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Internet Activities and Developmental Predictors: Gender Differences Among Digital Natives

Genevieve Marie Johnson
Curtin University

Abstract

Widespread adoption of the Internet during the past two decades has produced the first generation of digital natives. Ninety-five children (M_{age} = 10.4 years) completed a questionnaire that measured three clusters of variables: 1) Internet use at home and school, 2) peer, school, and home self-esteem, 3) and cognitive abilities (planning, attention, and simultaneous and successive processing. There were 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. Cognitive scores predicted girls' email use at home and website access at school. Self-esteem and cognitive scores predicted boys email use at home and school and online gaming at school. From a developmental perspective, Internet use may benefit girls more than boys because of gender differences in orientation to the Internet (i.e., accomplishment versus recreation). Although girls used email more than boys, of the current sample of digital natives, boys who used email were brighter and more popular than boys who did not use email.

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). Reportedly, 7% of British 10-year-olds have a webcam (Office of Communication, 2007). Approximately 20% of Canadian 9 year old children access the Internet through their own personal computer (Media Awareness Network, 2006). In Australia, nine in ten families have home Internet connectivity and 75% have broadband access (Australian Communications and Media Authority, 2007). Children in the slums of New Delhi learned to use the Internet without the benefit of instruction (Mitra & Rana, 2001). All 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). Common uses of the Internet during childhood include communicating (e.g., email), accessing information (i.e., visiting websites), and playing games (Johnson, 2006). "Internet usage patterns are strongly influenced by the user's age" (OECD, 2007, p. 40). The Internet is increasingly viewed as an environmental element with potential developmental impact (Greenfield & Yan, 2006; Johnson & Puplampu, 2008; Young, 2007).

Internet Use and Child Development

Cognitive (Luria, 1976) and psychosocial (Erikson, 1968) theorists maintain that neurological maturation and environmental experiences interact over time to result in child

developmental outcomes. Bronfenbrenner (1979) conceptualized environmental experiences as five nested systems with bi-directional influences within and among systems. The *microsystem* refers to the immediate or direct face-to-face interactions that occur, most notably, in family and school contexts. The *mesosystem* is comprised of connections between immediate environments (e.g., home-school interactions). The *exosystem* includes environmental settings that indirectly affect child development (e.g., the parent's workplace). The *macrosystem* refers to overarching social ideologies and cultural values. The *chronosystem* highlights the effect of time on all systems and all developmental processes. Bronfenbrenner (1989) conceptualized human development as:

> the progressive, mutual accommodation, throughout the life course, between an active, growing human being, and the changing properties of the immediate settings in which the developing person lives, as this process is affected by the relations between these settings, and by the larger contexts in which the settings are embedded. (p. 188)

As his theory evolved, Bronfenbrenner (2005) proposed a bio-ecological perspective which views the child's own biology as part of the microsystem.

Ecological systems theory (Bronfenbrenner, 1977, 1979) 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) proposed the *ecological techno-subsystem,* a dimension of the microsystem that includes child interactions with both human (e.g., communicator) and nonhuman (e.g., hardware) elements of information, communication, and recreation electronic 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 and school) 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 and school environments. Internet use is particularly sensitive to major life changes such as starting school and the transition to adolescence (i.e., the chronosystem).

