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Internet Use and Child Development: The Techno-Microsystem

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ABSTRACT

Ecological systems theory assumes that child development is the consequence of ongoing reciprocal and spiraling interactions between the child and his/her microsystem (immediate home, school, and community environments). The increasing presence of digital technologies in children's immediate environments suggests the need for the proposed theoretical *techno-microsystem*. The ecological techno-microsystem situates the developing child in the context of Internet use in home, school, and community environments. Preliminary validation of the ecological techno-microsystem requires description of children's uses of the Internet across three environments and comprehensive measures of child development. Ninety-one children (37 males and 54 females; mean age 10.7 years) completed rating scales of their Internet use. Additionally, parents and teachers completed rating scales of child social, emotional, physical, and cognitive development. Significant correlations between specific uses of the Internet in specific contexts and specific measures of child development support the theoretical utility of the ecological techno-microsystem. The developmental consequences of Internet use varied as a function of elements of the microsystem (e.g., home and school characteristics) and elements of the technology (e.g., instant messaging versus email).

INTRODUCTION

When asked about their activities the previous day, 22% of American 8 to 10 year old children indicated that they had visited websites (Roberts, Foehr, & Rideout, 2005). Approximately 20% of Canadian 9 year old children access the Internet through their own personal computer (Media Awareness Network, 2006). The Office of Communication (2007) reported that 7% of British 10-year-olds have a webcam. In Australia, nine in ten families have home Internet connectivity and 75% have broadband access (Australian Communications and Media Authority, 2007). Trends indicate continued increase in the number of children accessing the Internet, the amount of time they spend online, and the complexity of their online behavior (Livingstone & Helpsper, 2007). Currently, there are two conflicting public anxieties surrounding children and the Internet; first, that the Internet may harm children, for example, by exposure to inappropriate content and, second, that children without Internet access are socially and educationally disadvantaged (Jackson et al., 2006; Sandvig, 2003). In either case, the Internet is viewed as an environmental element with potential developmental impact. Such a view is increasingly supported by research findings and represented in theoretical models.

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Internet Use during Childhood: A Review of Recent Literature

Common uses of the Internet during childhood include communicating (e.g., email), accessing information (i.e., visiting websites), and playing games (Johnson, 2006). Bruner (2005) maintained "that our minds appropriate ways of representing the world from using and relating to the codes or rules of available technology" (p. x). According to Johnson and Johnson (2008), children who used the Internet at home for learning and communicating demonstrated better language and metacognition than children who did not report such online behavior. Valkenburg and Peters (2007) found that socially-comfortable children communicated online more than did socially-anxious children. Boys who used email, compared to boys who did not, were more cognitively sophisticated and more popular with peers (Johnson & Buck, 2009). Nonetheless, excessive use of screen media such as the Internet has been linked to childhood obesity (Vandewater, Shim, & Caplovitz, 2004).

A popular use of the Internet for both children and adults is playing games (Hammer & Black, 2009). Van Deventer and White (2002) observed proficient 10- and 11-year-old video gamers and noted extremely high levels of self-monitoring, pattern recognition, and visual memory. 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). Playing video games, however, has also been linked to childhood distractibility, over-arousal, hostility, and aggression (Anderson, Gentile, & Buckley, 2007).

From an educational perspective, the Internet helps children "exploit enormous information possibilities for schooling purposes and increase learning through communication" (Fuchs & Wößmann, 2005, p. 4). Li and Atkins (2004) noted that computer exposure during the preschool years was associated with subsequent school readiness. Kumtepe (2006) observed that computer literate children were rated by their teachers as demonstrating better social skills than children less computer proficient. Reportedly, Internet use during childhood supports emergent literacy and facilitates concept development (Ertl & Plante, 2004; Lynch & Warner, 2004). McLean Cole and Hilliard (2006) found that reading skills in a sample of third grade children increased more with web-based than with traditional literacy instruction. Jackson and colleagues (2006) provided low income children with home-based Internet access and continuously recorded time online. "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). Typically, however, school Internet access is restricted to protect children from inappropriate content and potential online predators (Livingstone, Bober, & Helpsper, 2005). While restricted Internet access may protect children, it also restricts access to developmentally-appropriate websites. Salpeter (2008) cautioned that schools need to "develop a new generation of knowledgeable digital citizens who can operate in the unregulated online world" (p. 24).

