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BRIDGING THE COMMUNICATION DIVIDE: CMC AND DEAF INDIVIDUALS' LITERACY SKILLS

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Deaf individuals frequently capitalize upon communication technologies that increase equitable access to communication in an ongoing, effortless manner. Those communication technologies create conditions that increase direct access to language and literacy. It is the lack of direct access to language that has been historically problematic for deaf individuals, contributing to English literacy achievement gaps that are evidenced in deaf education settings. This study explored the hypothesis that increased access to English through communication technologies would be related to stronger English literacy skills for deaf individuals. A secondary analysis approach using a longitudinal large-scale dataset, the second National Longitudinal Transition Study (NLTS2), was used to assess the frequency of computer-mediated communication as a predictor of English literacy skills in a sample of 510 deaf youths in the United States. Regression analyses demonstrated that deaf adolescents who e-mailed or chatted more frequently exhibited higher reading comprehension skills in the years ahead. These results suggest that communication technologies should be further explored as a potential avenue that may support deaf individuals' English language and literacy development.

Language(s) Learned in this study: English

Keywords: Computer-Mediated Communication, Second Language Acquisition, Computer-Assisted Language Learning.

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INTRODUCTION

Communication technologies have qualitatively transformed communications on a global level, across stratifications of income, language, ethnicity, culture, and disability. Increased access to information and communication technologies is particularly promising for individuals and communities that are historically marginalized, and is said to contribute to increased equity in outcomes across gender (Khan & Ghadially, 2010), income and ethnicity (London, Paster, Servon, Rosner, & Wallace, 2010), and disability (Bowker & Tuffin, 2007). In particular, visible indicators of physical differences such as disability that can contribute to increased isolation are said to disappear in virtual settings, emerging globally in countries such as Israel (Barak & Sandovsky, 2008) and New Zealand (Bowker & Tuffin, 2002, 2007). Yet, disability characteristics interact with how individuals choose to use information and communication technologies. In the US, individuals whose disability characteristics were directly tied to barriers that may inhibit technology use (e.g., visual impairment, difficulties typing) were less likely to use the Internet, but deaf individuals used the Internet as much the general population (Dobransky & Hargittai, 2006).

Across the world, deaf individuals are more likely to utilize technologies in their everyday life when compared to their peers in the general population, and often emerge as early adopters of technology, particularly communication technologies (Barak & Sadovsky, 2008; Okuyama & Iwai, 2011; Valentine, Skelton, & Levy, 2006). The unique dynamics of the experience of being deaf creates a context in which access to communication, and the languages in which communication takes place, is complex. The spoken language of the environment is not always fully accessible for the deaf individual. Thus, deaf individuals increasingly capitalize upon technologies that enable increased equitable access to communication in an ongoing, effortless manner. Furthermore, communication technologies create conditions that increase direct access to language and literacy. It is the lack of direct access to language that has been historically problematic for deaf individuals, contributing to English literacy achievement gaps that are evidenced in deaf education settings in the US (e.g., Qi & Mitchell, 2012). We are placing this study within a second language acquisition framework, following in the footsteps of deaf education researchers that recognize how deaf individuals' challenges with English reading and writing share similar traits with other English language learners (Antia, Reed, & Kreimeyer, 2005; Berent, 2009; Berent, Kelly, & Schueler-Choukairi, 2009; 2012). This study explored the hypothesis that increased access to English via communication technologies would be related to stronger English literacy skills for deaf individuals.

BACKGROUND

Language and Communication Access

Deaf individuals exhibit characteristics that are very similar to English language learners even if they use spoken English as a primary or secondary language. Deaf students' gaps in English literacy achievement have been demonstrated across multiple contexts and data sources. Generally, the literature suggests that students who are deaf do not demonstrate English literacy skills comparable with their peers upon graduation from high school in the US (Paul, 2003; Qi & Mitchell, 2012; Schirmer & McGough, 2005). Despite challenges in obtaining accurate measures, most sources suggest that the average deaf high school graduate reads at the fourth grade level (e.g., Qi & Mitchell, 2012). Factors that contribute to successful mastery of English literacy for the deaf language learner are largely unknown (e.g. Luckner, Sebald, Cooney, Young, & Muir, 2005), but the lack of full access to English clearly plays a significant role in language and literacy development.

