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On-line behavior and cognitive development

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ON-LINE BEHAVIOR AND COGNITIVE DEVELOPMENT

BY

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Abstract

Parents of 128 children in a rural elementary school provided information on home Internet access and children's online activities. Children were individually administered four measures of cognitive development (expressive language, metacognition, visual perception, and auditory memory) and were asked to define ten Internet terms (e.g., email, chat, website). The ability to define an Internet term was assumed to be indicative of experience with that application. Parent response to the open-ended item "what does your child do when he/she uses the Internet at home" was thematically organized into four types of Internet behavior: learn, play, browse, and communicate. Children's ability to correctly define Internet terms as well as parent reported online learning and communicating (but not playing and browsing) were associated with increased cognitive scores. Focused and goal-directed online activities (e.g., learning and communicating) are recommended for children 6 to 12 years of age.

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During an international survey across OECD countries, data suggested that almost all 15-year-olds in these countries (95%) have internet access at home. Roughly 18% of students by 2015 accessed the internet for the first time prior to the age of six (OECD, 2017). Within the United Kingdom, a third of 3–4-year-olds go online, a significant percentage that is still surpassed by countries such as the Netherlands (78%), Belgium (70%), and Sweden (70%) (Holloway et al., 2013). All trends indicate that the number of children accessing the Internet and the amount of time they spend online are steadily increasing (DeBell & Chapman, 2006; Livingston & Bober, 2005; Statistics Canada, 2004; U.S. Census Bureau, 2005). Within the short period between 2012 and 2015, access to an internet accessible tablet at home for students expanded by 30 percentage points. Smartphone access increased by 19 percentage points (OECD, 2017). Greenfield and Yan (2006) conceptualize "the Internet as a new object of cognition, neither a concrete artifact nor a visible social partner" (p. 393). From a developmental perspective, "the Internet is a cultural tool that influences cognitive processes and an environmental stimulus that contributes to the formation of specific cognitive architecture" (Johnson, 2006, p. 565).

The Internet and Cognitive Development

As children develop, their cognitive processes and abilities (e.g., language, metacognition, perception, and memory) mature in response to genetic and environmental forces (Garcia, Bearer, & Lerner, 2004). Environmental forces include parents, peers, schooling, and media (Gentile & Walsh, 2002). The Internet is not like other media "in the sense that it is used primarily for communication, information gathering, and games rather than for passively experiencing narrative stories" (Tarpley, 2001, p. 551). Further, different sites support (Dix, 2005), and different users require (Johnson, in press; LaRose & Eastin, 2004), variation in sensory stimulation and active involvement. In this regard, Internet use during the developmental years may have a greater cognitive impact than previous technological

innovations (Johnson, 2006). While video games are not dependent on the Internet, the Internet provides access to many gaming experiences. Approximately one-third of the time that children are online, they report playing games (Roberts et al., 2004). DeBell and Chapman (2006) concluded that Internet use promotes cognitive development in children, "specifically in the area of visual intelligence, where certain computer activities -- particularly games -- may enhance the ability to monitor several visual stimuli at once, to read diagrams, recognize icons, and visualize spatial relationships" (p. 3). Greene and Bavelier (2003) noted that on a range of visual attention skills, video game players out-performed those not exposed to video games. They concluded that "although video-game playing may seem to be rather mindless, it is capable of radically altering visual attention processing" (p. 536). Reportedly, visual-spatial skills such as mental rotation of shapes are superior in those who play video games (Sims & Mayer, 2002). In a comprehensive review of the literature, Subrahmanyam, Kraut, Greenfield, and Gross (2001) concluded that cognitive processes improve by playing video games.