Internet use during childhood occurs at home, school, and, to a lesser extent, in the community (Palfrey & Gasser, 2008). Kerawalla and Crook (2002) noted that parents took few steps to orchestrate the content of children's online activities and rarely became directly involved in those activities. Cho and Cheon (2005) surveyed families and found that parents' perceived control, obtained through shared web activities and family cohesion, reduced children's exposure to negative Internet content. Lee and Chae (2007) reported a positive relationship between parental mediation techniques (website recommendation and Internet co-use) and children's educational attainment. Johnson, Code, and Zaparyniuk (2007) found that at-home online learning and communicating (but not playing and browsing) were associated with advanced child development in expressive language and metacognitive planning. Steeves and Webster (2008) concluded that "parental supervision cannot adequately protect children who have integrated the Net most fully into their social lives, especially given the high premium that children place on the use of the Net to talk to friends and explore social roles" (p. 4).

In comparing home-based and school-based computer activity, Murphy and Beggs (2003) observed that, at home, children choose their own activities, have ample time for exploration, and learn incidentally. In contrast, at school, teachers control activities, computer time is limited, and learning is teacher-directed. Based on detailed interviews and repeated observation of six children (three boys and three girls), Burnett and Wilkinson (2005) concluded that creative problem solving was evident in home-based, but not necessarily school-based, use of the Internet. Johnson and Buck

(2009) reported no gender differences in school-based Internet use and only one gender difference in home-based use. Girls were significantly more likely than boys to report using email at home.

Review of the literature supports the conclusion that Internet use during childhood is associated with both positive and negative developmental outcomes. Additionally, there is considerable support for the assumption that the contexts of Internet use mediate the relationship between online activities and child development. A conceptual framework is required, one that considers the effect of Internet use on all aspects of child development across all environmental systems (i.e., home, school, and community).

The Ecology of Child Development

Ecological theory provides a comprehensive view of environmental influences on development by situating the child within a system of relationships affected by multiple levels of the surrounding environment (Darling, 2007; Johnson & Johnson, 2008). Bronfenbrenner (1979, 1989) organized the contexts of development into five nested environmental systems, with bi-directional influences within and among systems. The *microsystem* refers to direct or immediate interactions (i.e., family, peers, and school). The *mesosystem* is comprised of connections between immediate environments (e.g., home-school interactions). The *exosystem* includes settings that indirectly affect child development (e.g., parent's workplace). The *macrosystem* refers to social ideologies and cultural values. The *chronosystem* highlights the effect of time on all systems and all developmental processes. As his theory evolved, Bronfenbrenner (2005) proposed a bio-ecological perspective, which views the child's biology (e.g., genetics) as part of the microsystem.

Ecological systems theory (Bronfenbrenner, 1977) emerged prior to the Internet revolution and the developmental impact of then available technology (e.g., television) was conceptually situated in the child's microsystem. Johnson and Puplampu (2008) recently proposed the ecological *techno-subsystem* a dimension of the microsystem which includes child interactions with both human (e.g., communicator) and nonhuman (e.g., hardware) elements of information, communication, and recreation digital technologies. Presented in Figure 1, the developmental impact of Internet use during childhood is, theoretically, mediated by techno-subsystem interactions which occur in the microsystem. To illustrate, in industrialized nations, elements of children's microsystem (e.g., home, school, and community) are affected by the Internet (e.g., online communication with peers). School Internet portals are mesosystemic, allowing parents online access to their children's homework assignments, attendance records, and grades. Parent use of the Internet at work, an element of the exosystem, may indirectly affect children's home Internet access. The macrosystem reflects selective cultural endorsement of Internet uses (e.g., as a tool for learning but not as a mechanism of social deviance) which are expressed in home, school, and community environments. Internet use may be particularly sensitive to major life changes such as starting school and the transition to high school (i.e., the chronosystem).

While the techno-subsystem (Johnson & Puplampu, 2008) highlights the importance of technology in children's development, it fails to provide precise description of the mechanisms of influence. Specific uses of the Internet as well as specific contexts of Internet use are linked to developmental outcomes during childhood. In this regard, theoretical models of childhood Internet use should reasonable include the differential effects of various uses across contexts of use. As depicted in Figure 2, the proposed ecological *techno-microsystem* constitutes departure from two- dimensional representation of environmental influences on child development. Instead, child social, emotional, cognitive, and physical development are conceptualized as the consequence of ongoing reciprocal and spiraling interactions between child characteristics (i.e., bio-ecology) and use of communication, information, and recreation technologies (i.e., techno-subsystem) across home, school, and community environments (i.e., microsystem).