The typically developing hearing child is fully immersed in the language of the environment from birth and on, ideal conditions for language acquisition. This is not the case for deaf children, of whom more than 90% are born to parents that do not have hearing losses and do not use sign language (Mitchell & Karchmer, 2011. Thus, for children with any level of hearing loss, exposure to language that is immediately and fully accessible is lacking. Even if deaf children receive direct linguistic access through sign language, whether in the home or at school, signed language development does not automatically transfer to language and literacy development in the spoken or written language of the environment (i.e., English). Sign and spoken languages have significant structural differences at the lexical and grammatical level (Krakow & Hanson, 1985). For deaf children who are able to access spoken language through auditory channels using residual hearing or auditory technologies such as cochlear implants or hearing aids, it is still questionable whether or not that access is equitable because gaps in comprehension still occur (Hyde, Punch, Power, Hartley, Neale, & Brennan, 2009) and the success rate with cochlear implants is highly variable (Peterson, Pisoni, & Miyamono, 2010). Even when a deaf child uses spoken English in school, language delays that are similar to English language learners are present (Antia, Reed, & Kreimeyer, 2005).

Language acquisition approaches that rely on audition are gambling upon the efficacy of those approaches, as the possibility exists that the deaf child will not benefit from those approaches and thus lose years of language acquisition opportunities and risk becoming linguistically deprived (Humphries et al., 2012). Technological interventions designed to provide auditory access to spoken languages are not benign; those interventions often restrict the use of sign language and thus runs the risk of perpetuating linguistic deprivation, which can confer severe long-term harms, both personal and social (Humphries et al., 2012). Instead of using technology to provide auditory access to the target spoken language, digital communication technologies can be used to provide equitable, direct access to the target language in another modality, that of text. These are technologies that deaf individuals are increasingly adopting and utilizing in their daily lives, thus the use of communication technologies aligns with personal preferences and life choices that deaf individuals demonstrate.

Computer-Mediated Communication

Communication technologies are often said to equalize the playing field, particularly for individuals and communities that have historically been marginalized. The Internet creates conditions where communication can increasingly occur across global and cultural boundaries. In 2000, only 41% of homes in the US had Internet access, while 72% had Internet connectivity in 2012 (NTIA, 2000; 2013). As penetration of technology increases, technology continues to evolve. For example, mobile phones, once only able to send and receive phone calls, are now utility devices that serve as handheld computers, navigational devices, music players, music and picture archives, still picture cameras, video cameras, mobile payment devices, video game platforms, and dating hubs. As technology evolves, prices drop, and the financial barrier to technological inclusion is lowered. In 1995, only 13% of the United States population owned a mobile phone, increasing to 38% in 2000, and 69% in 2005. In 2011, the number of wireless subscriptions in the U.S. population exceeded the U.S. population estimates for that year (CTIA, 2013). Despite digital inequalities that still exist (Hargittai, 2002), smartphones and Internet access are now ubiquitous, bringing with them a new level of digital connectivity that reaches beyond lines of socio-economic status, ethnicity, or disability status. Internet usage has increased steadily, yet differentiations across stratifications are still present.

Communication technologies have largely been integrated in daily life for much of the global population that is connected to the Internet. While digital communications can involve multiple modalities, ranging from video, text, images, and voice, this study focuses on communication technologies that enable direct communication in a text modality, which we conceptualize as computer-mediated communication (CMC). Computer-mediated communication includes multiple ways of communicating online, including e-mailing, blogging, instant messaging, texting (SMS), and engaging in chat rooms, among others. The method of communicating online is dependent on the technological capacities available, restricted by technology or device limitations. In the last two decades, CMC has increasingly become more mobile as the penetration rates of mobile devices have showed steady gains (CTIA, 2013). However, the goals and uses of CMC have stayed constant: the desire to communicate directly with other individuals or communities through digital methods.

Deaf Individuals and Computer-Mediated Communication

Deaf individuals may be more likely to capitalize on technological advances that provide increased equity to communication access, as demonstrated by the literature exhibiting higher rates of computer-mediated communication usage by deaf individuals. Research on internet usage reveals that deaf individuals use the internet at higher rates than their peers in the general population for personal and group uses (Barak & Sandovsky, 2008), e-mailing, chatting (Valentine et al., 2006), and texting (Okuyama & Iwai, 2011). Among individuals with disabilities, deaf youths communicate by computer at a significantly higher percentage than their peers of other disability types (Newman et al., 2011). Communication technologies are clearly a significant part of life for deaf individuals, who use a variety of CMC tools on a daily basis, including SMS, e-mail, chat rooms, or instant messaging (Akamatsu, Mayer, & Farrelly, 2006; Garberoglio, 2013; Newman et al., 2011). Penetration rates of mobile phone ownership and SMS usage among the deaf are, not surprisingly, high; surveys of Australian and German deaf individuals reveal that 94% to 96% of respondents had access to SMS messaging (Power, Power, & Horstmanshof, 2007a; Power, Power, & Rehling, 2007b). In a comparison of the cell phone usage patterns as they apply to contacting friends amongst Japanese high-school DHH students and their hearing peers, Okuyami & Iwai (2011) found that, compared to their hearing peers, a greater percentage of deaf students fell within the frequent text sender range.

