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RESEARCH ARTICLE

Impact of Classroom Computer Availability on Preschoolers' Social Interactions

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Despite increases in computer availability in the classroom, very little data exists on computer availability and its use in Head Start classrooms. Therefore, the purpose of this study was to examine the impact of availability of computers on urban preschoolers' naturally occurring social interactions in Head Start classrooms across one school year. The sample consisted of 66, predominantly African American, children in four urban, Head Start classrooms. A quasi-experimental design was employed in which three classrooms had computers, while one classroom served as the control. Naturally occurring social interactions were observed during free-play sessions over an 8-month period. Hierarchical linear modeling was used to analyze differences in social interactions across classrooms and school year. Results suggest that classroom computer availability may increase the interactive behavior of preschoolers. Results suggest that investing resources into a computer center in the Head Start classroom can have a positive effect on social development.

Keywords: social interaction, computers, African American

Advancement of educational technology over the past two decades has resulted in government policy to increase computers in the classroom (McMillan Culp, Honey, & Mandinach, 2003). Children now get an early start on becoming technologically literate (e.g., No Child Left Behind Act, 2001; NAEYC, 2012). Therefore, computers are increasingly being integrated into young children's classrooms.

In 1987, only 15% of the surveyed preschool programs in one Midwestern county had computers available for children (Donohue, Borgh, & Dickson, 1987). However a decade later, 80-90% of early childhood educators reported availability of computers in the classroom (Haugland, 1997; National Center for Educational Statistics [NCES], 2003). A random sample of Head Start teachers in one state found that 88% had at least one computer available inside the classroom to use with children (Bewick, 2000). The ratio of computers to students has changed from 1:125 in 1984 to 1:22 in 1990 (Clements & Swaminathan, 1995) to 1:6 in 1999 (NCES, 2003), thus indicating that their availability for use has increased rapidly.

Despite this increase, there is a substantial disparity in access to and functionality of technology between different socio economic status (SES) niches. Judge, Pucket, and Bell (2006) found that 96.5% of upper-income households had a computer for child use, while only 45.5% of lower-income households had a computer. Regardless of SES, Caucasian parents were more likely than African American or Latino parents to have Internet access (Calvert, Rideout, Woodlard, Barr, & Strouse, 2005). Furthermore, kindergarteners from minority or low SES families are less likely to attend schools that provide students with access to the Internet (Parsad & Jones, 2005; Rathbun, West, & Hausken, 2003) and the ratio of students to computers was higher in schools with higher poverty concentrations (5.1 to 1 versus 4.2 to 1, respectively; Parsad & Jones, 2005).

Despite the general increases in computer availability in the classroom, very little data exists on computer availability and its use in Head Start classrooms (Bewick, 2000). According to Bewick (2000), the majority of Head Start teachers in one state reported that they had computers available for use with children. However, 17% said they didn’t use them at all with the students. The majority (68%) had only one computer for a classroom of 16-20. Furthermore, lack of incorporation of the computers into the curriculum, inadequate equipment, and some concern over the appropriateness of use with young children was noted by some respondents. Therefore, the purpose of this study is to examine the impact of availability of computers on urban preschoolers’ naturally occurring social interactions in the Head Start classroom across one school year.

MAJOR ISSUES ON COMPUTERS AND SOCIAL INTERACTIONS

The following review examines the issues related to computers and social interactions that have arisen over the past few decades. We aim to provide a new direction and shift the old debates on this topic.

Are Computers Developmentally Appropriate Materials?

The first issue is the debate among educators and researchers regarding the value of personal computers in early childhood development (Clements & Samara, 2003; Cordes & Miller, 2000; Haugland & Wright, 1997; Lepper & Gurtner 1989; National Association for the Education of Young Children [NAEYC], 1996; Scoter, Ellis, & Railsback, 2001). The major debate in the 1990’s was whether computers were developmentally appropriate for young children (Clements & Nastasi, 1993; NAEYC, 1996; Shade & Watson, 1990) and if so, could young children operate the computers (Borgh & Dickson, 1986; King & Alloway, 1992).

To resolve this debate, computer proponents have provided empirical evidence that computers, when used appropriately and interactively, have the potential to transform conventional material for children, making it easier to organize and access information (Freeman & Somerindyke, 2001) and can benefit children's cognitive and social development (NAEYC, 2012). Moreover, they have found that young children can use computers; activate them, follow pictorial directions, and use cues to reason about their activity (Clements & Nastasi, 1993; Hess & McGarvey, 1987). However, some educators have cautioned that assumptions about children's cognitive development cannot be made based on children's proficiency in manipulating computer icons (e.g., Elkind, 1996).