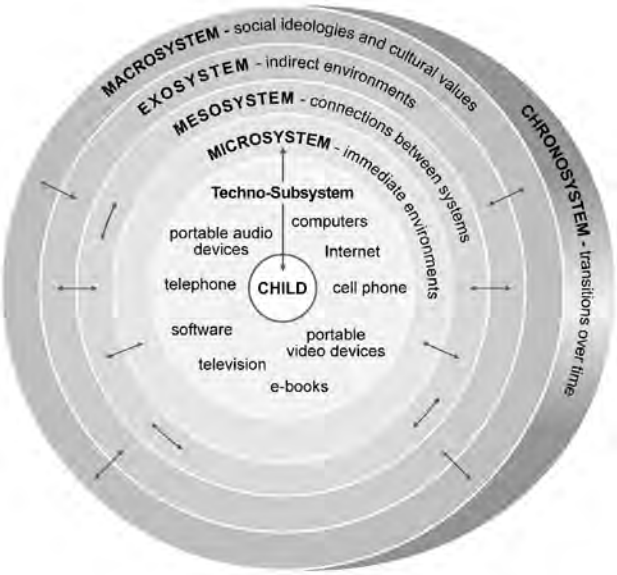

Figure 1. The Ecological Techno-Subsystem. Johnson & Puplampu, 2008, *Canadian Journal of Learning & Technology, 34*, p 23.

The neurological mechanisms that drive cognitive development involve sensory stimulation and repeated exposure to activities that facilitate the development of culturally-valued skills such as literacy and problem solving (Maynard, Sabrahmanyam, & Greenfield, 2005). 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). 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). Jackson et al. (2006) provided low income children with home-based Internet access and continuously recorded time online. Reportedly, "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 (2008) proposed a reciprocal spiraling relationship between Internet use and cognitive development, that is "cognitive capacity causes the individual to use Internet applications, use of Internet applications causes increased cognitive capacity which in turn causes the individual to seek out more stimulating Internet applications, and so on" (p. 2103).

In addition to cognition and learning, Internet use during childhood has been linked with a variety of psychosocial variables (Greenfield & Yan, 2006). If Internet use is a culturally-valued behavior, children who use the Internet, as opposed to those who do not, should be more popular and have higher self-esteem. Valkenburg and Peters (2007) found that socially-comfortable children communicated online more than did socially-anxious children. Higher friendship quality and less positive parental relationships were found to predict higher frequency Internet use during adolescence (Willoughby, 2008). Kumtepe (2006) observed that computer literate children were rated by their teachers as demonstrating better social skills than children less computer proficient. Playing violent online games, however, has been linked to distractibility, over-arousal, hostility, and aggression in boys (Anderson, Gentile, & Buckley,

2007). From a psychosocial perspective, gender differences in Internet activities and online behavior reflect differences in neurological maturation and socialization experiences (Bonanno & Kommers, 2005).

Gender Differences in Internet Activities and Online Behavior

A large body of research supports the existence of small, but significant, gender differences (Burman, Bitan, & Booth, 2008). Commonly reported cognitive and psychosocial gender differences include female advantage in language and cooperation and male advantage in visual-spatial reasoning and competitiveness (Bonanno & Kommers, 2005; Hyde, 2005). Such gender differences have generalized to online environments (Lee, 2007; Cooper, 2006). Lee and Chae (2007) observed that, among 10 to 12 year old children, boys were more likely than girls to play online games; girls were more likely than boys to be involved in online communities. Based on a large sample of school children, Murphy and Beggs (2003) concluded that girls were more positive than boys regarding the educational utility of the Internet; boys were more positive than girls about the play-value of the Internet. Correspondingly, Papastergiou and Solomonidou (2004) found that boys used the Internet more than girls for entertainment and Web page creation. Colley (2003) noted that girls had a greater work orientation and appreciate for email while boys showed a greater affinity for online games. Cooper (2006) identified increased female, as opposed to male, computer anxiety as persistent over time and across international borders. However, Williams (2007) argued that the notion that technology is more attractive to males than females may not be reasonably applied to Internet technologies for individuals immersed in that technology at home and school from a young age.

Gender differences in childhood Internet use vary, not only in terms of specific applications (e.g., communication versus recreation) but also in relation to individual behavior when using specific applications. Large, Beheshti, and Rahman (2002) collected data on gender differences in collaborative web searching in a sixth grade classroom. Analysis of the search sessions revealed that boys formulated queries comprised of fewer keywords than girls, boys spent less time on individual pages than girls; and boys clicked more hypertext links per minute than girls. Jackson et al. (2007) noted no gender differences in the overall number of websites visited by children but a difference in the category of sites visited. Reportedly, boys visited more pornography websites while girls visited more world/environment websites. In a recent Canadian survey on Internet use, girls tended to prefer social network and music websites while boys gravitate towards sports and games sites (Media Awareness Network, 2006).