It has been proposed that lower English literacy levels that may be exhibited by deaf individuals serve as an impediment to the use of communication technologies (Okuyama & Iwai, 2011; Power et al., 2007a; 2007b). However, studies of deaf students in developmental English programs, whether adolescents (Lissi & Schallert, 1999) or adult college students (Garberoglio, 2013) do not support this proposition. Lissi and Schallert (1999) reported:

> although they were reading under grade level, students had meaningful conversations in written English, addressing questions posed by the teacher, posing their own questions to the teacher or other students, reacting to other participants' messages, sharing information, and generally having fun (p. 373).

Deaf adults who were in developmental English classes, which can be thought of as an indicator of lesser English proficiency, overwhelmingly reported that CMC technologies were a large part of their daily lives, and generally felt confident about using English in informal communicative uses despite their weaknesses with English in more formal school-based settings (Garberoglio, 2013). Studies conducted in the United Kingdom, Germany, Australia, Israel, and the United States all reveal that CMC technologies are a significant part of daily life for deaf individuals, despite low literacy levels that are expected in those populations (Barak & Sandovsky, 2008; Garberoglio, 2013; Lomicky & Hogg, 2010; Power et al., 2007a; 2007b; Valentine et al., 2006).

The increasing use of computer-mediated communication has created an authentic context in which communication can take place using English in daily life for deaf individuals. As mobile phone penetration rates and CMC usage increases, exposure to the printed word will concurrently increase, and this exposure has been found to result in positive outcomes for the general population including not only reading skills but also other cognitive abilities (Stanovich, 1993). Increased access to communication also confers other benefits beyond the immediately apparent benefit of increased print exposure and direct access to text-based literacy. The ubiquitous use of text-based methods of communication is most often said to break down communication barriers, creating accessible spaces and leveling the playing field for deaf individuals (Barak & Sandovsky, 2008; Power et al., 2007a). In Japan, adolescents achieve a sense of *tsungarikan*, or closeness, via the constant connectivity with others provided by cell phone usage (Okuyama & Iwai, 2011). Deaf individuals often reveal that the use of communication technologies enable increased independence (Pilling & Barrett, 2008), social access to both deaf and hearing individuals (Power et al., 2007b), social support, and information access (Shoham & Heber, 2012; Valentine et al., 2006). The Internet may create increased communication opportunities that confer not only practical or technical benefits but also psychological benefits, as indicated by a study revealing that deaf adolescents who were intensive Internet users were less lonely and had higher self-esteem than those who used the Internet less (Barak & Sadovsky, 2008).

Computer-Mediated Communication and Language Development

Computer-mediated communication has been used in formal language learning settings across multiple contexts for some time. Synchronous CMC, in particular, was first used in the 1980's for language instruction at Gallaudet University, the world's only liberal arts university for deaf students located in

Washington, DC, where it was used as a tool to help deaf individuals communicate in English (Beauvois, 1998). Despite the origins of synchronous CMC in deaf education, the research is sparse on CMC usage in deaf education settings and is far more robust in other foreign language learning settings. The most consistent finding in CMC research in second language learning settings is that CMC usage results in increased quantity and quality of language production (Beauvois, 1992, 1998; Chapelle, 1994; Chun, 1994; Kelm, 1992; Kern, 1995; Warschauer, 1996). This increase in quantity and quality uses of the target language enabled by participation in synchronous CMC has been proposed to contribute to language outcomes that have emerged in specific areas such as reading, writing (Coniam & Wong, 2004; Sullivan & Pratt, 1996), greater syntactic and lexical complexity (Kern, 1995; Warschauer, 1996), and conversational skills including oral proficiency (Chun, 1994; Kern, 1995; Kitade, 2000; Payne & Whitney, 2002).