Do Computers Cause Social Isolation in children?

The second issue in the 1980's was a concern that computers in the classroom would cause children to be isolated from their peers and deprive them of socialization (Baker, 1985; Barnes & Hill, 1983; Lipinski, Nida, Shade, & Watson, 1986). This notion of "social interaction deprivation" by computer has not been supported in the research literature. Typically, children use computers in dyads or groups in classroom settings (e.g., Clements, 1994; Swigger & Swigger, 1984). Hence a plethora of social interactions are reported.

For example, Heft and Swaminathan's (2002) reported preschoolers observing and acknowledging each other; commenting, sharing and helping each other on the computer; as well as peer conflicts regarding turn-taking and sharing of the computers. Bergin, Ford and Hess (1993) reported that 95 kindergartners cooperated and took turns while on the computer. They observed only two aggressive behaviors during their four month study. Shahramin and Butterworth (2002) reported the most frequently coded interactions were directing partner's actions, providing and asking for information, self-monitoring, declarative planning, showing pleasure, and disagreeing with partner on the computer.

How Does Computer Activity Compare to Other Activity?

A third issue is to compare the social interactions when working on a computer, which is an object, to social interactions when playing with other objects. Some researchers suggest that young children show increased pro-social behaviors when working together on a computer compared to other classroom activities such as toy-focused play (Lipinski et al., 1986; McCormick, 1987; Svensson, 2000). Muller and Perlmutter (1985) found that preschoolers spent significantly less time engaging in peer interactions while at puzzle play (7%) than they did while at computer play (63%). Additionally, only 11% of the time was spent in solitary activity at the computer, while 55% of the time was spent in solitary activity with the puzzle. Anderson (2000) found that 4-year-old's cooperative play in the computer center paralleled the proportion of cooperative play in the block center. It also provided a context for sustaining interaction that could be transferred to play in other areas as well. These studies cumulatively suggest that availability of computers as objects solicits social interactions in children.

Do Computers Displace Important Activities?

A fourth issue is whether computer activity displaces other important developmental activities. Hohmann (1994) argues that for preschoolers and kindergarteners, the addition of computers to the environment has positive social consequences and appears not to disrupt other classroom social interactions. Lipinski et al. (1986) found that computer novelty initially interrupted free-play activity patterns by drawing children away from traditional activities. However, most activities returned to baseline levels within two weeks. Other research has supported this finding (e.g., Bergin et al., 1993; Clements & Nastasi, 1985). These studies suggest the hypothesis that the presence and use of computers does not adversely impact the behaviors occurring during other classroom activities.

LIMITATIONS OF PAST RESEARCH

The studies reported above have addressed many important questions regarding computer use in early education. However, these studies have several limitations. First, all studies examined the social interactions of children when they are *on* the computer and not the impact of availability of computers on social interactions during free play in the classroom. Second, no known studies have used a design in which they compare the social interactions of classrooms with and without computers. Third, most of these studies had predominantly middle class and European-American children (e.g., Baker, 2000), and not low-income, inner city, and/or minority children who have substantially less access to computers (Calvert et al., 2005; NCES, 2003). Fourth, most of the studies presently available involve small sample sizes, usually of only one or two preschool classrooms (e.g., Freeman & Somerindyke, 2001). Fifth, some studies did not operationally define specific behaviors such as sharing (Muller & Perlmutter, 1985) and cooperative play (Anderson, 1998). Sixth, most studies have examined computers in a pre-prescribed social context such as working together, working separately, or performing certain predetermined tasks (e.g., Shahramin & Butterworth, 2002).

Our study addresses these limitations by (1) examining the influence of availability of the computer on social behavior during free play; (2) having a contrast group; (3) examining lower income children in a community setting; (4) having a more adequate sample of four classrooms; (5) having operational definitions of all observed behaviors; and (6) examining social interactions in a naturally occurring classroom environment.

GOALS OF CURRENT STUDY

Given the above issues and limitations, our goal was to open up a new line of investigation; namely, to examine the impact of availability of computers on the social interactions of urban, low-income preschool children during indoor free play in classrooms.

Therefore our research questions are as follows: How does the availability of computers in classrooms impact 3 to 5- year-olds' (1) overall social interactions during indoor free play, (2) developmental trajectories of social interactions during indoor free play across the school year and (3) social interactions expressed verbally, the affect displayed during these interactions as well as the target of these social interactions? These questions are largely exploratory because the vast majority of past research has examined child activity while on the computer only.