According to early childhood educators, the Internet supports emergent literacy, builds problem-solving skills, and facilitates concept development (Lynch & Warner, 2004; Parette, Hourcade, & Heiple, 2000). Clements and Samara (2003) recommended Internet technology as a tool for improving children's learning through exploration, creative problem solving, and self-guided instruction. Fuchs and Wößmann (2005) claimed that the Internet helps children "exploit enormous information possibilities for schooling purposes and increase learning through communication" (p. 4). Jackson and colleagues (2006) provided low income children home-based Internet access and continuously recorded online behavior. "Findings indicated that children who used the Internet more had higher scores on standardized tests of reading achievement and higher grade point averages 6 months, 1 year, and 16 months later than did children who used the Internet less" (p. 429). Johnson (2006) cautioned that

"current anxiety surrounding children's Internet use should be for those whose cognitive processes are not influenced by the cultural tool" (p. 570).

Methods

Participants

Parents of children in first through sixth grade in a rural elementary school were sent an invitation to participate in the study. Participation required parents to complete a questionnaire and consent to cognitive-developmental assessment of their children. One hundred twenty-eight completed questionnaires and signed consent forms were returned to the school. Children (62 males and 66 females) ranged in age from 6 years, 4 months to 12 years, 5 months. With respect to the sample of children: 14.8% were in first grade; 12.5% were in second grade; 15.6% were in third grade; 25.0% were in fourth grade; 16.4% were in fifth grade; 15.6% were in sixth grade. Twelve of the 128 children were funded for special needs (e.g., communication disorder, learning disability, behavioral disorder, medical condition).

Measures

Participating parents completed a questionnaire on home Internet connectivity (e.g., dial-up or high speed, number of computers, years of home access) and child Internet behavior. The questionnaire included rating scales items (e.g., my child uses the Internet at home: never, rarely, a few times a month, a few times a week, everyday or almost every day) and the open-ended item, what does your child do when he/she uses the Internet at home? Individually, in a quite secluded room in the school, children were asked to define ten Internet terms. Examiners wrote the exact words that each child provided to orally-presented terms. Subsequently, a score of one was assigned for any indication of understanding (e.g., definition, example, function); zero was assigned if the child provided no response or an incorrect

response. Table 1 presents the ten Internet terms, sample correct responses, and the proportion of children who correctly defined each term.

Table 1. Number of Children Correctly Defining Internet Terms

Term	N/128	Percent
Internet	103	85.5%
Gamer	13	10.2%
On-line Game	82	64%
Cheats	46	35.9%
E-mail	101	78.9%
Chat	34	26.6%
Instant Message	39	30.5%
Website	89	69%
Search Engine	20	15.6%
Browser	1	00.8%

Three subtests from the Cognitive Assessment System (CAS; Das & Naglieri, 2001) and one subtest from the Wechsler Intelligence Scale for Children (WISC; Wechsler, 2003) were adapted as brief measures of children's cognitive development. The subtests were selected due to ease of administration and diversity of cognitive skills measured. The CAS has established reliability and validity (Johnson, Bardos, & Tayebi, 2003; Van Luit, Kroesbergen, & Naglieri, 2005). The WISC is the most widely used measure of children's cognitive functioning (Flanagan & Harrison, 2005). Four cognitive-developmental abilities were assessed; expressive language, metacognition, visual perception, and auditory memory. Expressive language was assessed with the vocabulary subtest of the WISC (children were asked to provide definitions of words); standard scoring criteria was maintained (Wechsler, 2003). With respect to the CAS, the matching numbers subtest measured metacognitive planning (find the two numbers that are the same in a series of numbers), the nonverbal matrices subtest assessed visual perception (select an option that best completes a matrix), and the word series subtest determined short-term auditory memory (repeat a string of words); standard scoring criteria was maintained (Das & Naglieri, 2001). A psychologist with extensive child assessment experience and a specially trained research assistant individually tested each of the 128 children. Completed in approximately 20 minutes, each individual assessment included administration of the four adapted cognitive subtests as well as oral presentation of the ten Internet terms. Rapport was initiated by in-class introduction of the examiners, explanation of testing procedures, and response to class questions. Rapport was further established by individual child-examiner interaction walking from the classroom to the testing room and as required upon entry into the testing room.