Synchronous CMC exhibits characteristics similar to face-to-face conversations that are an important part of language acquisition. Accessing those face-to-face conversations is problematic for the deaf learner who is unable to engage in conversational interactions via spoken English, and thus synchronous CMC offers a feasible avenue for increasing interactional dialogue. In particular, the quantity and types of discourse functions used in synchronous discussions were found to be similar to the interactional modifications that are characteristic of face-to-face conversations and support language acquisition (Sotillo, 2000). From an interactionist perspective of language acquisition, the similarity of CMC to face-to-face discussion is considered to be beneficial (Murray, 2000; Smith, 2003). Computer-mediated discussion can promote the type of specific interactional features in the negotiation of meaning that facilitates language development, according to second language acquisition theories (Blake, 2000; Kitade, 2000; Lee, 2001; Pellettieri, 1999; Salaberry, 2000; Smith 2003). Current researchers posit that digital literacies may not be entirely characterized as comparable to written or spoken communication, but has characteristics of both spoken and written communication (Greenfield & Subrahmanyam, 2003; Jarvis, 2005; Ling, 2005). The digital era may be reducing the traditional gap between "reading" and "writing" (Warschauer, Zheng, & Park, 2013), which supports the proposition that digital literacies can serve as a highly feasible way to engage in conversational negotiation of meaning via English text for deaf individuals. Communication technologies, particularly those that are increasingly used in the current age, such as SMS, allow for immediacy and informality in communication, sharing characteristics with spoken communication (Ling, 2005). Whatever the linguistic nature of CMC, it lowers the barriers to participation in communication and increases equitable and direct access to language via text modalities.

Empirical research on the use of computer-mediated communication in deaf education is lacking, despite the origins of CMC in college instructional settings for deaf students (Beauvois, 1998). From the initial investigation of literature on CMC in deaf education settings, it appears that deaf students may engage more in conversational discourse, especially those who may be less inclined to engage in face-to-face discussion (Lissi & Schallert, 1999; Liu, Chou, Liu, & Yang, 2006). Deaf students also report their experiences with CMC to be positive (Schirmer & Ingram, 2003), especially in the "quality and quantity of their interactions" (Long, Vignare, Rappold, & Mallory, 2007, p.1; Long, Marchetti, & Fasse, 2011). Computer programs designed for language instruction showed tentatively promising learning outcomes for Bulgarian deaf language learners of English as a 2nd or 3rd language (Zamfirov & Saeva, 2013). Synchronous CMC appears to be a viable avenue for increased direct engagement with English for deaf students, as long as ideal conditions are met (Garberoglio, 2013). Deaf young adults indicate that using English in conversational interactions mediated via electronic text (SMS, chat, e-mails) facilitate immediate and situational language learning, particularly in an active "seeing" of how others use English (Garberoglio, 2013). In instructional settings for deaf students, the literature appears to indicate that CMC is a promising instructional tool, yet more research in that area is needed.

It has yet to be investigated how the increased use of CMC in informal settings in daily life beyond school settings influences language use and language learning for deaf students. In the general population, there are some findings of interest about the relationship between use of informal communication technologies and English literacy. In two studies of British children's text messaging and literacy development, the use of textisms (common text-message abbreviations of words, such as LOL for laughing out loud or txt for text) was positively related to spelling attainment and other literacy skills (Wood, Jackson, Hart, Plester & Wilde, 2011; Wood, Meachem, Bowyer, Jackson, Tarzynski-Bowles, & Plester, 2011). In another study, Plester, Wood, and Joshi (2009) found a strong relationship between reading ability and age of first phone ownership and suggested that early exposure to the printed word, occurring before the ages of 10–12, in the form of text messages may independently increase reading ability. Other research on the relationship between SMS usage and literacy has yielded mixed findings. Drouin and Davis (2009) found that amongst hearing college students who communicate via SMS, there were no significant differences in GPA or literacy rate (as measured by the Letter-word Identification and Reading Fluency tests of the WJ III Achievement test) between those who used textisms on a regular basis and those who did not. A recent study indicated that for young adults around the age of 20, grammatical violations while texting were associated with specific grammatical errors that also emerged when using spoken or written forms of language, but that association was an isolated one, and no association was found in younger age samples who were in primary and secondary school (Wood, Kemp, Waldron, & Hart, 2014). This could indicate that younger children who have texted for longer periods of time and integrated SMS usage in their daily lives are demonstrating distinctly different language uses when texting than when using conventional written or spoken language structures. Concerns in the general public that increases in textisms negatively influence literacy skills appear to be unfounded, and indeed, those textisms may even positively influence literacy.