However, based on the research reviewed above and other studies that have found positive effects of computers on child development (e.g., Rhee, & Bhavnagri, 1991; Li & Atkins, 2004; Li, Atkins, & Stanton, 2006; Floyd, Canter, Jeffs, & Judge, 2008; Lonigan, Allan & Lerner, 2011; Diamond & Lee, 2011), we made the following conservative hypothesis: The availability of computers in the classrooms would not have a significant adverse impact on preschoolers' social interactions during indoor free play.

METHOD

Participants

The study sample consisted of 66 preschoolers enrolled in a Head Start Program in a Midwest urban city. Participants were drawn from a larger study examining the effects of computers on the development of Head Start children. Children were recruited from four classrooms at three Head Start sites. The mean age of the participants at the beginning of the school year was 48.71 months (*S.D.* = 6.59). The majority of the children were African American (95.5%), while 1.5% of the children were Caucasian, and 3% were identified as other. Annual household income ranged from below $5,000 to more than $50,000, with 50.9% of parents reporting their income was between $0-10,000 per year. The majority of mothers (78.6%) and fathers (77.5%) had at least a high school diploma or GED; 11.4% of mothers and 6.9% of fathers had a college degree. See Table 1 for details of socio-demographic characteristics by classroom. Classrooms did not differ significantly on any variables detailed in Table 1. All parents completed a written informed consent and agreed to let their child participate in the study.

TABLE 1
Sample Characteristics

	Computer Room 1	Computer Room 2	Computer Room 3	Control Room 4
N	17	16	18	15
Boys	8(47%)	7(44%)	13(72%)	9(60%)
Age in months	48.76(6.41)	48.06(6.72)	47.11(6.99)	50.13(6.30)
African American	94.1%	87.5%	100%	100%
Household income ≤$10,000	46.7%	50.0%	71.4%	57.1%
Mother <HS education	35.3%	20.0%	23.5%	33.3%
Father <HS education	35.3%	21.4%	21.4%	41.7%
Mother work full-time	58.8%	37.5%	70.6%	33.3%
Father work full-time	37.5%	53.3%	63.6%	50.0%
Access to home computer	24%	62%	44%	40%
Total # of observations	1046	1045	1130	1079
Mean child observations/day	2.78(.40)	2.89(.10)	3.22(.10)	3.12(.15)
Mean observations/child	61.53(32.67)	71.93(31.39)	65.31(18.54)	62.78(21.68)

Study Design

The study used a quasi-experimental design in which self-contained classrooms were randomly assigned to either a computer or control condition. Only classrooms that were considered typical and had not previously used computers were considered for inclusion.

The control and computer classrooms were similar in child demographics, teacher characteristics, and classroom climate. As stated above, children did not differ significantly on child/family characteristics. All teachers were African American, had a Child Development Associates degree, and followed standard Head Start curriculum. Informal observations suggest that teachers also had similar styles with regards to classroom guidance and discipline.

With regard to general classroom climate, there were many similarities because all classrooms were members of the same Head Start Agency. All classrooms met for a half-day session and had one teacher and one teacher's assistant present during class time. The physical arrangement and use of space was similar, including the availability of the same learning centers in each classroom. Classrooms followed the same curriculum and daily routine. Both the control and computer classrooms allowed for one hour of free-play in classroom learning centers and therefore provided opportunities for child interaction. Lastly, classrooms shared the same educational philosophy, based on developmentally appropriate practices by the NAEYC and followed the same rules governing classroom conduct and usage of equipment.

Four classrooms were selected from the larger study to participate in this observational study. Three of these classrooms had computers. The fourth classroom had no computer and served as the control. Treatment classrooms had two computers in each room. The "twin imagination station" (TIS) developed by Hatch, Inc (Winston Salem, NC) was installed in each of the computer classrooms. The TIS is a child friendly hardware system that includes two computers. The computers were pre-installed with age-appropriate educational software programs (e.g., Millie's Math House and Bailey's Book House) and were set up near one another with chairs for two children per computer.

Procedure

As part of the larger study's protocol, each child in a computer classroom had approximately 15 minutes per day, as part of their daily curriculum, to play on the computer with their choice of developmentally appropriate educational programs. Head Start teachers and/or graduate research assistants provided necessary assistance during the first couple of weeks to familiarize children with the login process and the operation of the mouse, keyboard, and printer. However, there was minimal adult involvement beyond the initial period. Although literature suggests that teacher involvement can greatly enhance student learning on the computer (Judge et al, 2006; Plowman & Steven, 2005), typical resources available in the Head Start classroom does not allow for one-on-one time with each child every day on a computer. Therefore the current study was designed to be ecologically valid with the goal of examining the impact of computer center *availability* in the classroom. Children's computer use was based on either self-selection of computer for play or direct solicitation of the teacher to take a turn on the computer if desired. Potential computer use occurred throughout the school day and was available for children to use during their free-play hour. Children were allowed to bring another child to the computer station to work together if desired. No specific teacher instruction was given to students regarding computer use. Other activities available during the free-play hour included the use of standard Head Start learning centers such as literacy, art, manipulative, dramatic play, and block centers.