In Figure 2, the microsystem rings surrounding the developing child are fluid and the descriptors in the rings are for purposes of illustrations. That is, child developmental outcomes are typically conceptualized in terms of domains which include social, emotional, cognitive, and physical. But child development is holistic (e.g., physical development includes brain changes and brain changes affect and are affected by cognitive development). Further, online behavior is not meaningfully described as use of communication, information, and recreation digital technologies. Online behavior "refers to organized (e.g., search) and unorganized (e.g., browse) interactions with both human (e.g.,

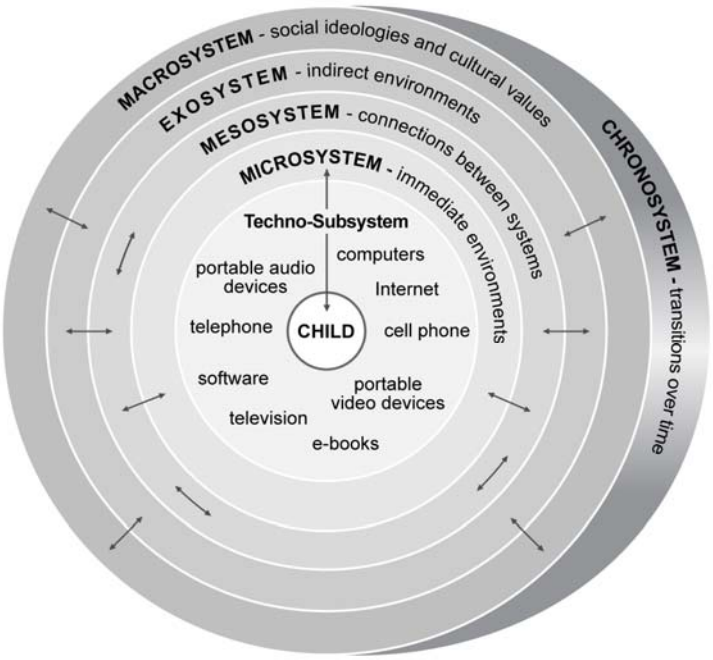

Figure 1: The Ecological Techno-Subsystem (Johnson & Puplampu, 2008)

chat) and nonhuman (e.g., database) elements in online environments" (Johnson & Kulpa, 2007, p. 773). Theoretically, the techno-microsystem has the capacity to, for example, coordinate children's learning experiences across home, school, and childcare environments, protect children from harmful at-home online experiences by community-based web-awareness initiatives, and prioritize school-based hardware for children without home connectivity.

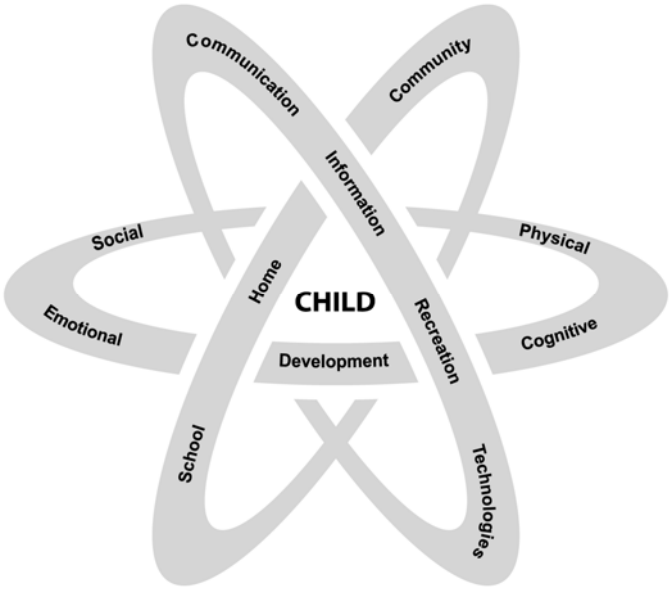

Figure 2: The Ecological Techno-Microsystem

Preliminary validation of the techno-microsystem requires measurement of two variables: 1) children's uses of the Internet across three immediate environments and 2) child social, emotional, cognitive, and physical development. Measuring such variables in children is labour-intense (Johnson, 2007); relationships are more evident with a large sample size. Children's use of the Internet is commonly described by directly asking children (Livingston et al., 2005; Media Awareness Network, 2006; Roberts et al., 2005). Completed by children, simple rating scales of specific and general online activities across three environments (home, school, and community) can be group-administered to allow for increased sample size (Johnson & Buck, 2009). Factor analysis has confirmed the theoretical utility 15 rating scale items: five uses (Internet, email, instant message, play games, and visit websites) across three environments (home, school, and community; Johnson, in press).

METHOD

Parents of children in third through sixth grade attending an elementary school in western Canada were asked to: 1) allow their children to complete a rating scale on Internet use, 2) permit teachers to rate aspects of their children's development, and 3) complete a brief questionnaire which included demographic queries and child development rating scale items.

