Purpose: This study explored the language-learning environments of typically developing dual language learners (DLLs) who learned Cantonese (first language [L1]) at home and English (second language [L2]) in preschool settings through direct and indirect measures.

Method: Nine typically developing Cantonese–English DLLs participated in this study. Participants’ daylong activities were audio-recorded using the digital language processor of the Language Environment Analysis system. A manual coding scheme was developed to examine the audio recordings with the focus of the amount of L1 and L2 use by participants, adults, and their peers across home and school settings. In addition, participants’ language use was indirectly examined using parent questionnaires, teacher reports, and classroom observations.

Results: The results of the audio recordings showed that Cantonese was the primary language used at home, and both Cantonese and English were used in school settings, consistent with the parent and teacher reports. Correlation analyses revealed that the amount of L1 used by the participants was associated with the L1 used by their peers: and the amount of L2 used by participants was positively related to the L2 used by adults at home.

Conclusions: The findings illustrate how parent/teacher reports and daylong audio recordings could complement each other in the investigation of DLLs’ language-learning environments.

Empirical research shows that one crucial factor that contributes to DLLs’ L1 and L2 growth is their language-learning environments (Bedore et al., 2016; Cheung et al., 2019; Paradis, 2016). Language-learning environments involve dynamic communicative interactions between communicative partners (e.g., parent–child communication) within structured and unstructured activities (e.g., classroom learning activities vs. free-play). Many factors could affect such interactions and the amount of L1 and L2 used across minority families and school programs. In home settings, the use of L1 and L2 depends on family members’ L1 and L2 proficiency, cultural beliefs, and community/cultural influences (Burchinal et al., 2012; Lee et al., 2015; Luo & Wiseman, 2000; Velazquez, 2009). In classroom settings, the use of L1 and L2 depends on the language of instruction (e.g., English-only, bilingual), language proficiency of the teachers (e.g., providing classroom instructions in the child’s L1), quality of the classroom instruction, and the preferred language(s) used among peers in school settings (Burchinal et al., 2012; Collins, 2014; Dickinson et al., 2008; Garcia, 2018; Palermo & Mikulski, 2014; Proctor et al., 2010; Sawyer et al., 2016).

Disclosure: The authors have declared that no competing interests existed at the time of publication.
This study examined the language-learning experience of preschool DLLs who were exposed to Cantonese (L1) at home from birth and started to learn English (L2) in preschool settings. Children’s language-learning environments have been studied using indirect measures (e.g., parent reports; Duursma et al., 2007) and direct measures (e.g., audio-recording; Oller, 2010). Much of our knowledge about DLLs’ language-learning environments (e.g., 80% L1 at home) is based on studies that utilized indirect measures such as parent reports (e.g., Bedore et al., 2011; Cheung et al., 2019; Duursma et al., 2007; Gutiérrez-Clellen & Kreiter, 2003; Hoff & Core, 2013; Paradis, 2016; Pua et al., 2017). With the advancements of technology, increasing studies have explored different methodologies that directly measure children’s language-learning environments. One of the methods that has been used is called the “Language ENvironment analysis (LENA) system” (LENA Research Foundation, 2019). It provides automated quantitative measures (e.g., adult word counts) to examine children’s daylong naturalistic communication samples (Oller, 2010; see also VanDam et al., 2016). When it comes to examining DLLs’ language environments using the LENA system, one major shortcoming is that the system is not able to distinguish between the two languages in bilingual environments (Marchman et al., 2016; Wood et al., 2016). To our knowledge, only a handful of studies have examined the naturalistic language-learning environments of DLLs using direct measures (Marchman et al., 2016; Wood et al., 2016). Moreover, few studies have directly examined L1 and L2 use across home and school settings. The main goal of the current study was to explore DLLs’ naturalistic language environments at home and in school settings using direct audio recording. The second goal was to establish a viable method for analyzing daylong audio recordings of DLLs’ language environments. A clear understanding of the diverse language-learning experiences of DLLs in naturalistic language environments has important implications for designing education programs for DLLs and training programs for clinical practitioners, teachers, and parents.