The control classroom received the standard Head Start curriculum including the availability of the standard learning centers listed above. Live observations of social interactions were conducted in the Head Start classrooms during each classroom’s one hour free-play session. The free-play session was chosen for observations because it typically provides optimum opportunities for self-selected social interactions. During free-play, the child could have been in the computer center or any other center in the classroom. Therefore, observations occurred across varied contexts. Observation sessions occurred twice a week, every other week for eight months (October through May), allowing for approximately 60 observations per child. Table 1 shows average number of observations overall and per day by classroom. Sixty observations were considered adequate based on previous studies using this methodology for observing peer interactions in classrooms (Bhavnagri, 1987; Ladd, 1981). Variation in number of observations per child (as shown in Table 1) occurred due to differences in attendance, drop-out and availability of each child. Classrooms did not differ significantly on number of observations per child.

Coding

Each child was observed using an event sampling method. The specific procedure used for this event sampling is called scan sampling. This approach is borrowed from the field of ethology where the social behaviors of a group of animals are observed in a natural setting. Each child was observed for about 10 seconds, which was adequate to determine the specific details regarding social interactions and then the observations were recorded on a coding sheet immediately. Next, the coder would scan the room looking for the next child to be observed.

The observers used a structured coding system developed by Bhavnagri (1987). This coding system was designed specifically for examining young children’s social competencies in early childhood educational settings and is representative of naturally occurring classroom interactions. All children’s social interactions, (i.e., inclusive of social play behaviors and other social behaviors which were not play) were recorded. These behavioral interactions were expressed simultaneously through three channels of communication, namely through their physical social interactions, labeled *Social Interaction* and verbal interaction labeled *Verbal Interaction* and through their affective communications labeled *Affect*. The *Target* to whom these behaviors were directed was also specified. Refer to Table 2 for operational definitions of the observational coding categories. The Social Interaction code, which must include some physical behavior, is considered the primary behavioral interaction category. The Verbal, Affect, and Target codes are considered supplementary categories and are treated as categorical. This coding scheme has demonstrated good reliability for use with preschool children. In an earlier study, the reliability ranged from .71 to 1.00 (Bhavnagri, 1987).

TABLE 2
Coding Scheme

Behavioral Categories	*Description*
I. Social Interaction	
1. Isolated Behavior	*No verbal or physical interaction with anyone, but child interacts physically with objects and self. No interest in peer is shown.*
2. Passively Observes	*Watches child, teacher, or peer group without any other social behavior*
3. Parallel Play	*Plays side by side with child, teacher or group with similar objects or actions, engaged in similar activity*
4. Positive Interactions	*Shares, takes turns, simultaneously acts upon toys, initiates, cooperates, joint activity with child, teacher or group*
5. Negative Interactions	*Hitting, punching, shoving, grabbing, pulling hair of child, teacher or group*
II. Verbal Interaction	
1. Positive Verbal Statements	*Verbal content is pro-social, e.g., requests and praises, agrees on goals, offers turns, encourages, suggests cooperation.*
2. Negative Verbal Statements	*Verbal content is antisocial, e.g., expresses aggressiveness, rejection, annoyance, refusal to cooperate, whines, complains*
3. Neutral Verbal Statements	*Verbal content is not related to social skills, e.g., talks about properties of objects, talks or reads to self*
4. Not Applicable	*Child is not engaged in any verbal activity*
III. Affect	
1. Positive Affect	*Smiles, laughs, giggles, claps, bounces, hugs or kisses*
2. Negative Affect	*Cries, sulks, frowns, fusses, acts agitated, pouts*
3. Neutral Affect	*No affect displayed*
IV. Target of Interaction	
1. Adult	*Teachers, parents, volunteers, observers*
2. Boy	*Boy*
3. Girl	*Girl*
4. Peers	*A group of children*
5. Self	*Alone with no object*
6. Object	*Toy or object*

Inter-coder agreement. An expert in the observational scan sampling method trained the coders in using this coding system. The expert also monitored the coders' observations when they started collecting data at the Head Start centers to address any issues. Twenty percent of total observations were coded independently by two trained graduate research assistants in order to establish inter-rater reliability. Cohen's kappa (Cohen, 1960) was used as a measure of inter-coder reliability. For this sample, kappa was equal to .95 for Social Interaction, .87 for Verbal Interaction, .93 for Affect, and .91 for Target.