Research into the specific patterns of digital technology use reveals complex relationships between a variety of use factors and literacy outcomes. In a massive study of the relationship between attitudes and access to Information Communication Technology (ICT) and engagement in online reading activities and literacy, Lee and Wu (2012) analyzed data from 297,295 students from 42 countries and regions. They found that access to ICT at school failed to have a significant effect on either engagement in online reading activities or overall reading literacy, but that access to ICT at home was positively predictive of online reading activities. Interestingly, home access to ICT was found to be negatively predictive of reading literacy, but when engagement in online reading was analyzed as a mediator of home ICT access, the indirect effect of home ICT access on reading literacy was found to be positive and significant (Lee & Wu, 2012). It appears that the ways digital technologies are used affect the outcomes that may emerge, as indicated by studies that attend to specific types of technology usage. For example, students who used digital technology primarily for non-communicative purposes had lower literacy rates than those who used CMC technology primarily as a means of connecting to others (Grimley, Allan, & Solomon, 2010). Increasing use of communication technologies to connect to others, as measured by frequency, content, and varying types of language usage (i.e., textisms) may make a positive contribution to literacy outcomes. It has been suggested that those individuals with better literacy skills are able to use multiple registers of language usage, as a potential indicator of stronger metalinguistic skills (Coe & Oakhill, 2011; Plester, Wood, & Joshi, 2009).

This study is an exploratory analysis that examines the relationship between use of CMC and English literacy levels for deaf adolescents in the United States. To do an initial exploration of this relationship, a secondary analysis approach is appropriate. This approach allowed us to use information from a broad spectrum of deaf adolescents about their CMC practices, as this is a low-incidence population and thus large sample sizes are a challenge to obtain. The dataset used in this study, the second National Longitudinal Transition Study (NLTS2), collected information about students with disabilities in the United States, with a total sample size of more than 11,000, of whom more than 1,000 were deaf or hard of hearing. As this is a longitudinal dataset, this analysis could assess how student frequency of CMC usage may be related to English literacy skills that were measured at a later time point.

METHODS

Dataset

The U.S. Office of Special Education Programs commissioned NLTS2 to create a nationally representative dataset for students with disabilities. Data was collected between 2001 and 2009, and this study used data from the first two waves, from 2001-2003. To be included, students had to be between thirteen and sixteen years of age on December 1, 2000. Students, their parents and guardians, and school staff responded to computer-assisted telephonic interviews, mail surveys, and direct assessments. This particular inquiry uses parent data on their adolescents' CMC usage from the first wave to predict students' English literacy skills, which were directly assessed in the second wave.

Like many national datasets, NLTS2 used a sampling scheme that employed weighting and stratification. This was intended to make the dataset nationally representative, and to improve the efficiency of estimation. The efficiency of estimation and the representativeness are of particular concern for studies that attempt to predict outcomes from later waves of NLTS2. In later waves, attrition may limit generalizability and reduce the researcher's power to detect a statistically significant difference. However, this particular inquiry only used data from the first two waves of NLTS2. As such, methods such as Taylor Linearization to account for weighting and stratification were deemed unnecessary.

Variables

Although the predictor variable and all the covariates were collected from the first wave of NLTS2, the dependent variable was collected in the second wave.

Covariates in this analysis included demographic information, including gender, an indicator variable for Caucasian ethnicity, and a measurement of household income. Gender and ethnicity were taken from the cross-instrument dataset, which consisted of data that were collected and verified from multiple sources. No cross-instrument data reported on household income, so the parent survey in wave one provided that information.

Parents rated from one to six "how often [the youth] interacts with others using e-mail/chatrooms": the predictor variable consisted of this single question from the wave one parent survey. For this study, these data were recoded so that higher scores indicated a greater use of computer-mediated communication than the lower scores. These data were collected through computer-assisted telephonic interviews.

The dependent variable was a reading comprehension measure, which is an average of two different subtests on the Woodcock Johnson III Research Edition (see Woodcock, McGrew, & Mather, 2001, for details). We used the averages of the passage comprehension and synonym-antonym standard scores to obtain the reading comprehension score. The passage comprehension subtest assesses linguistic and cognitive skills, asking youth to notice and use textual information to respond to items that range in difficulty. The synonym-antonym subtest assesses vocabulary comprehension, asking youth to supply synonyms and antonyms to the words that are provided.