**Indirect Measures of Bilingual Children’s Language-Learning Environments**

Indirect measures for examining young children’s language environments rely on reports from caregivers and/or teachers. Examples of indirect measures include parent or teacher questionnaires (Ebert, 2017; Paradis, 2011), interviews (Gutiérrez-Clellen & Kreiter, 2003; Hampton et al., 2017), focus groups (Lee et al., 2015), home and school observation ratings (Downer et al., 2012; Rogman et al., 2016), and diary/checklist records (Kim et al., 2000; Place & Hoff, 2016). These measures have been widely used to examine bilingual children’s language experience quantitively (e.g., the amount of time) and qualitatively (e.g., the richness of language-learning activities) in research and/or clinical settings (Bedore et al., 2011; Cheung et al., 2019; Dixon & Wu, 2014; Gutiérrez-Clellen & Kreiter, 2003; Lee et al., 2015; Paradis, 2011; Sawyer et al., 2016). The advantages of using indirect measures are that it is relatively inexpensive and easy to distribute to participants. For example, Cheung et al. (2019) used parent questionnaires to examine relative L1 and L2 input patterns of 92 Cantonese–English DLLs from immigrant families living in the United States. Their findings revealed that the use of L1 and L2 significantly varied across home language-learning activities (e.g., reading out loud, playing word games, watching TV, eating dinner). Although the majority of families used Cantonese (L1) exclusively during dinner, only 33.7% of the families used L1 when reading aloud to their children.

Indirect measures have also been used to address questions about the relationships between the use of L1 and L2 in school settings and children’s language outcomes (Burchinal et al., 2012; Collins, 2014; Duursma et al., 2007; Uchikoshi & Maniates, 2010). One measure, in particular, is the Head Start Family and Child Experiences Survey. It is a large-scale longitudinal study of preschool children and families served by the Head Start programs in the United States (Malone et al., 2013). Garcia (2018) analyzed the responses by the lead teachers of 531 Spanish–English bilingual preschool children from the Family and Child Experiences Survey and found that 75.4% of teachers used both Spanish and English in the classroom, 17.1% used only English, and 7.54% used mostly Spanish. These results help reveal the ratio of dual language exposure that bilingual preschool children received in different classroom settings. Moreover, children who were in English-only classrooms had significantly higher English vocabulary skills than children in Spanish-dominant classrooms. Importantly, exposing students to both English and Spanish in the classroom did not negatively affect preschoolers’ growth in English vocabulary skills.

Despite its advantages, responses from indirect measures may not always be reliable (Carroll, 2017). For example, Marchman et al. (2016) examined Spanish–English bilingual children’s language-learning environments using both parent reports and daylong audio recordings. They found that the proportion of Spanish use reported by parents was significantly lower than the proportion obtained by audio recordings. Moreover, predetermined questions used in questionnaires or interviews might not entirely capture all that happens in natural and spontaneous environments. Although questionnaires can obtain information such as the estimated amount of L1 and L2 use during typical home and classroom activities (Cheung et al., 2019; Gutiérrez-Clellen & Kreiter, 2003; Malone et al., 2013), other experiences outside the home and school settings, such as traveling home from school, interactions within the greater community, and field trips, are usually missed.

**Direct Measures of Bilingual Children’s Language-Learning Environment**

In contrast to indirect measures, direct measures involve the direct or recorded observation of communicative interactions between the child and their communicative...
partners (e.g., parent–child communication). Direct measures may be in the form of short, naturalistic observations (Hurtado et al., 2008; Wang et al., 2000) or daylong extensive audio recordings (Ganek & Eriks-Brophy, 2018a, 2018b; VanDam et al., 2016). The LENA system has been considered as a user-friendly method to acquire and analyze daylong naturalistic communication samples. This system involves a small digital language processor (DLP) that records a child’s interactions for up to 16 hr. Specialized speech recognition algorithms are used to segment the audio data into subcategories such as adult, child, and noise to provide information about child vocalization, adult words, and conversational turns (Ford et al., 2008; Xu et al., 2009). According to the technical report (Xu et al., 2009), the audio segments of the adult speech estimated by the LENA system had an agreement of 82% with the segments identified by human coders, whereas the segments of the child speech had an agreement of 76%. In addition, the adult word counts between the LENA system and human transcribers were significantly correlated ($r = .92$).