Cooper (2006) provided a comprehensive review of the literature and concluded that males are more comfortable with technology than females and that the roots of the gender digital divide lie deep in the socialization patterns of boys and girls. During the 1990s, improvements in personal computing and network technologies made the Internet more access to everyone including females (Turkle, 1997). Williams (2007) proposed that technology shapes culture, "but technology does not escape being shaped by culture at the same time" (p. 303). Contemporary research increasingly reports no significant adolescent gender differences in, for example, "communication via e-mail, chat or videoconferencing, Web surfing and information search for personal or school purposes" (Papastergiou & Solomonidou, 2004, p. 377). Among Taiwanese children in fifth and sixth grade, Lin and Yu (2008) failed to find gender differences in motives for using the Internet (i.e., searching for information, socializing, and boredom avoidance were equally reported by boys and girls). Studies have demonstrated that females are more productive,

prolific, and effective than males in online environments (Caspi, Chajut, & Saporta, 2006; Li, 2006; Lin & Overbaugh, 2009).

Widespread adoption of the Internet during the past approximate 20 years has produced the first generation of digital natives (Palfrey & Gasser, 2008). Tapscott (1998) predicted that individuals born into the digital-age would experience gender equity in Internet technology utilization. This study attempts to answer three questions related to gender differences among digital natives. Are there gender differences in Internet activities among individuals born into the digital-age? Do cognitive and psychosocial gender differences persist among digital natives? Do cognitive and psychosocial characteristics equally predict Internet activities for boys and girls?

Methods

Parents of children in third through sixth grades attending a school in western Canada were asked to allow their children to complete a questionnaire on Internet use and child developmental characteristics. Because valid questionnaire completion required reading ability, children in first and second grade were not invited to participate. Fifty-one boys and 44 girls completed the questionnaire: 21 were in third grade, 25 were in fourth grade, 30 were in fifth grade, and 19 were in sixth grade. The youngest child in the sample was 8.1 years old and the oldest child was 12.3 years (M_{age} = 10.4 years). Completed in their classrooms toward the end of the school year and developed specifically for this study, the questionnaire included items that measured three clusters of variables: 1) Internet use at home and school, 2) peer, school, and home self-esteem, 3) and cognitive abilities (planning, attention, and simultaneous and successive processing).

1. Six questionnaire items measured children's Internet activities at home and school for email, accessing websites for information, and playing games (e.g., *I use email at home*. *I play Internet games at school. I visit websites at home*). Children rated each items on a three-point scale (1 = never, 2 = sometimes, 3 = often).
2. Fifteen items from the Hare Self-Esteem Scale (HSS: Kelley, Denny, & Young, 1997) measured psychosocial development in terms of peer self-esteem (e.g., *Kids in my neighborhood like to play with me*), school self-esteem (e.g., *My teacher likes my work*), and home self-esteem (e.g., *I have fun with my family*). Children rated each item on a four-point scale (1 = never, 2 = sometime of the time, 3 = most of the time, 4 all of the time). Scores for each of the three self-esteem measures could potentially range from 5 (rating of one on each of five items) to 20 (rating of four on each of five items).
3. The questionnaire included items, adapted for group administration, that measured four cognitive abilities: metacognitive planning, visual attention, and simultaneous and successive cognitive processing. Metacognitive planning items were adapted from the *Cognitive Assessment System* (CAS; Naglieri & Das, 1997) Matching Numbers subtest (find the two numbers that are the same in a list of numbers). Visual attention items were adapted from the CAS Number Detection subtest; children were required to find a particular stimulus (the number 1, 2, and 3 printed in a specific font) on a page containing many distracters (the same numbers printed in different fonts). Simultaneous cognitive processing items were adapted from the *Kaufman Assessment Battery for Children* (K-ABC; Kaufman & Kaufman, 2004) Block Counting subtest (count the number of blocks in various pictures of stacked blocks configured such that some blocks are hidden). Successive cognitive processing items were adapted from the K-ABC number recall subtest (after a brief delay, write numbers in the

same sequence as orally presented). The cognitive subtests were scored according directions (e.g., number correct minus number incorrect).