Participating Children

Ninety-one children (37 males and 54 females) returned signed research participation consent forms. Twenty-one of the children were in third grade, 22 were in fourth grade, 17 were in fifth grade, and 31 were in sixth grade. The youngest child in the sample was 8.3 years old and the oldest child was 12.9 years (mean age 10.7 years). The majority of parents (87.5) described their family type as traditional, 10% described their families as blended, and 2.5% indicated single-parent family type. All fathers and 71.2% of mothers reported being employed (full-time or part-time).

Measures

Sent home via the school and attached to the research participation consent form, parents provided demographic information that described families and also rated their children in terms of four questionnaire items, one for each of social, emotional, physical, and cognitive development. Each child's teacher also rated four items that assessed each of these aspects of development for each participating child. Table 1 provides parent and teacher rating scale items, response options, and descriptive statistics for the sample of participating parents and teachers. Exact wording necessarily differed across parent and teacher rating scale items. Teachers completed numerous rating scales (i.e., one for each participating child in his/her classroom) and thus items typically included fewer words and more technical terminology, for example, the teacher cognitive rating scale item, *General Ability (e.g., memory, problem solving).*

Based on previously validated instruments (Johnson, in press; Johnson & Buck, 2009), child Internet use was determined with 15 general and specific rating scale items; five items queried home use (e.g., *I use the Internet at home*), five items queried school use (e.g., *I visit websites at school*), and five items queried community use (e.g., *I use email at someone else's house*). Completed in their classrooms toward the end of the school year, children rated each of the Internet use items on a four-point scale (1 = never or hardly ever, 2 = once or twice a month, 3 = once or twice a week, 4 = every day or almost every day). While items are simplistic and subject to confusion (e.g., online games are accessed by visiting websites), during data collection, no child sought clarification in such regard, although some children asked for the meaning of words (e.g., instant message).

Data Analysis

Frequency of Internet use (i.e., communicating with email and instant message, playing online games, and visiting websites) at home, school, and in the community (i.e., someone else's house) was determined for the sample of children. Correlational analysis revealed relationships between child-reported Internet use, child characteristics (e.g., age) and child social, emotional, physical, and cognitive development as rated by parents and teachers.

Table 1: Parent and Teacher Ratings of Child Development

	Development	Mean	SD
Parent Ratings			
My child has _____ friends 1 2 3 4 no a few several many	Social	3.62	.590
My child enjoys physical activity (sports or dance). 1 2 3 4 never always	Emotional	3.00	.641
My child is learning ____ children in his/her grade 1 2 3 4 5 slower than about the same as faster than	Physical	3.27	.759
My child is able to control his/her emotions 1 2 3 4 never always	Cognitive	3.30	.840
Teacher Ratings			
Classroom popularity 1 2 3 4 5 very low average very high	Social	3.28	1.028
Ability to control emotions 1 2 3 4 5 very low average very high	Emotional	3.36	.825
Physical ability (e.g., gym) 1 2 3 4 5 very low average very high	Physical	3.33	.936
General Ability (e.g., memory, problem solving) 1 2 3 4 5 very low average very high	Cognitive	3.32	.732

RESULTS

Table 2 presents the proportion of children selecting each response option for the 15 Internet use rating scale items. Only 20% of children reported *never or hardly ever* using the Internet at home; less than 9% reported *never or hardly ever* using the Internet at school; 56.7% reported *never or hardly ever* using the Internet at someone else's house (i.e., community use). In general, Internet communication (i.e., email and instant message) in the community was rare, although, in almost 30% of cases, children reported using the Internet at someone else's house to play games and visit websites *once or twice a month*. As child age and grade increased, Internet use tended to increase; correlational strength was strongest for school-based Internet use. Such correlations, because anticipated, provide support for the validity of the Internet use rating scale items used in this investigation. Perhaps because instant messaging was uncommon at school and in the community, correlations with age and grade failed to reach significance.

As expected, parent and teacher ratings of the four child development items were mildly to moderately correlated (Table 3) suggesting that the rating scales used have some degree of validity. Parent and teacher ratings of children's cognitive development and physical development correlated .66 and .50, respectively ($p < .001$, in both cases) suggesting that parents and teachers, in making

evaluations, responded to similar child characteristics. In contrast, correlations between parent and teacher ratings of children's emotional development failed to reach significance, although item wording was identical (*My child is able to control his/her emotions* and *Ability to control emotions*). It may be that teachers, compared to parents, have higher expectations of children's emotional control. Alternatively, it may be that children behave differently at home and school in terms of emotional self-regulation. The pattern of correlational significance between parent and teacher ratings of child development items establishes, at least to some extent, the validity of both. Parent and teacher ratings of child development should be similar, but not identical.