In a recent study, Gilkerson et al. (2017) obtained daylong LENA recordings from a large sample of English-speaking children ($N = 329$, age range: 2–48 months). The authors showed that the average daily adult word count for children between 2 and 4 months of age was around 15,000 words and then at a relatively stable average of 12,600 words after 5 months of age. They also found that children’s vocalization and conversational turns were positively correlated with their standardized test scores from the Preschool Language Scale–Fourth Edition (Zimmerman et al., 2002) and the MacArthur–Bates Communicative Development Inventories (Fenson et al., 2007). In addition to English-speaking children, previous studies have examined the feasibility of using LENA with other monolingual populations, including Spanish, French, Mandarin, Korean, and Vietnamese (Canault et al., 2016; Ganek & Eriks-Brophy, 2018a; Pae et al., 2016; Weisleder & Fernald, 2013). Although these studies suggest the possibility of using LENA with different monolingual populations, researchers also noted that some factors could affect the accuracy of the results attained by LENA. These factors include background noise, cultural differences in mother–child interactions, acoustical and/or physical characteristics of the room/building (e.g., concrete walls, wood furniture), and even the local climate (e.g., hot and humid weather; Ganek & Eriks-Brophy, 2018a; Xu et al., 2009).

One major limitation of using LENA to analyze DLLs’ language environments is that the technology does not provide automated measures for distinguishing each of the two languages in bilingual environments (Marchman et al., 2016; Wood et al., 2016). Some studies have reported that the two languages were manually separated from LENA audio recordings for analysis. For example, Marchman et al. (2016) examined the language-learning environments of 18 typically developing Spanish–English bilingual preschool children using LENA. Along with the automated measures calculated from the LENA software, the authors manually examined language use (i.e., Spanish, English, or both) within 5-min segments of child-directed speech (CDS). The proportion of Spanish exposure was calculated using Spanish CDS per hour (CDS/hr) divided by total CDS/hr.

In another study, Wood et al. (2016) examined the language-learning environments of 42 Spanish–English bilingual preschool children and 39 monolingual English-speaking children. Because LENA’s automated measures do not distinguish between the two languages, Wood et al. (2016) sampled the first minute of speech in each 5-min segment of the bilingual daylong recordings. Each first-minute segment was then coded as Spanish only, English only, or mixed use of Spanish and English. The percentage of Spanish use was the number of segments containing Spanish divided by the total number of segments in the daylong recording. Using this method, Wood et al. (2016) found that 78% of the segments across all samples contained exclusively (or mostly) in Spanish, 19% contained both languages, and 20% were exclusively in English.

**The Current Study**

In the current study, we operationally defined language-learning environments as the amount of L1 and L2 used by DLLs, adults, and peers at home and in school. Built from the methodology developed in previous research (e.g., Cheung et al., 2019; Marchman et al., 2016; Wood et al., 2016), this study examined the language-learning environments of DLLs from Cantonese-speaking (L1) homes using direct (i.e., daylong audio recordings) and indirect (i.e., parent reports, teacher interviews, observations, classroom visit ratings) measures. DLLs’ naturalistic language environments were recorded using LENA DLP recording devices, and a coding scheme was developed to manually identify the amount of time (in seconds) that L1 and L2 were used across home and school contexts. Indirect measures were also used to examine L1 and L2 use across home and school language-learning contexts. The current study addressed the following research questions:

1. **What is the amount of L1 and L2 used across home and school contexts, as measured by indirect methods (i.e., parent questionnaire, teacher interview, classroom observations)?**
2. **What is the amount of L1 and L2 used across home and school contexts, as measured by daylong audio recordings?**
3. **What are the differences between home and school settings in terms of the amount of L1 and L2 used by adults, peers, and the participants?**
4. **Are there any relationships between the amount of L1 and L2 used by adults, peers, and the participants?**