Statistical analysis

Hierarchical linear modeling (HLM; Bryk & Raudenbush, 1992; Raudenbush & Bryk, 2002) was used to address the first two research questions of this study (How does the availability of computers in classrooms impact 3 to 5- year-olds' (1) overall social interactions during indoor free play, (2) developmental trajectories of social interactions during indoor free play across the school year.) HLM methodology is ideally suited for the current study given the nested nature of the data (longitudinal data collected from children nested within classrooms). Taking the nested nature of the data into account is important for several reasons. Children within a particular classroom share the same teacher and physical environment and have similar learning experiences, which may lead to increased homogeneity over time (Osborne, 2000). Therefore, observations are not fully independent, which violates a primary assumption of most analytic techniques and increases Type I error (Tabachnick & Fidell, 2007). Hence, HLM was implemented through HLM 6.0 (Raudenbush, Bryk, Cheong, & Congdon, 2004). The dependent variable used in this analysis was *Social Interaction*.

In order to answer research question 3 (Are there differences in verbal interaction, affect, or the target of social interactions based on computer availability?) analysis of covariance (ANCOVA) was employed. The broad categories of *Verbal Interaction*, *Affect*, and *Target* were transformed into variables that represent the proportions of all observed interactions across the school-year that fell into each possible sub-category reflected in the coding scheme described in Table 2 (e.g., proportion of interactions that included positive affect, proportion with negative affect, and proportion with neutral affect). One proportion variable for each sub-category was obtained for each child. Therefore these analyses did not include a repeated measures component and had a total sample size of 66 children. HLM was not utilized for these analyses because the sample size was insufficient (66 children nested within four classrooms).

Variables were screened for univariate and multivariate outliers. Five univariate outliers were found on proportion scores and winsorized. No extreme skewness was detected; therefore all variables were left untransformed to increase interpretability of findings.

RESULTS

Preliminary Analyses

Preliminary analyses revealed that the three computer classrooms were not significantly different from one another on *Social Interaction, Verbal Interaction*, *Affect*, or *Target*. Therefore, classroom was assigned to control (0) versus computer (1) for further analyses. There continues to be no significant differences on measured demographic or classroom characteristics from Table 1 based on this reassignment of classroom.

For HLM analysis, Social Interaction was treated as an interval level outcome. Isolate play was given a value of 1, passively observing was given a value of 2, and parallel play was given a value of 3. Positive and negative social interactions were combined because they both reflect that there was the presence of a socially interactive behavior, be it positive or negative, and given a value of 4. It should be noted that negative social interactions were relatively few (4% of total behavior). Therefore the Social Interaction outcome used in the HLM analysis reflects a continuum of social interactions on a scale of 1 to 4. Past literature has supported the conceptualization of these behaviors as correlated to maturity and therefore ordered (e.g., Rubin & Krasnor, 1980; Smith, 1973).

To account for changes across time, a time variable was created ranging from -240 days to zero. Time was calculated this way so that the last observation of the year was zero. Hence, significance tests of effects of the intercept would reflect differences at the end of the school year, taking start values into account. This allowed for testing general differences between classrooms on Social Interaction while including the time effect in the model. The average number of observations per student was 65.15 (*Range* = 4-107, *S.D.* = 26.32, *Median* = 71.0).

Hierarchical Model of Social Interaction

The current data structure represents a three-level model. First level units were individual observations of social interactions, resulting in a total of 4300 observations for analysis. Second-level units were the 66 children enrolled. The four classrooms comprised the third-level units. The small number of classrooms would not allow for analysis of the classroom effect at level three. Therefore, the classroom effect was entered as a covariate in the level-two model.

A full model was analyzed that allowed for an estimation of the effects of child and classroom predictors on the shape of the trajectory of Social Interactions (i.e., physically communicated social interactions). The focus was on assessing the importance of child characteristics including gender, age, and family income and classroom assignment. The model is represented as follows:

Status at end of school year:

$$\pi_0 = \beta_{00} + \beta_{01}*(INCOME) + \beta_{02}*(GENDER) + \beta_{03}*(AGE) + \beta_{04}*(CLASS) + r_0$$

Growth Rate/Slope:

$$\pi_1 = \beta_{10} + \beta_{11}*(INCOME) + \beta_{12}*(GENDER) + \beta_{13}*(AGE) + \beta_{14}*(CLASS) + r_1$$

The constants (β_{00} and β_{10}) in the equations define the status of the outcome variable at the end of the school year and the growth curve of the outcome when all other variables in the equation equal 0. Gender and class assignment were left un-centered. Income and age were centered on the grand mean. Therefore, the coefficients for gender and classroom assignment represent differences between groups at the end of the school year and differences between the groups on growth rate. The coefficients for age and income represent changes in status at the end of the school year and on growth rate as a function of income and age. Because the equation for the growth rate reflects change across time, the variable coefficients in that equation represent the interaction between model variables and time (e.g., class assignment by time).