Table 4 summarizes significant correlations between parent ratings of child development and child ratings of Internet use. Emotional development was not related to any type of Internet use in any context (i.e., home, school, or community). Social development as rated by parents, in contrast, was related to email use at home, Internet use at school, and instant messaging and visiting websites at someone else's house. As playing Internet games at school increased, parent ratings of child physical development tended to decrease. As instant messaging at school increased, parent ratings of cognitive development tended to decrease.

Table 5 summarizes significant correlations between teacher ratings of child development and child ratings of Internet use. Emotional development and physical development were not related to any type of Internet use in any context (i.e., home, school, or community). In contrast to parent ratings, social development as rated by teachers only related to child Internet use at home. Cognitive development as rated by teachers, however, related to Internet use at home and exchanging email and visiting websites at school. Similar to parent ratings, as instant messaging at school increased, teacher ratings of cognitive development tended to decrease.

Table 2: Child Ratings of Internet Use

	Never	Monthly	Weekly	Daily
Home Internet Use				
I use the Internet at home.	29.2%	22.5%	28.1%	20.2%
I use email at home.	56.7%	12.2%	15.6%	15.6%
I instant message at home.	70.8%	10.1%	11.2%	7.9%
At home, I use the Internet to play games.	25.6%	21.1%	31.1%	22.2%
At home, I visit websites	29.2%	22.5%	28.1%	20.2%
School Internet Use				
I use the Internet at school	8.9%	7.8%	68.9%	14.4%
I use email at school.	67.8%	6.7%	21.1%	4.4%
I instant message at school.	85.4%	7.9%	5.6%	1.1%
At school, I use the Internet to play games..	20.0%	26.7%	47.8%	5.6%
At school, I visit websites	18.0%	21.3%	51.7%	9.0%
Community Internet Use				
I use the Internet at someone else's house	56.7%	28.9%	11.1%	3.3%
I use email at someone else's house	80.9%	14.6%	4.5%	0.0%
I instant message at someone else's house.	85.2%	10.2%	3.4%	1.1%
I play Internet games at someone else's house	60.7%	28.1%	7.9%	3.4%
I visit websites when I am at someone else's house	62.9%	28.1%	9.0%	0.0%

Note. Never = never or hardly ever, Monthly = once or twice a month, Weekly = once or twice a week, Daily = every day or almost every day

Table 3: Relationships between Parent and Teacher Ratings of Child Development

	Teacher Ratings of Child Development			
	Social	Emotional	Physical	Cognitive
Social Development	36**	35**	41***	40***
Emotional Development	27*			35*
Physical Development	38**		50***	24*
Cognitive Development		32**		66***

* $p < .05$ ** $p < .01$ *** $p < .001$

Table 4: Relationship between Parent Ratings of Child Development and Child Ratings of Internet Use

	Social	Emotional	Physical	Cognitive
Home Internet Use				
I use the Internet at home.				
I use email at home.	.28*			
I instant message at home.				
At home, I use the Internet to play games.				
At home, I visit websites				
School Internet Use				
I use the Internet at school	.24*			
I use email at school.			24*	
I instant message at school.				-.35**
At school, I use the Internet to play games..			-.25*	
At school, I visit websites				
Community Internet Use				
I use the Internet at someone else's house				
I use email at someone else's house				
I instant message at someone else's house.	.25*			
I play Internet games at someone else's house				
I visit websites when I am at someone else's house	.33*			

* $p < .05$ ** $p < .01$

Table 5: Relationship between Teacher Ratings of Child Development and Child Ratings of Internet Use

	Social	Emotional	Physical	Cognitive
Home Internet Use				
I use the Internet at home.	25*			24*
I use email at home.				
I instant message at home.				
At home, I use the Internet to play games.				
At home, I visit websites				28**
School Internet Use				
I use the Internet at school				
I use email at school.				26*
I instant message at school.				-36**
At school, I use the Internet to play games..				
At school, I visit websites				25*
Community Internet Use				
I use the Internet at someone else's house				
I use email at someone else's house				
I instant message at someone else's house.				
I play Internet games at someone else's house				
I visit websites when I am at someone else's house	.*			

* $p < .05$ ** $p < .01$

DISCUSSION

Preliminary Validation of the Ecological Techno-Microsystem

Consistent with emerging trends (Livingstone & Helpsper, 2007; Palfrey & Gasser, 2008), the current sample of 8 to 12 year old children overwhelmingly used the Internet at school and 80% reported using the Internet at home. Community-based Internet use occurred in approximately 60% of Internet at someone else's house and instant messaging rarely occurred in the school or in the community. Internet use increased with child age (bio-ecology). In a preliminary sense, the proposed ecological techno-microsystem (Figure 2) is validated; that is, contexts of Internet use (home, school, and community) are associated with variation in the nature of online activities (communication, information, and recreation) during middle childhood.