Although no previous studies have documented the potential barriers for using LENA with children from minority families, the nature of daylong audio recordings could affect recruitment and participation from minority populations. Previous studies showed that racial and ethnic minorities are reluctant to participate in clinical research (George et al.,
2014; Harrigan et al., 2014; Katigbak et al., 2016). In a systematic review, George et al. (2014) found that mistrust is the most common barrier for research participation in immigrants. Daylong audio recordings, unlike parent reports or interviews, could pose additional challenges for recruiting of immigrant children (or children of immigrants). Immigrants might fear or become skeptical of such procedures that invade one’s privacy, such as daylong audio recordings of language use. Adapting from the community-based participatory research approach (Wallerstein & Duran, 2010), we consulted community members, including teachers, parents, and family advocates, about potential immigrant families’ concerns and any issues that the daylong recording methods might pose. Based on their feedback, we developed a coding scheme that took into consideration the responses from the community members. Rather than following conventional word counts used in previous research (e.g., Marchman et al. 2016), the coding scheme focused on the duration of L1 and L2 use (in seconds) across the school and home settings.

**Method**

**Participants**

Cantonese–English bilingual participants and their caregivers were recruited from a pool of 300 preschool children who were enrolled in a Head Start program in the city of San Francisco, California. The majority of the preschool teachers at the Head Start program were bilingual speakers of Cantonese and English; some were monolingual English speakers, and some were from other cultural–linguistic backgrounds (e.g., Tagalog–English). The Cantonese–English bilingual teachers reported that they used both Cantonese and English in the classrooms. In the United States, Head Start programs provide free preschool education for children aged from birth to 5 years from low-income families (see the maximum annual household income at “California Head Start,” 2019).

Upon approval of the study by the institutional review board, recruitment flyers were distributed to six Head Start centers in San Francisco. Due to the daylong requirement of audio recording for each participant (Ganek & Eriks-Brophy, 2018b) and the potential research recruitment barriers (e.g., mistrust, fear) among Asian immigrants, we addressed these potential issues by having trained bilingual and bicultural research assistants to be available during school days to meet with parents who had questions about the study and the LENA audio-recording procedures (George et al., 2014).

Nine typically developing DLLs (five girls, four boys), ranging from 41 to 60 months of age ($M = 49.78$ months, $SD = 7.34$), were included in the final analysis. One child was excluded because parents had concerns about her language skills, and one child was excluded because of recorder problems. According to the parents, these participants were predominately exposed to Cantonese (L1) at home from birth and started learning English (L2) in school settings. The parents also reported that their children did not have any history of hearing loss, symptoms of autism, emotional or behavioral issues, or other developmental concerns. Table 1 summarizes the language and demographic characteristics of the participants. On average, the participants had attended the Head Start program for 10.9 months ($SD = 6.8$). A story-retell task was used to obtain information about the participants’ language skills in Cantonese (L1) and English (L2). Each participant was asked to retell the story from the wordless picture book *Frog, Where Are You?* (Mayer, 2003) in L1 and L2 in two different sessions. The order of the languages was counterbalanced. As shown in Table 1, the participants produced more different words when retelling the story in L1, $t(8) = 3.51, p < .01$. The mean length of utterance (MLU) in words in L1 was 4.91 ($SD = 1.22$), and MLU in morphemes in L2 was 3.89 ($SD = 1.35$). In addition, we gathered information about the parent’s education and current job status in order to calculate the Hollingshead index (HI; Hollingshead, 1975). In this study, the composite HI score for each family was computed based on both parents’ education and occupation. The mean HI score for our sample was 21.22 ($SD = 3$, range: 16–23), a score that indicates lower socioeconomic status.