The full model as a whole was significantly better than the null model in which only the intercepts were included, $\chi^2_{diff}(11, N=4300) = 14611.95-14538.97 = 72.98$, $p < .001$. Thus the predictors as a group improved the model beyond that produced by chance. Class assignment was a significant predictor of status at the end of the school year and there was a significant change in outcome across time for all groups. All other predictors were non-significant.

Therefore, a reduced model was proposed in which only predictors with *p* values < .20 were included in the model. In this model, class assignment and gender were included as predictors of end of school year status (age and income were omitted) and gender and age were entered as predictors of growth rate (class assignment and income were omitted). This reduced model did not differ significantly from the full model, χ^2_{diff} (4, N=4300) = 14539.72-14538.97 = .75, $p > .05$. Estimated fixed and random effects for this model are presented in Table 3.
Results show that classrooms (control versus computer) differed on end of school year status. On average, computer classrooms showed significantly higher levels of social interaction at the end of the school year. Computer classrooms had a .44 point higher level of social interaction than the control classroom on a scale of 1 to 4. Post hoc analyses revealed that this difference is largely due to a higher proportion of positive social interactions in the computer classroom (34% for computer room versus 19% in control room).

Table 3 also shows that there was a significant effect of time (intercept for growth rate) across all groups for Social Interaction. Both classroom conditions showed a significant increase in level of Social Interaction across the school year. This suggests that, in general, children were likely to show increasingly interactive behavior and play as the school year progressed.

No statistically significant associations were found for gender, age, family income and Social Interaction. That is, there is no evidence that level of Social Interaction was generally related to the gender, age, or family income of the child or that the trajectory of Social Interaction across the school year was influenced by these child demographics.

TABLE 3
Final HLM Results for Social Interaction

Fixed Effect	Coefficient	SE	t-ratio	*p* value
Model for end of school-year status				
Intercept	2.22	0.11	19.96	<.001
Gender[a]	-0.21	0.11	-1.83	.071
Class[b]	0.44	0.11	4.20	<.001
Model for growth rate				
Intercept	0.01	0.00	2.68	.010
Gender	-0.001	0.00	-1.58	.119
Age	-0.0001	0.00	-1.64	.105
Random Variance	Coefficient		df	*p* value
Level 1 variation	1.68			
Level 2				
End of school-year status (r_0)	0.08		57	<.001
Growth rate (r_1)	0.00		60	<.001
Level 3 Intercept	0.002		3	.136

[a] 0=male, 1=female; [b] 0=control, 1=computer; Effects non-significant at $p \geq .20$ were not retained in the final model.

ANCOVA Analyses

ANCOVA was employed to examine differences in proportions of behaviors observed for Verbal Interaction, Affect, and Target of social interactions separately. Observed proportions for each behavioral category by classroom can be seen in Table 4. Because of the small sample size for these analyses (N=66), only demographic characteristics and two-way interactions that were significant at $p < .20$ were included in the final models and presented here. Table 4 also presents the Univariate F-test results for these ANCOVA analyses.

TABLE 4
Proportion Behaviors Observed (Standard Deviation) by Classroom Condition and Univariate F Statistics from ANCOVA Analyses (N=66)

	Proportion Observed (*S.D.*)		Effect				
	Control	Computer	Class[a]	Gender[b]	Age	Income	Class x Gender
Verbal Interaction							
1. Positive	.08 (.08)	.09 (.08)	.26	n/a	n/a	2.77	n/a
2. Negative	.01 (.02)	.03 (.04)	5.79*	n/a	n/a	n/a	n/a
3. Neutral	.18 (.08)	.26 (.09)	11.86**	2.34	2.36	n/a	n/a
4. Not Applicable	.73 (.13)	.62 (.14)	9.28**	n/a	n/a	3.15†	n/a
Affect							
1. Positive	.18 (.13)	.21 (.09)	2.75†	5.83*	n/a	n/a	8.23**
2. Negative	.02 (.02)	.04 (.04)	6.74*	n/a	n/a	n/a	n/a
3. Neutral	.80 (.12)	.74 (.10)	7.45**	5.48*	n/a	n/a	8.47**
Target							
1. Adults	.14 (.07)	.12 (.05)	2.51	9.31**	n/a	n/a	2.77
2. Boy	.12 (.07)	.15 (.08)	4.82*	28.95**	n/a	n/a	n/a
3. Girl	.07 (.04)	.12 (.09)	4.95*	23.24**	n/a	3.68†	n/a
4. Group	.11 (.05)	.13 (.07)	.88	8.54**	n/a	3.33†	n/a
5. Self	.03 (.02)	.01 (.01)	7.79**	n/a	n/a	n/a	n/a
6. Object	.54 (.11)	.46 (.14)	3.76†	n/a	n/a	n/a	n/a