Inclusion Criteria and Participants

There were two inclusion criteria for this study. First, the student had to be deaf or hard of hearing; this data was based on parental response that their child was deaf, hard of hearing, or hearing impaired. This criterion allowed our study to include students across all levels of hearing loss. Secondly, listwise deletion was employed; in other words, students were deleted from the analysis if they were missing any data that were in the regression model. In particular, students had to have taken the direct assessment in the second wave, which likely excludes participants with more severe disabilities due to the assessment criteria, which required the evaluator to assess whether or not the student was able to participate independently in the academic assessment (Carter, Austin, & Trainor, 2012). Of the 1070 deaf students in wave one, 680 students participated in the direct assessment. These numbers are rounded to the nearest tens value, in accordance with Institute of Education Science (IES) policy. Of these 680, about 170 parents did not provide adequate information for the analysis. The remaining sample consisted of 510 participants. Descriptive statistics for these participants are provided in the results section.

Data analysis strategy

Since there was only one dependent variable and only one predictor variable of interest, the data analysis was relatively straightforward. An ordinary least squares regression regressed the literacy score (described above), on household income, age, gender, a Caucasian indicator variable, and the degree to which the student participated in computer-mediated communication at home.

Assumptions

A possible concern in this analysis was that the assumption of independence was violated. This assumption, practically speaking, claims that the data are not clustered, or in other words, that students were sampled independently. For this analysis, many students came from the same local education agency (LEA). However, for most of the sample, there was not a great deal of clustering. Of the 199 LEAs included in the analysis, 180 of them had less than five deaf students in the study. On average, each LEA had 2.61 students, and the intra-class correlation was estimated at 0.161. A table of the actual type one error rate in this sort of situation suggests that the type one error has roughly doubled (Stevens, 2007, p. 324). One could easily adopt a more stringent alpha level to compensate for this, by, say, adopting alpha = 0.01 instead. However, since the *p*-value of the independent variable's coefficient would remain significant with this criterion, this concern would not result in inferential differences. Therefore, for the sake of parsimony, analysis continued as planned. Other than the independence assumption, all other assumptions seem to have been met. Residuals were normally distributed, with homogenous variance.

RESULTS

Descriptive statistics

Recall that the requirements of this dataset require reporting participant numbers at the nearest tens value, so descriptive statistics may not equal 510. Of the 510 participants, 180 were male and 350 were Caucasian, 80 African-American, 70 Hispanic, and 20 Asian. Ages ranged from fourteen to eighteen at wave one; 220 participants were fourteen to fifteen years of age, 250 were sixteen to seventeen, and the remaining 50 were eighteen. There was a wide range of household incomes, with 100 parents reporting household incomes less than $20,000 a year, 170 reporting incomes between $20,000 and $40,000 a year, 110 reporting incomes between $40,000 and $60,000, and 150 reporting incomes greater than $60,000. Parents reported household income within units of $5,000, but, for the sake of simplicity, they are reported within $20,000 here.

Frequency statistics on the independent variable are provided in Table 1. Overall, there was good variability in the use of computer-mediated communication. The levels ranged from one to six, and the item had a mean value of 3.18, with a standard deviation of 1.74.

Finally, the reading comprehension score, which consisted of the average of the synonym-antonym subtest and the passage comprehension subtest of the Woodcock-Johnson, was found to be roughly symmetric in distribution. The mean score was 76.52, and the standard deviation was 21.08 points.

Table 1. *Frequency Statistics for the Independent Variable: "How Often [the Youth] Interacts with Others Using E-mail/Chatrooms"*

Level		Frequency
(1)	Never	110
(2)	Less often than once a week	120
(3)	Once a week	60
(4)	Several times a week	90
(5)	Once a day	60
(6)	Several times a day	80

Note: These numbers are rounded to the nearest tens place, in accordance with IES policy.

Zero-order correlations

Before presenting the primary analysis, the zero-order correlations between variables in the linear model are presented. A complete listing of these zero order correlations may be found in Table 2.