**Indirect Measures: Home and School**

Prior to LENA audio recording, parents of the participants were asked to fill out a questionnaire about the language environments at home. The questionnaire was adapted from Cheung et al. (2019) and was available in Chinese (the written form of Cantonese) and English. The questionnaire inquired about the amount of L1 and L2 used by each family member at home and during various home activities. Family member options included Mother, Father, Older sibling(s), Younger sibling(s), Grandmother, and Grandfather. Home language activities of interest were (Book) Reading out loud, Telling stories, Playing word games, Watching TV, Playing with family, Playing with friends, Breakfast, Lunch, and Dinner. Relative amounts of L1 and L2 use were provided for each family member and each activity: 100% English; 20% Cantonese, 80% English; 40% Cantonese, 60% English; 50% Cantonese, 50% English; 60% Cantonese, 40% English; 80% Cantonese, 20% English; 100% Cantonese. The completion of the questionnaire took no longer than 10 min.

The nine participants were from four different classrooms. To gain a general understanding of L1 and L2 use in the classroom, the first author interviewed the teachers of the participants. All four teachers were Cantonese–English bilinguals. Each teacher was asked the proportion of Cantonese versus English they used during (a) dining (breakfast and lunch), (b) circle group time (songs), and (c) learning activities (storytelling, reading). In addition to the interviews, a trained research assistant observed each teacher during the school day. The observation started from the beginning of the day to the beginning of nap time in the early afternoon. The observations of the four teachers were done on different
days, and the focus was on each teacher’s L1 and L2 use. The proportion of L1 and L2 used by each teacher was rated by the trained research assistant every 15 min, using the same rating scale in the parent questionnaire, ranging from 100% English to 100% Cantonese.

**Direct Measures: Home and School**

The LENA DLP recording devices were used to obtain audio recordings of each child’s interactions with caregivers, teachers, and others in 1 day. The children were recorded on different days. Parents and teachers of the participants were notified on the day before that they would be recorded the next day. A typical full-day preschool program at the Head Start starts at 8 a.m. and ends at 4 p.m. On the day of the recording, each child was provided with a t-shirt attached with a DLP device in the front pocket. The research assistant turned on the device after the parents and teachers were briefed about the audio-recording process. Parents were also provided with instructions on how to turn the DLP device on or off. Then, the parents were asked to return the t-shirt and DLP to the preschool the next day.

The audio recordings were used to examine participants’ school and home language environments. The “school language environment” was operationally defined as the duration between the beginning of the school day and the moment the child was picked up by their caregiver at the end of the school day. The start of the “home language environment” was defined from the moment the child was picked up by their caregiver and ended when the parents turned off the DLP at bedtime. The mean length of recording time was 10.17 hr (range: 8.89–13.42 hr). There were no significant differences between home and school recording times, t(8) = .73, p > .05. As the focus of this study was on the L1 and L2 use by adults, peers, and the target child across home and school settings. As the DLP was positioned at the front of the t-shirt, speech from direct conversation partners and target children were distinguished by the loudness and the consistency of the voice quality during the daylong recordings. The participants’ speech was defined as the voice that was louder, and the voice quality that was consistent throughout the day. In contrast, the speech of peers was defined as child speech from a distance, and there were multiple children coded as “peers” for one participant. Across all participants, the peers spoke either in Cantonese or in English. No other languages were noted. Figures 1 and 2 display two target children’s language use (in seconds) during the day.

Ten segments of each participant were randomly selected for a reliability check. Two raters were asked to identify whether the speakers were adults, peers, or participants. The two raters reached 100% agreement.

Due to the varying durations of the audio recordings, the analysis for each child was based on the amount of L1 and L2 used in (seconds) by speaker type (child, adults, peers) by setting (home, school). There were 12 indexes for each child: 2 languages (Cantonese vs. English) × 3 speaker types (adults vs. peers vs. target child) × 2 settings (home vs. school). The L1 and L2 use by speaker type by setting for each child was based on the amount of L1 and L2 used (in seconds) by speaker type (child, adults, peers) by setting (home, school, respectively). There were concerns about their conversations at home being analyzed. Rather than following the transcription methods used in previous studies (e.g., Wood et al., 2016), trained research assistants used a software program named “Praat” (Boersma & Weenink, 2012) and manually measured the duration (in seconds) of L1 and L2 use by adults, peers, and the target child across home and school settings. As the LENA DLP recording device had no automated measures calculated from the LENA software, we did not use the automated measures calculated from the LENA software. The samples were exported as .wav files and analyzed using our coding scheme.

