance for repeated measurements, with media sign literacy and intelligence as dependent variables. Next, we explored the interrelationships between media sign literacy and intelligence throughout the whole inquiry period, as well as the precursors of language and mathematical skills assessed at MP 4 only. Subsequently, the results of the longitudinal analysis were used to assess the effects of media sign literacy and intelligence on mathematical and linguistic competencies. To this end, structural equation modeling (SEM) procedures were used to test the assumption that media sign literacy and intelligence have long-term effects on the precursors of language and mathematical skills.

**Development of Media Sign Literacy and Intelligence over the Period of Inquiry**

To test the development of media sign literacy and intelligence, analyses of variance for repeated measurements were calculated for each variable across all four MPs. The calculations indicated significant effects for media sign literacy ($F(3, 372) = 335.70, p < .001$) and for intelligence ($F(3, 372) = 186.40, p < .001$). As expected, the results reflected normal age-related development, and both variables showed relatively constant increases over time (see Figure 1). The increase was significant for every interval ($p < .001$).

![Insert Figure 1 about here](image1.png)

Table 1 shows the mean scores, standard deviations, and ranges of the subscales for media sign literacy and intelligence at MP 1 and the subscales for precursors of academic competencies at MP 4. As shown in Table 1, scores on the subscales for media sign literacy vary between .36 (subscale 5) and .72 (subscale 4), indicating that the envisaging of characters’ perspectives was the most difficult task while the detection of comic characters’ emotions was the easiest.

![Insert Table 1 about here](table1.png)

The participants’ sex did not have a significant influence on the precursors of academic skills (mathematical competencies: $t(123) = 1.28, p = .201$; linguistic competencies: $t(123) = -0.84, p =$
We calculated correlations between sex, SES of both parents, and the variety and duration of media use with media sign literacy, intelligence, and precursors of linguistic and mathematical skills. The variety of media use correlated significantly with media sign literacy at all MPs (with an $r$ between .24 and .33) but duration of media use did not. This can be seen as evidence that media sign literacy is influenced by the range of different symbol systems utilized by the child rather than by the extent of exposure to a specific medium. There were no other significant correlations with media sign literacy. In relation to intelligence and precursors, a few correlations reached the significance level. (See Table 1 in the Appendix for an overview.)

**Inter-Correlations among Measures of Media Sign Literacy, Intelligence, and Precursors of Linguistic and Mathematical Competencies**

As seen in Table 2, media sign literacy and intelligence were positively related across all four MPs. Correlations between media sign literacy and intelligence (between $r = .30$ and $r = .48$) indicate that these constructs jointly explain between $R = .10$ and $R = .23$ in the variance. Additionally, there were significant positive correlations between both media sign literacy and intelligence and the four measures of linguistic competencies. This was also true for the four measures of mathematical competencies, other than at MP 1, where no significant effects could be found between intelligence and linguistic competencies ($r = .15, p = 0.91$). This indicates that both variables (media sign literacy and intelligence) are related to mathematical and linguistic competencies. However, correlations between media sign literacy and linguistic competencies were slightly higher than those between intelligence and linguistic competencies, regardless of MP, whereas correlations between media sign literacy and mathematical competencies were numerically slightly lower than correlations between intelligence and mathematical competencies (see Table 2).

Table 2 in the Appendix provides an overview of the correlations of single subscales of the media sign literacy test with total media sign literacy score, as well as with intelligence and linguistic and mathematical competencies. Correlations of media sign literacy subscales with total score were all highly significant, varying between .37 and .53. Correlations of subscales with intelligence and academic precursor skills were low to medium; some of these reached the level of significance.

Subsequent analyses were performed to resolve the question of whether media sign literacy or intelligence is a better predictor of mathematical and language competencies.