Results

Approximately 83% of the families reported home Internet access and, of those, almost 90% indicated that children used the Internet at home (all children used the Internet at school). On average,

parents reported having home Internet access for 5.2 years (minimum 2 months, maximum 12 years, SD 2.96). Almost 86% of parents with home Internet reported dial-up connection; 14.2% reported high speed service (the school had high speed Internet). Eighty-two per cent of families had a wired Internet connection, 11% had wireless, and 7% reported both. Slightly less than 80% of families with home Internet access had only one computer at home (mean 1.3, maximum 7). The rating scale item, my child uses the Internet at home, included five response-options (1 = never, 2 = rarely, 3 = a few times a month, 4 = a few times a week, 5 = everyday or almost every day). Parents, on average, expressed the perception that their children used the Internet at home a few times a month (mean rating 3.01). Based on a rating scale item that ranged from 1 (a few minutes) to 5 (many hours), parents reported that their children were typically online for approximately 40 minutes. With respect to the amount of time their children used the Internet at home, 89.7% of parents were satisfied, 6.9% wanted child use to increase, and 3.4% wanted child use to decrease. In response to the questionnaire item, I am happy with what my child does when he/she is online, 2.2% of parents selected the negative response-option and indicated that they wished their child engaged in more educational activities.

Thematic analysis of parent response to the open-ended item (what does your child do when he/she is uses the Internet at home) revealed four distinct categories or types of online behavior: learn (e.g., schoolwork, math practice, research for assignments), play (e.g., play games, have fun with friends), browse (e.g., visit websites, find things of interest), and communicate (e.g., email, chat). Approximately 17% of parents listed one type of online behavior, 35.9% listed two, 14.1% listed three, and 3.1% described all four types of online behavior. Almost 30% of parents did not respond to the open-ended item, including those without home Internet connection and those who reported that, despite connectivity, their children did not use the Internet at home. As illustrated in Figure 1, learning was

reported in 65 cases, playing in 57 the cases, browsing in 35 cases, and online communication was noted in 27 cases.

Significant cognitive differences emerged between children whose parents did and those who did not report at-home online learning and communication. Children who engaged in online learning demonstrated better expressive language (32.9 vs. 28.4, $t = 3.11$, $df = 125$, $p < .01$), better metacognitive planning (7.6 vs. 6.6, $t = 3.15$, $df = 124$, $p < .01$), and better auditory memory (10.2 vs. 9.3, $t = 2.02$, $df = 126$, $p < .05$) than children whose parents did not report online learning. Children who engaged in online communication demonstrated better expressive language (36.9 vs. 29.0, $t = 3.11$, $df = 125$, $p < .001$) and better metacognitive planning (8.0 vs. 6.9, $t = 2.75$, $df = 124$, $p < .01$) than children whose parents did not report online communication. Visual perception was not related to any type of parent reported Internet behavior. Online playing and browsing were unrelated to any measure of cognitive development. Table 2 presents the cognitive differences between children who did and those who did not correctly define the Internet terms. Numerous significant differences emerged, in every case favoring children who correctly defined the Internet term. For example, children who correctly defined the term online game scored significantly higher on expressive language, metacognitive planning, visual perception, and auditory memory than did children who could not define the term. Two terms (gamer and browser) were not related to any measure of cognitive development.

Figure 1. Frequency of Parental Response: What does your child do when he/she uses the Internet at home?