**Coding Procedure**

Following the sampling methods from previous studies (e.g., Wood et al., 2016), we sampled the first 1 min of speech for each 5-min segment of each recording for analysis. On average, there were sixty-two 1-min segments from school settings (SD = 11.14) and 52 from home settings (SD = 14.78). As we considered the potential negative attitudes on daylong recordings from immigrant families, we consulted with the Head Start program and learned that parents had concerns about their conversations at home being analyzed. Rather than following the transcription methods used in previous studies (e.g., Wood et al., 2016), trained research assistants used a software program named “Praat” (Boersma & Weenink, 2012) and manually measured the duration (in seconds) of L1 and L2 use by adults, peers, and the target child across home and school settings. The L1 and L2 use by speaker type by setting for each child was written as

\[ \chi_{ijk} = \frac{1}{n_k} \sum \chi_{ijk} \]  

(1)

where the subscripts i, j, k indicate language (L1 or L2), speaker type (child, adults, peers), and setting (school or home), respectively. \( n_k \) was the number of 1-min segments by setting for each child. For example, for one child,

### Table 1. Participants’ characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in months)</td>
<td>49.78</td>
<td>6.94</td>
<td>40–60</td>
</tr>
<tr>
<td>Age at first English exposure (in months)</td>
<td>38.89</td>
<td>2.89</td>
<td>36–44</td>
</tr>
<tr>
<td>Months in the preschool program</td>
<td>10.9</td>
<td>4.8</td>
<td>4–17</td>
</tr>
<tr>
<td>Hollingshead index (SES)</td>
<td>21.22</td>
<td>3</td>
<td>17–25</td>
</tr>
<tr>
<td>No. of different words (Cantonese)</td>
<td>66.63</td>
<td>19.25</td>
<td>40–96</td>
</tr>
<tr>
<td>No. of different words (English)</td>
<td>44.05</td>
<td>19.22</td>
<td>24–74</td>
</tr>
<tr>
<td>MLU-words in Cantonese</td>
<td>4.91</td>
<td>1.22</td>
<td>3.21–6.22</td>
</tr>
<tr>
<td>MLU-morphemes in English</td>
<td>3.89</td>
<td>1.35</td>
<td>1.7–5.2</td>
</tr>
</tbody>
</table>

*Note.* SES = socioeconomic status; MLU = mean length of utterance.
Figure 1. Child 1: The distributed first language (L1) and second language (L2) use (in seconds) across home and in school settings.

Figure 2. Child 2: The distributed first language (L1) and second language (L2) use (in seconds) across home and in school settings.
Results

Indirect Measures: Home and School

Results for the parent questionnaire for each participant are shown in Figures 3 and 4. Figure 3 contains percent responses (from 100% Cantonese to 100% English) for each family member regarding the Cantonese versus English language use at home. Each point represents each child in each family member category. Overall, the family members reported that they primarily used Cantonese (L1) at home. Results showed that all nine children’s fathers spoke 100% Cantonese at home, eight children’s mothers spoke 100% Cantonese, and one mother spoke 80% Cantonese at home. Five children lived with their grandparents, and all grandparents spoke 100% Cantonese at home. Five participants had older siblings who used 80%–100% of Cantonese at home. One child had one younger sibling, who spoke 100% Cantonese at home.

Results of the home activities are presented in Figure 4. Cantonese was the primary language used, whereas some English was used during home activities. Most families reported that they used 80%–100% Cantonese during dinner and playing with family members at home. Several families used a combination of Cantonese and English when they engaged in home literacy activities (i.e., reading out loud, telling stories, playing word games). All but two parents reported both L1 and L2 were used while watching TV.