For the current sample of children, various uses of the Internet in various contexts were positively related to social development. In contrast, parent report of child emotional self-regulation was unrelated to any type of online behavior. As playing Internet games at school increased, parent evaluation of child physical development tended to decrease. As exchanging email at school increased, parent evaluation of child physical development tended to increase. Children who use the Internet to play games at school may be more sedentary and solitary than children who, for example, prefer free-time physical activities at school. At the same time, children who used email may be more socially active which is associated with increased physical activities. Most contemporary interpretation of causation suggest a reciprocal and spiraling relationship between children's abilities and environmental stimulation, that is, ability causes the individual to seek out stimulating experiences, which in turn increase ability, which causes the individual to seek out more stimulating experiences, and so on (Johnson, 2008). Results of the current investigation may be interpreted from a similar perspective; that is, social skills cause the child to use email, use of email increases social contact, which in turn improved social skills, which causes the child to increase the use of email, and so on.

Instant messaging at school was rarely reported by children (< 15% of the sample) but that minority of children was as rated by both parents and teachers as less cognitive competent that children who did not report such use of the Internet. As child-report of instant messaging at school increased, 1) parents tended to evaluate their children's school learning as below average and 2) teachers tended to evaluate the children as below average in general ability such as memory and problem solving. Instant messaging is real-time text-based communication which does not conform to standards of formal written language (e.g., u = you; 4 = for). It may the case that children with literacy limitations prefer the flexible text-based communication style associated with instant messaging. Alternatively, it may be that instant messaging during childhood modifies some aspects of the trajectory of cognitive development. The popularity of text messaging, particularly among adolescents (Palfrey & Gasser, 2008), negates a meaningful recommendation to curtail instant messaging during childhood. More likely, the nature of formal written language and description of cognitive competence may change as patterns of text-based communication evolve (Johnson, 2008). Merchant (2001) concluded that adolescent "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).

For the current sample of children, various uses of the Internet at home and school were positively related to teacher evaluation of cognitive development. In contrast, teacher reports of child emotional and physical development were unrelated to any type of child reported online behavior (e.g., instant messaging at home). As visiting websites and emailing at home and school increased, teacher evaluation of children's general ability tended to increase. Children who reported using the Internet at home were rated by teachers as having more friends than children who did not report using the Internet at home. The ecological techno-microsystem is further validated; aspects of development (i.e., social and cognitive) are differentially affected by various patterns of online behavior during childhood. Some uses of the Internet (i.e., email and visiting websites) across some contexts (i.e., home and school) were associated with child cognitive ability as determined by classroom teachers.

Previous research reports a link between online gaming and cognitive and emotional development (DeBell & Chapman, 2006; Anderson et al., 2007). Current findings did not support such conclusions. On the contrary, playing Internet games was not associated with any measure of cognitive, social, or

emotional development. Using the Internet at home and school to play games was commonly reported by children, although it seems likely that different types of games were played at home and school (Hammer & Black, 2009). Playing school-based educational online games may, over time, compensate for disparity in home-based access to stimulating games. Further, school-based games do not promote violence and thus are unlikely to generate previously reported associations with, for example, aggression. As cautioned by Livingstone and Haddon (2008), children's online activities are time-sensitive and context-dependent. The techno-microsystem captures such ecological assumptions.

Research Limitations and Theory Refinement

Ecological conceptualization of child development includes child characteristics (i.e., bio-ecology) and environmental influences (i.e., nested systems) in ongoing reciprocal and spiraling interaction over time (i.e., the chronosystem). Such a theoretically inclusive orientation, unfortunately, is not easily validated. The current sample of 91 children may not represent all children to which developmental theory is meaningfully applied (i.e., children in industrialized nations). Additionally, determining childhood Internet use with a self-report rating scale may have introduced bias into measures of Internet use. The validity of measures of child development (in this case, teacher and parent ratings of four items assessing each of the four developmental domains) can be challenged. Subsequent research may further validate the ecological techno-microsystem by increased and varied samples of children, more objective measures of child developmental, and alternative measures of Internet use. Description of community-based Internet use as "at someone else's house" is limited and should be expanded to include, for example, public library Internet access (Sandvig, 2003).

The proposed ecological techno-microsystem reflects conceptual refinement of the techno-subsystem (Johnson & Puplampu, 2008). Nonetheless, the techno-microsystem is a crude framework for organizing the developmental relevance of communication, information, and recreation technologies across microsystemic contexts (i.e., home, school, and community). Each potential interaction is multi-dimensional including a specific developmental domain, a specific online activity, in a specific context. Development is holistic and thus change in one domain affects change in other domains. For example and with respect to current findings, school-based email may facilitate physical activity which is typically social in nature during middle childhood. In contrast, playing online games at school (asocial behavior) may interfere with physical activity, often related to social functioning.