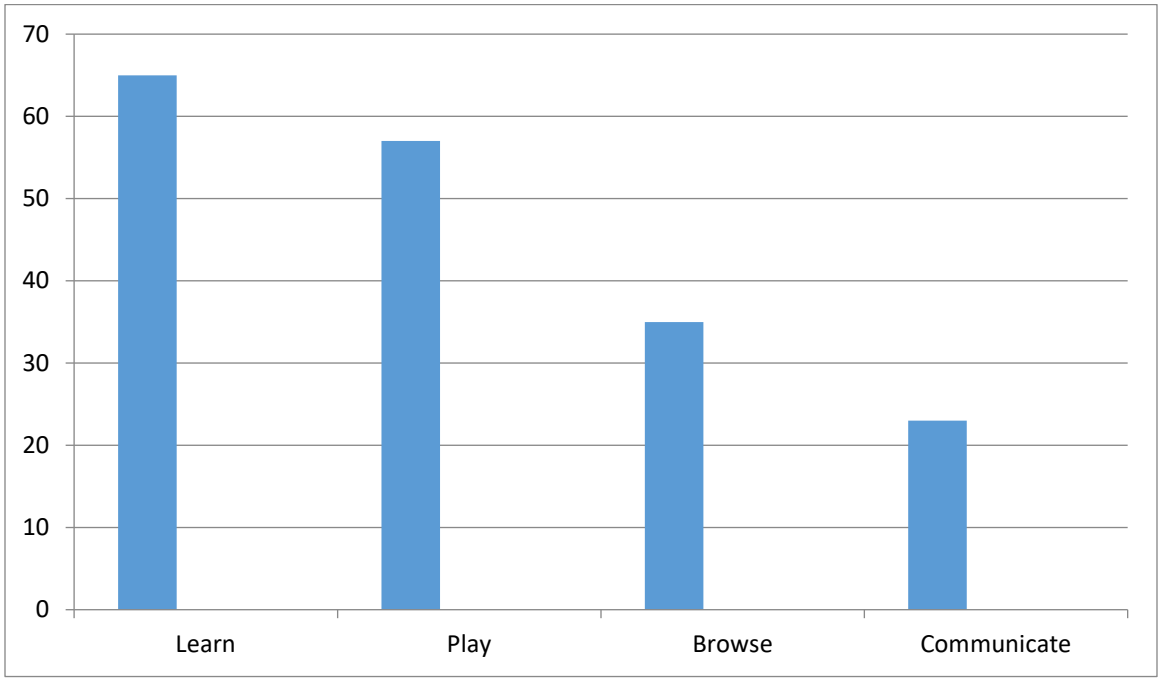

Table 2. Mean Scores a on Measures of Cognitive Development by Internet Terms

Internet Term		Expressive Language	Metacognition Planning	Visual Perception	Auditory Memory
Internet					
	Correct	32.7	7.6	14.9	10.2
	Incorrect	22.6	5.1	11.4	7.8
	t	6.15***	7.38***	3.52**	4.48***
Online Game					
	Correct	33.6	7.8	15.2	10.4
	Incorrect	25.6	6.0	12.7	8.6
	t	5.73***	5.94***	3.01***	4.14***
Cheats					
	Correct	35.4	7.7	15.7	10.6
	Incorrect	28.0	6.8	13.5	9.2
	t	5.31***	2.73**	2.66**	3.11**
Email					
	Correct	32.7	7.6	14.8	10.1
	Incorrect	23.2	5.4	12.2	8.3
	t	5.94***	6.28***	2.61*	3.36**
Chat					
	Correct	37.2	7.8		10.9
	Incorrect	22.6	6.9		9.3
	t	6.13***	2.36*		3.19**
Instant Message					
	Correct	37.3	7.8	16.2	10.6
	Incorrect	276.8	6.8	13.4	9.3
	t	7.00***	2.87**	3.2*	2.66**
Website					
	Correct	33.4	7.6	15.2	10.1
	Incorrect	27.8	6.8	13.4	9.3
	t	6.19***	5.00***	3.67***	2.59*
Internet					
	Correct	3.85		15.6	
	Incorrect	23.2		12.2	
	t	4.95***		2.73**	

p*<.03; **p < .01; ***p < .001

Significant cognitive differences emerged between children whose parents did and those who did not report at-home online learning and communication. Children who engaged in online learning demonstrated better expressive language (32.9 vs. 28.4, $t = 3.11$, $df = 125$, $p < .01$), better metacognitive planning (7.6 vs. 6.6, $t = 3.15$, $df = 124$, $p < .01$), and better auditory memory (10.2 vs. 9.3, $t = 2.02$, $df = 126$, $p < .05$) than children whose parents did not report online learning. Children who engaged in online communication demonstrated better expressive language (36.9 vs. 29.0, $t = 3.11$, $df = 125$, $p < .001$) and better metacognitive planning (8.0 vs. 6.9, $t = 2.75$, $df = 124$, $p < .01$) than children whose parents did not report online communication. Visual perception was not related to any type of parent reported Internet behavior. Online playing and browsing were unrelated to any measure of cognitive development. Table 2 presents the cognitive differences between children who did and those who did not correctly define the Internet terms. Numerous significant differences emerged, in every case favoring children who correctly defined the Internet term. For example, children who correctly defined the term online game scored significantly higher on expressive language, metacognitive planning, visual perception, and auditory memory than did children who could not define the term. Two terms (gamer and browser) were not related to any measure of cognitive development.