**Impact of Media Sign Literacy and Intelligence on Subsequent Mathematical and Linguistic Competencies in a Structural Equation Model**

The analyses reported in the preceding section confirmed a positive association between media sign literacy and mathematical and linguistic competencies as well as between intelligence and the relevant skills. However, these analyses did not support any firm conclusions about structural interrelationships among the variables assessed in the longitudinal study. For that reason, a causal model was specified to test whether media sign literacy and intelligence could predict precursors of mathematical and linguistic competencies. More precisely, the model assessed the
impact of media sign literacy and intelligence (measured at four MPs) on mathematical and linguistic competencies; the latter were assessed only at MP 4. In this model, media sign literacy and intelligence served as exogenous (independent) factors that influenced both mathematical and language competencies, which served as endogenous (dependent) factors. Overall, the model fit was acceptable, indicating that the theoretical assumptions were compatible with the data: $\chi^2(149, N = 125) = 190.7, p < .05$, root mean square error of approximation (RMSEA) = 0.05, comparative fit index (CFI) = .97 and Standardized Root Mean Square Residual (SRMR) = 0.05.

As expected from the correlational analyses, a mutual relationship was found for intelligence and media sign literacy at MP 1 ($r=.36, p < 0.01$). Additionally, there was significant first-order autoregressive development for intelligence over the whole period of inquiry—that is, intelligence at each MP predicted intelligence at the next MP. For media sign literacy, on the other hand, a more divergent pattern of significant paths coefficients was found. Scores obtained at MP 1 predicted results at all subsequent MPs. Although score at MP 2 was a significant predictor of media sign literacy at MP 4, there was no auto-correlative structure between MPs 2, 3, and 4.

As shown in Figure 2, media sign literacy at MP 2 had a direct and significant effect on mathematical competencies and an indirect effect on precursors of reading and writing skills. Media sign literacy at MP 4 allows prediction of precursors of reading and writing skills by direct link. Intelligence, on the other hand, shows a direct link to precursors of mathematical skills at MP 4 but no direct link to precursors of reading and writing skills. The parsimonious path model shows a rich structure of interconnectedness between media sign literacy and intelligence. Media sign literacy at MP 1 predicts intelligence at MP 2, whereas intelligence at MP 2 shows direct links to media sign literacy at MP 3 and MP 4.

The longitudinal study demonstrates that children with higher abilities in media sign literacy also show greater ability in precursors of mathematical and reading and writing skills. This suggests that media use can support acquisition of academic skills. Media sign literacy can be conceived of as a unique symbolic-cognitive domain, which is to some extent tied to intelligence but also clearly differs from nonverbal intelligence.

**Discussion**

**Explanation of the Effect of Media Sign Literacy on Precursors of Academic Skills**

The studies referred to in the opening section suggest that media literacy is central to the development of children’s academic competencies. However, empirical research on media literacy and its relevance for young children’s academic development is still in its infancy. To explore the impact of media sign literacy in early childhood, we analyzed the relationship of media sign literacy to linguistic and mathematical competencies and intelligence. As a principal finding of the longitudinal study, media sign literacy was shown to be a reliable predictor of the two academic competencies. The structural equation model confirmed the direct and significant effect of media sign literacy on linguistic competencies at MP 4 and on mathematical competencies at MP 2.
One possible explanation of this finding relates to the transfer of symbolic meaning that becomes possible once representational insight is reached (DeLoache, 2000). Children are able to transfer relations and structures learned in one symbolic domain to another domain (Marzolf & DeLoache, 1994; Troseth, Casey, et al., 2007). For this reason, we assume that children can transfer knowledge of symbols acquired through media sign literacy to the symbol systems of numbers and digits as well as to written letters and words.

Explanation of the Connection between Media Sign Literacy and Intelligence

We found that media sign literacy and intelligence share a mean common variance of about $R = .16$, indicating some degree of overlap. This result is not entirely surprising. Consider an adult or child undertaking an intelligence test; it is effectively impossible to complete this task without a high level of media sign literacy. For example, to place pictures in the correct order, it is necessary to understand the semiotic status of pictures and syntagmas in coherent narrative sequences. To make an inference based on a sequence of figurative patterns (e.g., the matrices task in the CFT), it is necessary to understand the figurative elements and generative rules constituting the patterns, and so the understanding of symbols and their patterns is highly relevant when solving intelligence tests.