With regard to teacher reports, all four teachers reported that they used 50% Cantonese and 50% English across the three categories of classroom activities: dining, circle time, and learning activities. Figure 5 displays the classroom visit rating results, which indicated that the teachers used both L1 and L2 during all classroom activities.

Direct Measures: Home and School

Table 2 presents the means and standard deviations of the amount of L1 or L2 use (in seconds per minute) across speaker types and settings. Figure 6 displays the percentage of L1 and L2 use across speakers at home and in school settings for each child. Separate repeated-measures analyses of variance were used to examine the language use (in seconds) for adults, peers, and participants, with language (Cantonese vs. English) and communicative settings (home vs. school) as within-subject factors. The analysis of the adults’ use of L1 and L2 revealed significant main effects for language, \( F(1, 8) = 13.73, p < .01, \eta^2_p = .66, \) and setting, \( F(1, 8) = 15.42, p < .01, \eta^2_p = .66. \) Post hoc testing at the .05 level revealed that adults significantly used more Cantonese than English \((p < .01)\) and that adults talked more in school than at home \((p = .01)\). In addition, the Language × Setting interaction was significant, \( F(1, 8) = 15.59, p < .01, \eta^2_p = .66. \) The findings indicated that adults used a similar amount of Cantonese and English in school settings, but adults used primarily Cantonese at home (see Figures 6 and 7).

The analysis of the peer use of L1 and L2 revealed that there was no effect of language, \( F(1, 8) = 3.3, p > .05. \) However, there was a significant effect of setting on peers’ language use, \( F(1, 8) = 16.07, p < .01, \eta^2_p = .67, \) which suggested that peers used more language in school (see Table 2). The interaction between language and setting did not reach significance, \( F(1, 8) = 45, p > .05, \) thereby suggesting that there were no differences between peers’ L1 and L2 use in school or home settings.

The analysis of the participants’ use of L1 and L2 showed that there was no main effect of language, \( F(1, 8) = 2.38, p > .05, \) or setting, \( F(1, 8) = .27, p > .05. \) However, there was a significant interaction between language and setting, \( F(1, 8) = 11.4, p < .05, \eta^2_p = .59. \) The findings suggest that, at home, participants used more Cantonese than English \((M = 5.79 \text{ s/min in L1 vs. } M = 1.27 \text{ s/min in L2}), \) whereas they used similar amounts of Cantonese and English in school \((M = 3.29 \text{ s/min in L1 vs. } M = 4.63 \text{ s/min in L2}). \)

Correlation analyses were not conducted to examine the relationships between the indirect (i.e., parent and teacher reports) and direct measures (i.e., LENA audio recording) due to the lack of variation in the reported results and our small sample size. However, Pearson correlation analyses were done to examine the relationships between the amount of L1 and L2 use across adults, peers, and participants from the direct measures. Table 3 reveals that participants’ L1 use at home was significantly related to their peers’ L1 use \((r = .76, p < .05)\) and participants’ L2 use at home was related to adults’ L2 use \((r = .8, p < .05)\). Interestingly, children’s L1 use in school was related to their peers’ L1 use \((r = .71, p < .05)\), but not with adults’ L1 or L2 use.

Discussion

The current study examined the language-learning environments of DLLs who learned Cantonese (L1) at home from birth and started to learn English (L2) in preschool settings. Direct and indirect measures were used to measure the amount of L1 and L2 used at home and in school settings. The indirect measures, which included parent questionnaires, teacher interviews, and classroom visit ratings, provided information about the children’s relative language experience in L1 and L2 (e.g., 100% Cantonese; 50% Cantonese and 50% English) across teachers, family
members, and language-learning activities. In addition to the indirect measures, this study obtained temporal information about the amount of L1 and L2 used at home and in school using LENA DLP recording devices and a novel manual coding scheme. The first minute of each 5-min segment was sampled for analysis. This study was unique in that the coding scheme was developed with consideration for the family needs, as it can be concerning...
for some families to record a full day of conversation. This coding scheme, which measured the time that each language was used, provided information about the amount of L1 and L2 (in seconds per minute) used by adults, peers, and target children at home and in school (see also limitations below).