Table 3 presents a summary of significant differences in ability to correctly define Internet terms for children grouped according to parent reported vs. unreported at-home online behavior. For the most part, children who reportedly played and browsed online were not more likely to correctly define Internet terms than children whose parents did not report such online behavior. However, children who reportedly learned and communicated online were significantly more likely to correctly define Internet terms than children whose parents did not report such online behavior.

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Table 3. Mean Scores for Children with Reported vs. Unreported Online Behavior

Internet Term	Learn	Play	Communicate	Browse
Internet				
Reported		0.88	0.92	
Unreported		2.11	0.73	
t		2.11*	2.37*	
Online Game				
Reported		.72	.85	
Unreported		.56	0.58	
t		2.11*	2.37*	
Cheats				
Reported			.056	
Unreported			.31	
t			2.43*	
Email				
Reported		.88	1.00	
Unreported		.70	.75	
t		2.52*	3.11**	
Chat				
Reported			.63	
Unreported			.17**	
t			5.29***	
Instant Message				
Reported		.43	.70	
Unreported		.17	.20	
t		3.25**	5.63***	
Website				
Reported			.85	
Unreported			.65	
t			3.67*	
Search Engine				
Reported		.25	.33	
Unreported		.06	.11	
t		2.92**	2.01**	

p*<.03; **p < .01; ***p < .001

Discussion

Results of the current investigation confirm previous findings that a majority of elementary school children use the Internet at home (DeBell & Chapman, 2006) and that rural area's have limited broadband connectivity (Statistics Canada, 2004). The overwhelming majority of parents were satisfied with their children's online behavior and did not describe such behavior as excessive or problematic. Results also establish a relationship between at-home online behavior as reported by parents and cognitive development during middle childhood. Children whose parents reported online learning and communicating demonstrated better language and metacognition than children of parents who did not report such Internet behavior. At least two explanations are possible. Children who are cognitively well-developed use the Internet in ways that stimulate further cognitive development. Alternatively, children who use the Internet to learn and communicate may stimulate cognitive development, regardless of initial levels of development. DeBell and Chapman (2006) reported that 36% of children use the Internet for email and instant messaging. From a cognitive perspective, "both forms of online communication require expressive and receptive written language competencies which involve successive cognitive processing" (Johnson, 2006, p. 569). Merchant (2001) investigated female adolescent language in Internet chat rooms and concluded that "use of popular electronic communication is resulting in linguistic innovation within new, virtual social networks in a way that reflects more wide-reaching changes in the communication landscape" (p. 293). Current findings establish the developmental value of Internet use during middle childhood, particularly as a source of language stimulation. Children whose parents reported online playing and browsing were not cognitively different than children whose parents who did not report such Internet behavior. Past research reporting the cognitive benefits of playing video games has focused on adolescents and those in early adulthood (Farley-Gillispie & Gackenbach, 2006). While results of the current investigation do not suggest that online play behavior