The physical symbol systems approach (Newell & Simon, 1963) views human thinking as a kind of symbol manipulation. Cognitive operations are modeled as symbolic operations, executed on internal representations. While the construct of intelligence focuses on internal representations, the construct of external cognition (Rogers, 2004), including media sign literacy, entails the interplay of internal and external representations in information processing. From this external cognition perspective, it is self-evident that the use of symbolic external representations, which are present during information processing and match internal representations, should result in a positive interplay between external and internal representations. On this view, children who can activate an elaborate interaction of internal and external representations are likely to develop a high level of media literacy. On the other hand, children exhibiting a higher level of media sign literacy should also be more advanced manipulators of internal symbol systems. At the level of manifest variables, this connection accounts for the correlations between media sign literacy and intelligence reported in the present study.

Based on this perspective, it is also possible to explain the existence of correlations and causal connections between media sign literacy and precursors of academic skills, as these skills and their precursors are also tied to an understanding of symbol systems, more closely even than in intelligence tests. The learning of letters and words, digits and numbers, and operations that can be performed with those entities is always embedded in a triadic process of persistent interaction between cognitive concepts, abstractions of physical objects, and external representations. A high level of media sign literacy reflects an ability to perform this triadic interaction at a more skillful level. This ability to foster learning and to perform academic tasks is an aspect of media sign literacy that is independent of the common variance it shares with intelligence, which suggests that teaching media sign literacy in the preschool context may be a worthwhile endeavor.
The model by Schneider (2009) has connected intelligence, phonological awareness, and verbal information processing speed in kindergarteners with spelling skills in the 2nd grade of elementary school. Interestingly, in this model, early literacy in kindergarten served as an important predictor for spelling skills in the 2nd grade. Early literacy was operationalized by means of a letter-naming task that assessed children’s knowledge of grapheme–phoneme correspondences; a sign knowledge test realized as a letter-finding task; and a writing task. These tasks represent a specific subsample of media sign literacy tasks: a sub-dimension focused on the symbol system of letters as external representations of phonemes. Children who are skilled in media sign literacy are equipped to understand this specific graphemic symbol system when confronted with it in early childhood. For this reason, we propose that future studies should integrate media sign literacy as an additional variable.

**Limitations and Conclusions**

The study by Schneider (2009) also highlights a minor shortcoming of the present study. We used CFT tasks, which are assumed to be highly correlated with a general factor model of intelligence. However, in the path model described by Schneider (2009), verbal intelligence in particular exhibited a small but significant association with early literacy, suggesting that subsequent studies should include not only the general intelligence factor g but also verbal intelligence components.

The present study has shown that media symbolic literacy develops rapidly between the ages of about 4 and 6 years, and to acquire media symbolic literacy, it is necessary to use media. This is not to recommend that children should be heavy media users; rather, high media symbolic literacy should be associated with a variety of elaborate experiences in a wide range of different media. This recommendation is supported by our finding that media sign literacy is correlated with range of different media used rather than with duration of media use. Diergarten (2010) reported a similar finding, in that media sign literacy positively predicted the development of emotional knowledge in 4- to 6-year-old children while high media usage did not. However, a further shortcoming of the present study is that we based our measurement of media use solely on parents’ reports. This is not a reliable source, as some parents may have been dishonest about the actual extent of their children’s use of different media. Their answers may have been further blurred by difficulties in estimating children’s actual media use, and future research should therefore employ more valid measures, such as media diaries (e.g., Wright et al., 2002).