Data analysis included comparison of male/female-mean ratings of Internet use items and average scores on the psychosocial and cognitive measures (t-tests). Separate regression analyses for boys and girls used the psychosocial and cognitive scores (independent variables) to predict Internet activities (dependent variables).

Results

For the sample of digital natives, there were 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 ($t = -2.93$, $p < .01$). On the three-point scales, on average, boys reported using email at home 1.7 (between *never* and *sometimes*) and girls rated the same at-home Internet activity as 2.4 (between *sometimes* and *often*). In every other case of Internet use, including playing online games both at home and at school, male and female mean difference in self-reported Internet use did not reach significance. However, as presented in Table 1, girls scored significantly higher than boys on peer, home, and school self-esteem and on three of the four cognitive tests.

Regression analysis tested the ability of the psychosocial and cognitive scores to predict Internet use for boys and girls. For the sample of female digital natives, psychosocial measures (peer, home, and school self-esteem) did not predict any Internet activity. With respect to the cognitive measures, visual attention scores predicted girls' email use at home ($t = 2.21$, R^2 (adj) = .085, $p < .05$) explaining 8.5% of the variance in girls' email use at home. Simultaneous cognitive processing scores (visual-spatial reasoning) accounted for approximately 11% of the variance in female report of visiting websites at school ($t = 2.51$, R^2 (adj) = .110, $p < .05$).

For the sample of male digital natives, psychosocial and cognitive scores predicted some Internet activities. Male differences in metacognitive planning ($t = 2.81$, $p < .01$) and peer self-esteem ($t = 2.18$, $p < .05$) explained approximately 16% of the variance in male use of email at home (R^2 (adj) = .157, $p < .05$). Increased capacity to attend to visual stimuli ($t = 3.42$, $p < .01$) coupled with less positive home self-esteem ($t = -2.47$, $p < .05$) predicted boys' email use at school (R^2 (adj) = .208, $p < .01$) accounting for 20% of the variance in boys' email use at school. Male school self-esteem predicted playing online games at school ($t = 2.57$; R^2 (adj) = .101, $p < .05$) accounting for approximately 10% of the variance in boys' online game playing at school.

Table 1
Gender Differences in Psychosocial and Cognitive Scores (Independent Variables)

Psychosocial and Cognitive Scores	N	Mean[a]	T	Significance
Home Self-Esteem				
Boys	51	16.5	-2.66	$p = .009$
Girls	44	18.0		
School Self-Esteem				
Boys	51	16.1	-2.02	$p = .046$
Girls	44	17.1		
Peer Self-Esteem				
Boys	51	13.3	-3.27	$p = .002$
Girls	44	15.2		
Planning (Metacognition)				
Boys	51	4.56	-2.95	$p = .004$
Girls	44	4.00		
Visual Attention				
Boys	51	20.4	-2.01	$p = .047$
Girls	44	23.3		
Simultaneous Processing (Visual)				
Boys	51	17.6		
Girls	44	16.8		
Successive Processing (Auditory)				
Boys	51	7.4	-3.40	$p = .001$
Girls	44	8.4		

[a] The higher the score the greater the level or ability.

Discussion

For the current sample of digital natives (8 to 12 year old children), lack of significant differences between male and female Internet use at school suggests Internet literacy curriculum and classroom instructional practice may have closed the technology gender gap (Enochsson, 2005). Regardless of self-report as *boy* or *girl*, children reported similar school-based Internet activities. Since males, as opposed to females, have traditionally demonstrated superior aptitude for technology, gender similarities may be the consequence of increased female use rather than decreased male use. From a developmental perspective and for digital natives, school-based applications of Internet technologies may be more attractive to girls than to boys. Indeed, the high proportion of female elementary school teachers may affect instructional interpretation of digital teaching tools. For example, female elementary school teachers may be less likely than male elementary school teachers to include competitive online games in lesson planning. Male teachers may be less likely to use cooperative online learning groups. For the current sample, two teachers were male and two teachers were female. It is possible that as the children moved through the elementary grades in the participating school, culminating Internet experiences resulted in gender equity in school-based use of the Internet.