has negative developmental consequences, there is no evidence that such use of the Internet facilitates cognitive development during middle childhood. Since visual perception was not related to any type of parent reported at-home Internet behavior, there is also no evidence to support the claim "that computer use has changed the balance of cognitive skills from the verbal to the visual" (Subrahmanyam et al., 2001, p. 96). Current findings do not unanimously support the developmental value of at-home Internet use during middle childhood. Instead, specific patterns of online behavior (i.e., learning and communication) may stimulate specific types of cognitive development (e.g., expressive language and metacognitive planning). Children's ability to define Internet terms also related to cognitive development during middle childhood. In the current context, the ability to define an Internet term was assumed to reflect children's experience with that application. Children who correctly defined Internet terms out-performed children who did not on every measure of cognitive development. Several explanations are possible. Children, who were more cognitively developed, benefited more from online experience than children who were less cognitively developed and, thus, were more likely to correctly define Internet terms. Alternatively, children who correctly, as opposed to incorrectly, defined Internet terms may have more online experience; such increased online experience may stimulate cognitive development, regardless of initial levels of development. Parent report of children's at-home online behavior and children's ability to define Internet terms, although related, did not measure equivalent constructs. In one case, parents were asked a direct question (what does your child do when he/she uses the Internet at home) and their responses were organized into four behavioral categories (i.e., learn, play, browse, and communicate). In the other case, online behavior was inferred from children's ability to define Internet terms. If ability to define terms reflects experience with Internet applications, parent-reported online behavior should relate to specific terms. For example, children whose parents reported online playing should be more likely to define gaming terms (i.e., gamer, online game, cheats) than

children whose parents did not report such online behavior. This was not the case. Children whose parents reported at-home online learning and communication were significantly more likely to define Internet terms compared to children whose parents did not report such online behavior. Children whose parents reported online playing and browsing did not differ in their ability to correctly define Internet terms from children whose parents did not report such at-home Internet behavior. Children's capacity to define Internet terms is a measure of global cognitive ability (Table 2) that relates to patterns of online behavior (Table 3). Online behavioral categories (learn, play, browse, communicate) emerged from thematic analysis of parent response to the open-ended questionnaire item. In this regard, the proposed types of Internet behavior reflect abstraction and assumption. Alternative abstraction is possible. For example, parent description of children's at-home online behavior is dichotomized into directed vs. undirected or focused vs. unfocused. Descriptors categorized as learn (e.g., schoolwork, math practice, research for assignments) and communicate (e.g., email, chat) reflect goal-directed and focused behavior; descriptors categorized as play (e.g., play games, have fun with friends) and browse (e.g., visit websites, find things of interest) refer to behavior that is unfocused and undirected. Indeed, Hope (2005) argued that children's virtual play "is essentially a learning activity" (p. 363).Thus it may be that focused and goal-directed Internet behavior, not specifically learning and communicating, facilitates cognitive development during childhood. Implications for Theory, Research, and Practice Socio-cognitive theorists (Bruner & Olson, 1977; Luria, 1976; Piaget & Inhelder, 1973; Vygotsky, 1978) propose a continuous spiralling relationship between cognitive development and environmental stimulation, that is, cognitive ability causes the individual to seek out stimulating experiences, which increases cognitive ability, which causes the individual to seek out more stimulating experiences, and so on. Current findings may be interpreted from a similar perspective; cognitive ability influences virtual behavior, which causes increased cognitive ability, which in turn causes the child to seek out more

stimulating online experiences, and so on. During middle childhood, cognitive development mediates, and is mediated by, online behavior. The relationship between at-home online behavior and Internet use in other contexts was not addressed in the current investigation. Because all children in the sample attended the same elementary school and because rural schools typically have stable student populations, school-based Internet experience was assumed equivalent across children. However, Gibson and Oberg (2004) noted that the quality of school-based Internet experience varies widely across classrooms. Internet behavior at school and with friends likely influences cognitive development during middle childhood. Subsequent research may clarify the relationships between Internet behavior in different contexts and the extent to which cognitive development is differentially affected by such contexts. Fuchs and Wößmann (2005) reported that, when socio-economic factors are controlled, there is "a negative relationship between home computer availability and student achievement, but a positive relationship between home computer use for Internet communication and educational software" (p. 581). In the current investigation, children who learned and communicated online (or who engaged in otherwise goal-directed and focused behavior) were cognitive more developed than children who played and browsed. Children who learned and communicated online, compared to those who played and browsed, were better able to define Internet terms. During the elementary school years, all children should be encouraged to use the Internet at home for purposes of learning and communicating, but not necessarily for undirected and unfocused activities such as playing and browsing.

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