† $p < .10$, * $p < .05$, ** $p < .01$; [a] 0=control, 1=computer; [b] 0=male, 1=female; n/a = not entered based on $p < .20$ criterion

For verbal interaction, computer classrooms displayed significantly more verbal statements that were neutral in content (e.g., verbal content that focused on topics such as properties of objects, talking or reading to self. See operational definitions, Table 2 for details), some negative statements and significantly less non-verbal interactions (see Table 4). This indicates that children in the computer classroom condition talked significantly more than the control group, as indicated by significantly less non-verbal interactions. Furthermore, it informs us about the verbal content of their conversations when compared to the control group. They talked significantly more about non-social topics (i.e., neutral statements). They also had more negative communications, such as expressing aggressiveness, annoyance, or complaints, although these negative communications were relatively few (3%).

Results for the affect showed that the computer classrooms displayed significantly more negative and less neutral affect. There was a trend toward more positive affect displays by children in the computer classrooms ($p < .10$). There was a main effect of gender for positive and neutral affect. Girls displayed significantly less positive affect and more neutral affect. The class by gender interaction was also significant for positive affect and neutral affect. Post hoc analyses show that boys in the control classroom displayed more positive affect and less neutral affect than girls. Also, girls seem to carry the effect of classroom assignment. It was girls in the computer classroom condition who showed significantly less neutral affect, more negative affect, and a trend toward more positive affect.

Results for the target of behavior proportions show that computer classrooms were significantly more likely to target behaviors toward boys and girls, and less likely to target self. This finding suggests the children in the computer classroom targeted interactions with persons, rather than playing alone. Girls were more likely to target behavior toward adults and other girls and less likely than boys to target other boys or groups of peers. This suggests that both girls and boys preferred to interact with other peers of their own sex. There was no significant difference on targeting adults or groups based on computer availability.

DISCUSSION

Overall, our hypothesis that the presence of computers in the classroom would not have an adverse impact on preschoolers' social interactions was largely supported. Children in classrooms with computers did not show lower amounts of interactive behavior across social, verbal or affect domains. On the contrary, the children in computer classrooms were more likely than children in classrooms without a computer to display socially interactive behaviors, to be verbal, and to display more affect. Children in the computer classroom condition were also more likely to interact with peers and less likely to play alone.

There was some evidence that negative social, verbal, and affective interactions were more prevalent in the computer classroom. However, negative interactions were infrequent ($\leq$ 4%) and this difference may be a consequence of increased social interactions. Both positive interactions and negative ones are likely to increase across the school-year (Ramsey, 1995) and friends are likely to engage in more cooperation and conflict than non-friends (Hartup & Brett, 1987; Hartup, 1992). Because children are interacting with one another more frequently, it increases the chances of positive and negative behaviors. We do not interpret this as an indication that computer presence is harmful in light of the other findings.

Both computer and control classrooms displayed an increase in social interactions across the school year. This finding is fitting with developmental expectations for children of preschool age (Rubin & Krasnor, 1980; Smith, 1978) and therefore provides additional support for the validity of the coding scheme used in this study.

Together, the results from this study suggest that the availability of computers in urban preschool classrooms may have a positive influence on children's social interactions. This conclusion is consistent with past studies that have found the interactions of children *on* the computer to be interactive and social in nature (e.g., Bergin et al., 1993), perhaps more social that other classroom activities (e.g., Muller & Perlmutter, 1985). However, the results from this study are not limited to on-computer activities. Thus, these findings lead to the question; why might the very availability of computers foster more overall social interactions?

A potentially novel way to think about this question, particularly as it pertains to the effects of computers in the preschool classroom, comes from a social historian's theoretical perspective. This perspective suggests that it is the *availability* or introduction of technology (e.g., computers) that affects human being's social behavior. Theorists in behavioral archeology, modernism and cultural critics have all consistently reported that laws of behavioral change cannot be explained only through nomothetic studies (Fischer, 1992; Schiffer 1992). These theorists recommend that we also need to study and accept that artifacts or material culture, such as technology, always impacts human behavior. They report that the availability of transportation technologies such as bicycles and cars, household technologies such as vacuum cleaners and refrigerator and communication technologies, such as radio, telephones, televisions, and computers has impacted social behaviors (Fischer, 1992; Hughes Jr. & Hans, 2001). Television watching, for instance, has now commonly been known to replace other activities, especially interpersonal and social ones (Robinson & Godbey, 1997). However, technologies like email, the Internet and social media are still under debate (e.g., Franzen, 2000; Hampton & Wellman, 2000; Nie, 2001; O'Keeffe et al., 2011). Given this theoretical perspectives, it should not come as a surprise that computer availability in this study contributed to the presence of group differences on social behaviors. However, the underlying processes that contribute to this change are uncertain.