Only one gender difference in home-based Internet use reached significance; girls used email at home more than boys. Such a persistent research finding (Lee, 2007; Cooper, 2006)

requires interpretation. Perhaps in response to equitable school-based Internet experiences, girls were comfortable with Internet technologies. Such comfort may have generalized to home-based Internet use where female propensity to communication (Bonanno & Kommers, 2005) resulted in increased use of email. According to Williams (2007), "computers and online communication are an unremarkable but ubiquitous part of girls' lives" (p. 303). Alternatively (or perhaps correspondingly), boys' propensity to play online may limit their online text-based communication, which, over time, may further contribute to elementary school male literacy disadvantage (Burman et al., 2008).

For the current sample, boys and girls were equally likely to report using the Internet at home to play games. Since male preference for playing online games is well established (Colley, 2003; Lee & Chae, 2007), such an unexpected finding requires reflection. It may be the case that themes in online games have expanding to include opportunities to play that are valued by girls (Willett, 2008; Williams, 2007). It may also be the case that females are developing the visual spatial skills necessary to more fully enjoy digital games. Bonanno and Kommers (2005) reported that, regardless of gender, the most common reason given by children for playing online games was the need for challenge. For girls, the second most commonly reported motive for playing online games was arousal; for males, it was social interaction. Gender differences in motives and reasons for playing online games may result in differences in, for example, the type of games played which may, in turn, result in different developmental trajectories for boys and girls.

Significant gender differences, all favoring females, occurred on six of the seven independent measures (Table 1). It should be noted that the mean scores for both boys and girls fell within the average range; it was not the case that boys were inferior or girls were superior relative to children, in general. Nonetheless, for the current sample, girls scored higher than boys on the measures self-esteem and cognitive ability. Within the context of elementary school classrooms, boys are often at a developmental disadvantage compared to girls because, for example, boys have increased activity level and decreased fine motor control (Koepke & Harkins, 2008). Such disadvantage may result in decreased levels of self-esteem during elementary school.

Gender differences on three of the four cognitive subtests may be an artifact of adapted administration format. Under clinical conditions the subtests would be administered individually (one child and one tester). Under research conditions the subtests were modified for group administration. It may be that group-administration gave girls a behavioral advantage over boys (e.g., relatively better ability to follow oral directions in the presence of classroom distractions). It may also be that girls are, indeed, out-performing boys on cognitive skills. "Girls approach computers as tools for accomplishing tasks, while boys approach them as technology for play and mastery" (Colley, 2003, p. 673). Gender differences among digital natives may contribute to female psychosocial and cognitive advantage.

For the current sample of girls, psychosocial scores (i.e., peer, school, and home self-esteem) did not account for differences in self-reported Internet activities. That is, while girls varied with respect to their levels of self-esteem, such variation did not explain differences in girls' Internet use. On average and for example, girls who used email did not have higher or lower self-esteem than girls who did not use email. Girls may satisfy their self-esteem needs regardless of level of Internet use. Girls' sense of self appears unrelated to use of the Internet. Perhaps none of the current sample of female digital natives has experienced computer anxiety or functioned under the cultural assumption that girls are less digitally competent than boys.

Currently, girls may be rewarded for demonstration of technical competence; boys may be less rewarded for the same behavior due to cultural expectations of male technical competence.