Table 2. Z*ero-Order Correlations Between Variables in the Linear Model*

	Reading comprehension	Use of CMC	Household Income	Age	Female	Caucasian
Reading comprehension	1					
Use of CMC	**0.320	1				
Household income	**0.201	**0.145	1			
Age	0.011	**0.188	-0.017	1		
Female	0.028	0.056	-0.015	0.055	1	
Caucasian	**0.206	**0.242	**0.329	0.051	0.022	1

*Note: **: $p < 0.001$*

As presented in Table 2, the use of CMC was significantly correlated with the literacy score to a moderate degree (r=0.320, t[510] = 7.72, p<0.001). The literacy score was also correlated to a small, but meaningful degree, with household income (r=0.201, t[510] = 4.65, p<0.001) and being Caucasian (r=0.206, t[510] = 4.83, p<0.001). Moreover, the use of CMC was significantly correlated, to a very small degree, with household income (r=0.145, t[510] = 3.32, p<0.001), the youth's age (r=0.184, t[510] = 4.236, p<0.001), and being Caucasian (r=0.244, t[510] = 0.244, p<0.001).

Primary Analysis

As previously discussed, the reading comprehension score was regressed on household income, age, gender, a Caucasian indicator variable, and the independent variable. Overall, use of CMC was related to a small to moderate increase in the literacy score. One standard-deviation increase in CMC use was related to a 0.287 standard-deviation increase in the reading comprehension measure (t[510] = 6.64, p < 0.0001). This is considered a small to moderate relationship (Ferguson, 2009). Notably, although the Caucasian indicator variable and the household income variables were statistically significant, (t[510] = 2.29, p<0.05 and t[510] = 2.86, p < 0.01, respectively), their effect sizes were not practically meaningful (β< 0.2 in both cases; see Ferguson, 2009). See Table 3 for further details.

Table 3: *OLS Results, Regressing Reading Comprehension on CMC Use and Covariates*

Variable	b weight	β weight	t value	p-value
Caucasian indicator variable*	4.517	0.101	2.285	0.0227
Male indicator variable	0.784	0.019	0.453	0.6511
Household income**	0.570	0.125	2.862	0.0043
Computer-mediated communication use ***	6.045	0.287	6.635	<0.0001

*Note: *: p<0.05. **: p<0.01. ***: p<0.001*

Boxplots of the reading comprehension measure by CMC use display the magnitude of this relationship; shown in Figure 1.

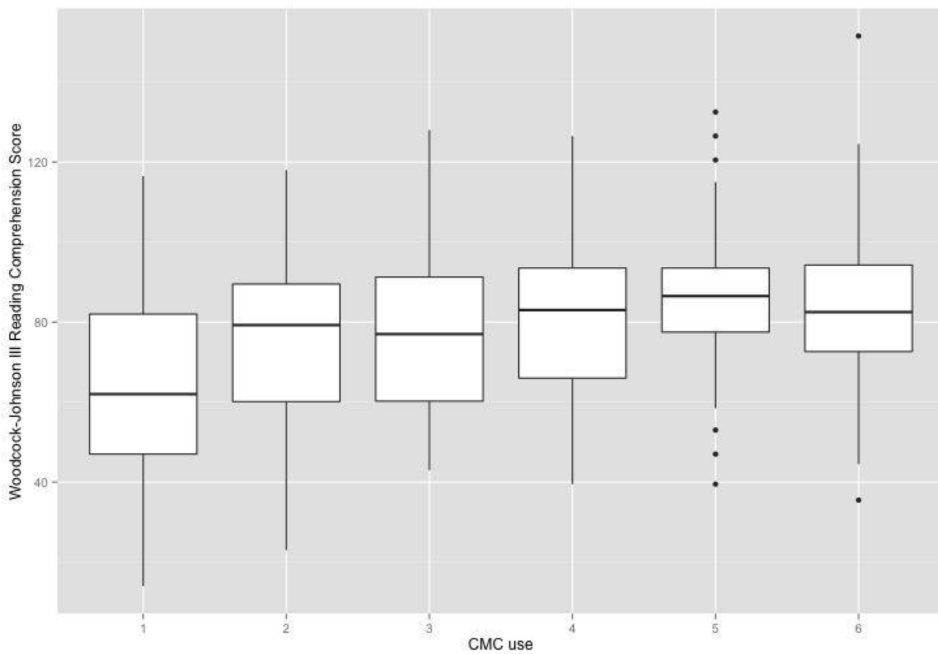

Figure 1. The moderate impact of CMC use on reading comprehension (β = 0.287; p <0.0001). The figure was generated using ggplot2 in R (Wickham, 2009).