Bronfenbrenner's (1989) *mesosystem* does not include specific elements, as is the case with the other systems (e.g., the microsystem includes all direct interaction). Instead, the mesosystem emphasizes connections between elements of the microsystem, for example, home-school interactions. Given a more fluid presentation of ecological systems theory (i.e., Figure 2, the techno-microsystem), the mesosystem may no longer be conceptually necessary. In the complex interaction between humans and their tools (Johnson, 2008), Bronfenbrenner's (1977) access to limited graphics technology may have influenced conceptual representation and corresponding visual presentation of ecological systems theory. Use of improved physical tools (e.g., graphics software) improves cognitive tools (e.g., theoretical models), and vice versa.

REFERENCES

Anderson, C. A., Gentile, D. A., & Buckley, K. E. (2007). *Violent video game effects on children and adolescents*. New York; Oxford University Press.

Australian Communications and Media Authority. (2007). *Media and communications in Australian families 2007*. Report of the Media and Society Research Project. Retrieved November 6, 2009, from http://www.acma.gov.au/WEB/STANDARD/pc=PC_310893

Bronfenbrenner, U. (1977). Toward an experimental ecology of human development. *American Psychologist, 32*, 513-531.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Bronfenbrenner, U. (1989). Ecological systems theory. *Annals of Child Development, 6*, 187-24

Bronfenbrenner, U. (2005). *Making human beings human: Bioecological perspectives of human development*. Thousand Oaks, CA: Sage.

Bruner, J. (2005). *Forward*. In R. J. Sternberg & D. D. Preiss (Eds.), *Intelligence and technology: The impact of tools on the nature and development of human abilities* (pp. ix-xi). Mahwah, NJ; Lawrence Erlbaum.

Burnett, C., & Wilkinson, J. (2005). Holy lemons! Learning from children's uses of the Internet in out-of-school contexts. *Literacy, 39*, 158-164.

Cho, C. H., & Cheon, H. J., (2005) Children's exposure to negative Internet content: Effects of family context. *Journal of Broadcasting and Electronic Media, 49*, 488-509.

Darling, N. (2007). Ecological systems theory: The person in the center of the circles. *Research in Human Development, 4*, 203-217.

DeBell, M., & Chapman, C. (2006). *Computer and Internet use by students in 2003*. National Center for Educational Statistics. U.S. Department of Education, Washington, DC. Retrieved November 6, 2009, from http://nces.ed.gov/pubs2006/2006065.pdf.

Ertl, H. & Plante, J. (2004). *Connectivity and learning in Canada's schools.* Science, Innovation and Electronic Information Division. Statistics Canada; Ottawa, ON: Retrieved November 6, 2009, from http://www.statcan.ca/english/research/56F0004MIE/56F0004MIE2004011.pdf

Fuchs, T., & Wößmann, L. (2005). Computers and student learning: Bivariate and multivariate evidence on the availability and use of computers at home and school. *Brussels Economic Review, 47*, 359-385.

Hammer, J., & Black, J. (2009). Games and (preparation for future) learning. *Educational Technology Magazine: The Magazine for Managers of Change in Education, 49*, 29-34.

Jackson, L. A., Von Eye, A., Biocca, F. A., Barbatsis, G., Zhao, Y., & Fitzgerald, H. E. (2006). Does home Internet use Influence the academic performance of low income children? *Developmental Psychology, 42*, 429-435.

Johnson, G. M. (2006). Internet use and cognitive development: A theoretical framework. *E-Learning, 4, 565-573*.

Johnson, G. M. (2007). The Internet Vocabulary Test for Children: Preliminary development. *Internet Research, 17*, 235-248.

Johnson, G. M. (2008). Cognitive processing differences between frequent and infrequent Internet users. *Computers and Human Behavior, 24*, 2094-2106.

Johnson, G. M. (in press). Young children's Internet use at home and school: Patterns and profiles. *Journal of Early Childhood Research.*

Johnson, G. M., & Buck, G. (2009, April). *Internet use during childhood: Gender differences in psychosocial and cognitive predictors*. Paper presented at the Annual Conference of the American Educational Research Association, San Diego, CA.

Johnson, G., Code, J., & Zaparyniuk, N. (2007). Online behavior and cognitive development. In C. Montgomerie & J. Seale (Eds.), *Proceeding of the World Conference on Educational Multimedia, Hypermedia & Telecommunications 2007*, (pp. 3279-3288). Norfolk, VA: AACE.