In contrast to the non-predictive psychosocial measures, two cognitive scores explained a significant amount of the differences in girls' self-reported Internet activities. Specifically, girls with increased visual attention (i.e., the capacity to attend to relevant stimuli while ignoring distractions) were more likely to have reported using email at home than girls with decreased visual attention. During childhood, female use of email at home may increase visual attention as measured in the current investigation. Alternatively, girls who are easily distracted by irrelevant visual stimuli may be more likely to communicate with, for example, the telephone rather than email. Additionally, girls with increased simultaneous cognitive processing scores (i.e., visual-spatial reasoning) were more likely to visit websites at school than girls with decreased simultaneous cognitive processing scores.

The two cognitive scores that explained differences in girls' self-reported Internet activities did not combine to increase predictive accuracy. That is, the visual attention score did not improve upon the predictive accuracy of the simultaneous cognitive processing score; the difference in children's self-report Internet activities that was explained by visual attention scores was also explained by simultaneous cognitive processing scores. These two cognitive subtests, both presented visually as opposed to orally, may be measuring a general visual-cognitive ability. For the current sample of girls, the relationship between visual-cognitive ability and Internet use may be explained by socioeconomic status (SES). Home connectivity is associated with economic factors (Livingstone & Helpsper, 2007) and children of high SES frequently outperform child of low SES on measures of cognitive ability (Croizet & Dutrévis, 2004).

In contrast to the current sample of girls, boys Internet activities were predicted by both psychosocial and cognitive scores. Specifically, boys who tended to exchange email at home, as opposed to those did not, scored higher on the measure of metacognitive planning and peer self-esteem. Naglieri and Das (1997) claimed that planning is a mental process by which the child determines, selects, applies, and evaluates solutions to problems. While boys may prefer to play rather than communication (Burman et. al., 2008), the social advantages of email may be particularly motivating to bright boys born in the digital-age. Additionally, compared to boys who did not, boys who used email at school tended to score higher on visual attention but had less positive home self-esteem. Bright boys who feel vulnerable in the family context may use email at school to satisfy psychosocial needs. As was the case with girls, boys' use of email at home may have increased visual attention over time and/or boys who were easily distracted by irrelevant visual stimuli may have preferred face-to-face, as opposed to online, communication.

Boys who tended to use the Internet at school to play games scored higher on the measure of school self-esteem than boys unlikely to play online games at school. The relationship between school self-esteem and academic achievement is well established (D'Amico & Cardaci, 2003). While low achieving boys may be expected to gravitate toward recreational online activities at school, for the current sample, this was not the case. Murphy and Beggs (2003) observed that, at home, children choose their own online activities and have ample time for exploration. In contrast, at school, teachers control activities, and computer time is limited. Elementary school teachers may reward academically competent children by allowing them to use the Internet at school; in such situations, boys, more often than girls, may choose to play games. Boys with a learning advantage may be further advantaged by experience with cognitively stimulating online learning games. Cognitive measures failed to explain variation in

playing online games at school suggesting that school self-esteem may reflect behavior (e.g., adherence to classroom rules) rather than learning potential.

For the current sample of digital natives, Tapscott's (1998) prediction that individuals born into the digital-age would experience gender equity in Internet technology utilization is accurate, to some extent. Children reported gender equity in school-based technology experiences and boys and girls were equally likely to report using the Internet at home to play games and visit websites. However, girls continue to use email at home more than boys. Vekiri and Chronaki (2008) highlighted "the role of socialization in the digital gender gap and the need for research and educational interventions that focus on the social practices that communicate gendered expectations to young boys and girls" (p. 1392).

In the short term, Internet technologies may developmentally benefit girls more than boys because of gender differences in orientation to the Internet (i.e., accomplishment versus recreation). However, in the long term, boys may begin to use the Internet for purposes of communication and accomplishment thereby contributing to enhance developmental outcomes. Williams (2007) challenged the existence of the digital gender divide and concluded "we need to understand the complexity and shifting nature of the cultural assumption and values that exits and offer possibilities and critiques for both boys and girls" (p. 306). With respect to the current sample of male digital natives, boys who used email at home were brighter and more popular than boys who did not use email at home.

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