DISCUSSION

The results of this study indicate that frequency of CMC usage at home is positively related to English literacy skills for deaf individuals. Deaf adolescents between the ages of 14 and 18 who e-mailed or engaged in chat rooms more frequently exhibited higher reading comprehension when those skills were assessed two years later. Frequency of CMC usage at time 1 had a small to moderate relationship with reading comprehension at time 2 (β = 0.3), explaining 8% of the variance in reading comprehension. This relationship is particularly significant, considering two primary issues: 1) the lack of evidence on what factors contribute to literacy skills for deaf individuals (Luckner et al., 2005), and 2) the difficulty in finding sufficiently large sample sizes with this low-incidence population that would garner likelihood of finding significance (Luckner, 2006). In addition, our analysis was extremely conservative due to the addition of multiple covariates, including gender, ethnicity, and family income. Previous research findings that revealed computer use at home to predict future academic achievement have revealed diminishing effects after socioeconomic status (SES) was accounted for (Bebell & Kay, 2010; Warschauer & Matchuniak, 2010). The significance of our findings that remain after controlling for family income supports the need to further investigate how CMC may contribute to English literacy skills for this population.

We have presented our arguments and discussion from a perspective that increasing use of CMC interactions would result in improvements of English literacy skills for deaf individuals, but we recognize that causation cannot be determined from this analysis. The data available to us did not allow for any controls of preexisting literacy skills that would explain the longitudinal relationship between CMC usage at time 1 and English skills at time 2. It is highly likely that individuals with preexisting higher literacy skills may have higher likelihoods of engaging in CMC during adolescence. Yet, it stands that the literature shows deaf individuals to be highly likely to engage in CMC even if their literacy levels are low (e.g., Garberoglio, 2013; Lissi & Schallert, 1999). In addition, the sample in this study had an average reading comprehension score that was around two standard deviations below the norms for the general population. This point supports the possibility that CMC may support English language and literacy development for deaf individuals despite low English literacy levels. Nevertheless, the longitudinal nature of this dataset, the large sample size, and the small to moderate positive association all lend themselves towards a call for future research continuing to investigate this relationship. Future research can more fully assess the directionality of the relationship between CMC and English literacy for deaf individuals, particularly through exploring longer-term relationships than were available in the NLTS2 dataset, and accounting for preexisting English skills.

Beyond a discussion of the directionality of the relationship between CMC and English skills, we suggest that these exploratory findings support language acquisition theories that posit increased interactions with the target language, conceptualized as continual modifications of input and output in an interactional relationship, to be important processes involved with reaching higher language proficiency (Long, 1996; Swain, 2006). Exposure to print alone, despite conferring positive results, is not sufficient to fully engage individuals in language learning (Swain, 1984). Active interaction with language is said to contribute to language and literacy development, and those interactions are made possible for deaf individuals through CMC. Engaging in online conversations through e-mailing, chatting, or texting also requires the user to develop capacities of communicating in differing registers, potentially contributing to stronger metalinguistic skills (Coe & Oakhill, 2011; Plester, Wood, & Joshi, 2009). For deaf individuals, CMC offers unparalleled opportunities to actively engage with English in multiple ways and registers that are not always available through auditory channels or static text found in reading or writing.

At a minimum, our findings demonstrate that e-mailing and chatting online are positively associated with English literacy skills for deaf youths. This relationship aligns with other research work demonstrating positive relationships between texting and traditional English literacy skills (Plester, Wood, & Joshi, 2009; Wood, et al., 2011a, 2011b), and answers Plester, Wood, and Joshi's call for longitudinal research on this relationship. The results of this study build upon these previous researchers' work, among others, and strengthen the argument against the popular media perspective that text literacy has a negative influence on English literacy (Thurlow, 2006).

CONCLUSION

The results from this study demonstrate that deaf adolescents who e-mailed and chatted online at higher frequencies also demonstrated higher reading comprehension skills in the years ahead. These findings indicate that a positive association exists between CMC and English literacy, and that CMC may be a promising avenue towards the development of English language proficiency for deaf individuals, upon further empirical investigation. Deaf individuals are a highly heterogeneous group, sometimes more so than the general population when considering the differing levels of auditory capabilities, language proficiencies, and preferred communication modalities that are found in this population (Easterbrooks, 1999). Deaf individuals of varying backgrounds can all capitalize upon digital communication technologies, pointing towards the universal potentials of CMC as that which can be equitably accessed and utilized. Computer-mediated communication appears to be a highly effective tool in the deaf individual's repertoire, with yet to be explored potentials of contributing to English language and literacy development.

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