Johnson, G. M., & Johnson, J. A. (2008). Internet use and cognitive development during childhood: The ecological techno-subsystem. In M. B. Nunes, P. Isaías, & P. Powell (Eds.), *Proceedings of the IADIS International Conference, Information Systems 2008*, (pp. 167-173). Algarve, Portugal: IADIS.

Johnson, G. M., & Kupla, A. (2007). Dimensions of online behavior: Toward a user typology. *CyberPsychology and Behavior, 10*, 773-780.

Johnson, G. M., & Puplampu, P. (2008). A conceptual framework for understanding the effect of the Internet on child development: The ecological techno-subsystem. *Canadian Journal of Learning and Technology, 34*, 19-28.

Lee, S. J., & Chae, Y. G. (2007). Children's Internet use in a family context: Influence on family relationships and parental mediation. *CyberPsychology and Behavior, 10*, 640-644.

Li, X., & Atkins, M. S. (2004). Early childhood computer experience and cognitive and motor development. *Pediatrics, 113*, 1715-1722.

Livingstone, S., Bober, M., & Helpsper, E. (2005). *Internet literacy among children and young people: findings from the UK Children Go Online Project*. London: LSE Research Online. Retrieved November 6, 2009, from http://eprints.lse.ac.uk/397/1/UKCGOonlineLiteracy.pdf

Livingstone, S., & Haddon, L. (2008). Risky experiences for children online: Charting European research on children and the Internet. *Children & Society, 22*, 314-323.

Livingstone, S., & Helpsper, E. (2007). Gradations in digital inclusion: Children, young people and the digital divide. *New Media & Society, 9*, 671-696.

Lynch, S. A., & Warner, L. (2004). Computer use in preschools: Directors' reports of the state of the practice. *Early Childhood Research and Practice, 4*. Retrieved November 6, 2009, from http://ecrp.uiuc.edu/v6n2/lynch.html.

Kerawalla, L., & Crook, C. (2002). Children's computer use at home and at school: Context and community. *British Educational Research Journal, 28*, 751-771.

Kumtepe, A. T. (2006). The effects of computers on kindergarten children's social skills. *Turkish Online Journal of Educational Technology, 5*, 52-57.

McLean Cole, J., & Hilliard, V. R. (2006). The effect of web-based reading curriculum on children's reading performance and motivation. *Journal of Educational Computing Research, 34*, 353-380.

Media Awareness Network. (2006). *Young Canadians in a wired world*. Media and Internet Education Resources, Ottawa, ON. Retrieved November 6, 2009, from http://www.media-awareness.ca/english/research/YCWW/phaseII/key_findings.cfm.

Merchant, G. (2001). Teenagers in cyberspace: An investigation of language use and language change in internet chatrooms. *Journal of Research in Reading, 24*, 293-306.

Murphy, C., & Beggs, J. (2003). Primary pupils' and teachers' use of computers at home and school. *British Journal of Educational Technology, 34*, 79-83.

Office of Communications. (2007). *The Communications Market, 2007*. London, UK. Retrieved May 15, 2009, from http://www.ofcom.org.uk/research/cm/cmr07/

Palfrey, J., & Gasser, U. (2008). *Born Digital: Understanding the First Generation of Digital Natives*. New York; Basic Books.

Roberts, D. F., Foehr, U. G., & Rideout, V. (2005). *Generation M: Media in the lives of 8 – 18 year olds*. Menlo Park, CA: The Henry J. Kaiser Family Foundation. Retrieved November 6, 2009, from http://www.kff.org/entmedia/loader.cfm?url=/commonspot/security/getfile.cfm&PageID=51809.

Salpeter, J. (2008). Make students info literate: There remains a larger challenge for schools -- how to develop a new generation of knowledgeable digital citizens who can operate in the unregulated online world. *Technology & Learning, 28*, 24-27.

Sandvig, C. (2003). Public Internet access for young children in the inner city: Evidence to inform access subsidies and content regulation, *The Information Society, 19*, 171-183.

Steeves, V., & Webster, C. (2008). Closing the barn door: The effect of parental supervision on Canadian children's online privacy. *Bulletin of Science, Technology & Society, 28*, 4-19.

Valkenburg, P. M., & Peter, J. (2007). Pre adolescents' and adolescents'' online communication and their closeness to friends. *Developmental Psychology, 43*, 267-277.

Vandewater, E. A., Shim, M., & Caplovitz, A. G. (2004). Linking obesity and activity level with children's television and video game use. *Journal of Adolescence, 27*, 71-85.

Van Deventer, S. S., & White, J. A. (2002). Expert behavior in children's video game playing. *Simulation and Games, 33*, 28-48.