A child development, empirical perspective, may also shed some light on this question. The computer may be a unique tool that fosters social learning. The presence of the computer could alter children's views about school or themselves. Haugland (1992) found that the self-esteem of 4-year-old children in classrooms with computers was significantly higher than the self-esteem of children in classrooms without computers. Haugland (1996) hypothesized that self-esteem increases in computer classrooms because children view computers as "adult machines" and when given the opportunity to explore them, children feel important, capable, and competent. This type of increase in self-esteem could conceptually lead to more positive social interactions.

It is also possible that the increased interaction by students could be due to reactions of their teachers. Teachers could be responding to the presence of the computers by altering the way they interact with children in some way (Zhoa & Frank, 2003). Hypothetically, availability of computers could influence instructional style, lead to increased monitoring, enhanced involvement in off-computer play, and conflict resolution.

Computers may offer an opportunity for children to engage in an activity that promotes child-child interactions. Research shows that children prefer to work on computers with peers (e.g., Swigger & Swigger, 1984). The indirect path could be such that the nature of social interactions on the computer actually promotes the learning of pro-social behaviors, which carries over to other classroom activities. This hypothesis is consistent with Vygotsky's developmental view on socially mediated learning (Vygotsky, 1978). Certainly the relation between the presence of computers and positive interactions is likely to be mediated by changes in other variables. Examining the ways the ecology of the classroom changes as a result of computer presence, or use, is a needed addition to the literature.

Potential Limitations & Strengths

The current study had limitations which should be noted. First, it was not possible to randomly assign teachers or students to classrooms. Consequently, effects of teacher and classroom are confounded with the effect of computer availability. Although every effort was made to best address this limitation by ensuring that the control classroom was similar to the intervention classroom in many ways, attributing differences between classroom conditions to effects of the presence of computers is provisional. Second, a larger sample of classrooms would have helped control for the lack of random assignment. It would have also allowed for enhanced use of HLM techniques, such as the ability to test and control for level-3 variables (i.e., classroom characteristics).

Despite these limitations, our results are provocative in suggesting that availability of computers in the Head Start classroom may increase the sociability of children during free play. Moreover, a significant strength of this study was that it had 4300 live observations of 66 children in four classrooms, done over eight months, which is considered sizable for an observational methodology. These data provided a rich, longitudinal picture of social behavior for these preschoolers. Furthermore, the current study attempted to address several limitations of previous research in this area. The examination of naturally occurring free-play activity and not researcher prescribed activity, the use of a control group design, extensive observations of low income urban children in multiple Head Start classrooms, and the use of an operationalized coding system are all strengths of the current study.

Implications: Future Research & Practice

The current study presents several possibilities for future research. Future studies should focus on possible mediators of an effect of computer availability on social interactions. For instance, observation and measurement of the on-computer interactions, teaching styles on and off computers, child-peer-adult triadic interactions on computers, gender effects, and other ecological variables could lead to a better understanding of how the ever-increasing availability of computers impacts young children and why positive effects might occur.

Overall, the results from this study have practical implications; namely that investing resources into a computer center in the Head Start classroom can have a positive effect, not just on the cognitive development of young children, which is often the focus of computer research (e.g., Li & Atkins, 2004), but also on social development. The results from this study suggest that the positive effect may be carried over to off-computer interactions between children, which in itself is a notable finding. Furthermore, these findings add to the limited research that has been done on the effects of computers in Head Start classrooms. Thus it expands our knowledge of potential benefits of the computer center in early childhood education. The NAEYC and Fred Rogers Centers highlight the importance of using technology and media appropriately in early childhood settings (2012). They emphasize that technology should be used for activities that are educationally sound and developmentally appropriate. They also highlight the importance of training and digital literacy for our early childhood educators. Consistent with these recommendations, we believe that the practical implications reported here could be further enhanced with greater teacher/adult involvement in the child's computer activity, greater integration of the computer into classroom curriculum, and computer training and assistance for teachers (Bewick & Kostelnik, 2004; Bergen, 2000, 2002; NAEYC, 2012).

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