One advantage of our concept of media sign literacy is its proven predictive power in assessing children’s potential to acquire new knowledge through different media (Diergarten, Möckel, Nieding, & Ohler, sub). Children with high media sign literacy scores acquired knowledge from expository texts (presented via films or interactive hypermedia) much better than children with low media sign literacy scores. Children with high media sign literacy scores were found to be better able to acquire knowledge from expository texts (e.g., films or interactive hypermedia) than children with low media sign literacy scores. On a related point, 5-year-old children with high media sign literacy were able to construct emotional inferences based on auditory or audiovisual narratives (Diergarten & Nieding, 2015). Those with high literacy scores were not only able to infer the valence of textually implicit emotions but also captured emotions precisely, whereas those with low scores failed to infer emotions at all. These results support our claim
that early training in media sign literacy has a positive influence on children’s development of further important skills.

With particular regard to the lack of studies examining precursors and initial development of media literacy, the present article makes an important contribution to the existing body of research. Despite the study’s limitations, it is possible to conclude that media sign literacy develops in the preschool years and is positively related to precursors of academic skills—specifically, mathematical and reading and writing skills. These results are encouraging as to the likely positive effects of early media literacy training, not only on media literacy itself but also on other skills that depend on understanding and using symbols. We are currently designing a project to scrutinize this hypothesis further in a longitudinal analysis of a media literacy training program.

References


Hobbs, R. (1997). Literacy for the information age. In J. Flood, S. B. Heath, & D. Lapp (Eds.), *Handbook of research on teaching literacy through the communicative and visual arts* (pp. 7-14). New York, NY: Macmillan.


Schneider, W., & Näslund, J. C. (1993). The impact of early metalinguistic competencies and memory capacity on reading and spelling in elementary school: Results of the Munich


Table 1

Means, standard deviations, minimums and maximums of the subscales of media sign literacy and intelligence at the 1\textsuperscript{st} MP and the subscales of precursors of academic competencies at the 4\textsuperscript{th} MP

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$SD$</th>
<th>Min</th>
<th>Max</th>
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<td></td>
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<tr>
<td>Differentiation between several film genres</td>
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<td>.00</td>
<td>1</td>
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<td>.00</td>
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<td>.00</td>
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<td>.24</td>
<td>.00</td>
<td>.80</td>
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<td>.31</td>
<td>.00</td>
<td>1</td>
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<td>Symbolic understanding in everyday use</td>
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<td>.00</td>
<td>1</td>
</tr>
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<td>.00</td>
<td>1</td>
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<td></td>
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<td>Understanding grammatical structures</td>
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<td><strong>Total score</strong></td>
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Table 2

*Correlations among media sign literacy, intelligence, linguistic and mathematical competencies at the four MPs*

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<td>MP2</td>
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*Note.* *p < .05;**p < .01.
Figure 1. Increase in Media Sign Literacy and Intelligence over the whole enquiry period with four MPs (MP 1-MP 4).
Figure 2. Structural equation model showing the impact of media sign literacy and intelligence predictor measures over the whole enquiry period on mathematical and linguistic competencies assessed at the 4th MP.
## Appendix

*Correlations between participant sex, socio-economic status (SES) of mother and father, and variety and duration of media use with media sign literacy, intelligence, and linguistic and mathematical competencies*

<table>
<thead>
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<th>Linguistic</th>
<th>Math</th>
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<td></td>
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<td>-.03</td>
<td>-.12</td>
<td>-.07</td>
<td>-.01</td>
</tr>
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<td>SES mother</td>
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<td>.06</td>
<td>.13</td>
<td>.14</td>
</tr>
<tr>
<td>SES father</td>
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<td>.05</td>
<td>.08</td>
<td>.11</td>
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<tr>
<td>Variety of media use</td>
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<td>.24**</td>
<td>.33***</td>
</tr>
<tr>
<td>Duration of media use</td>
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<td>.15</td>
<td>.04</td>
<td>.03</td>
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</table>

*Note. *p < .05. **p < .01. ***p < .001.*
Correlations between the subscales of media sign literacy with the total scores of media sign literacy, intelligence, and linguistic and mathematical competencies at the 4th MP

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<th>Linguistic competencies</th>
<th>Mathematical competencies</th>
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Note. *p < .05. **p < .01. ***p < .001.