Three main findings emerged from the analyses. First, both measures indicated that L1 was the primary language used by adults at home, and a similar amount of L1 and L2 was used by adults in school. Second, the peers of the participants, as a group, spoke more in school than at home, but the amount of L1 and L2 was similar across both settings. Third, the participants used more Cantonese at home but used a similar amount of L1 and L2 in school (see Figures 6 and 7). Interestingly, the amount of L1 used by the participants was associated with the amount of L1 used by peers at home and in school, and there was a positive relationship between the amount of L2 used by the participants and the amount of L2 used by the adults at home (see Table 3). These findings suggest future directions for professional development, parent training programs, and research.

**L1 and L2 Learning Environments at Home**

There were inherent differences in the ways that the amount of L1 and L2 was measured in the parent reports and daylong audio recordings. In the parent questionnaires,
parents were asked to report the relative amount of L1 and L2 used (e.g., 100% Cantonese; 50% Cantonese and 50% English) by different family members and activities on regular days. The parent reports suggested that Cantonese was the primary language used at home. However, when examining specific home activities, we found that some English (L2) was used during reading activities, playing word games, playing with friends, and watching TV. These findings were consistent with the language use in many minority families in the United States (Cheung et al., 2019; Duursma et al., 2007; Jia et al., 2002).

In contrast with parent and teacher reports, the audio recordings were obtained over the course of 1 day for each participant. It is important to note that these daylong audio samples may not be representative of the child’s overall language-learning environments. Also, due to the small sample size and the lack of variation in L1 and L2 use across family members in the parent reports (e.g., 100% Cantonese by most parents and grandparents; see Figure 3), we were unable to conduct statistical analyses to examine the link between direct and indirect L1 and L2 use. However, the estimates of the proportion of adult and peer use of L1 in the parent reports were somewhat consistent with estimates of exposure based on audio recordings.

The audio recording data indicated that Cantonese was the primary language used at home (see Figures 6 and 7; see also Figures 1 and 2), consistent with the parent reports. On average, adults at home spent 8.11 s/min speaking in Cantonese but only 0.7 s/min in English. Although the “adults at home” were likely to be the parents and/or grandparents, we cannot rule out that other adults (e.g., relatives, neighbors, and family friends) may have been recorded. Assuming that the “adults at home” were mostly parents and grandparents, the findings from the daylong audio recordings were in line with the parent reports.

The direct measure data showed that the DLL participants and their peers used both L1 and L2 at home. Participants used significantly more L1 than L2 (mean L1 = 5.79 s/min, mean L2 = 1.27 s/min), whereas peers used similar amounts of L1 and L2 in home settings (mean L1 = 1.01 s/min, mean L2 = 2.06 s/min). It is important to note that there was high variability in the language used by peers in both languages. For example, Figure 1 indicates that the child’s peers used more L1 at home, whereas Figure 2 suggests that no peers were present after school. Parent reports showed that four participants had an older sibling, one had two older siblings, and one had one younger sibling. All siblings were reported to use 80%–100% Cantonese at home. However, based on the LENA data gathered in the natural language environment, there were no significant differences between the amount of L1 and L2 used by peers at home. These discrepancies might have been the result of parents’ estimation based on the overall siblings’ language use, which was not captured in the daylong recordings. It might also be related to the small sample size (n = 9) in this study. Future research including a larger and more representative sample along with an additional parent diary/report about the communication partners and contexts would allow for a more rigorous evaluation of the language-learning environments at home.

Correlation analyses revealed a relationship between participants and adults speaking L2 at home, but no such adult–child relationship was found in L1 use at home. An important question to ask is why the child–adult relationship

Figure 5. Classroom visit ratings: the amount of first language (L1) and second language (L2) used by teachers.
Table 2. Audio recording: first language (L1) and second language (L2) use by the participants, adults, and peers across home and school settings.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Adults</th>
<th>Peers</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L1</td>
<td>L2</td>
<td>L1</td>
</tr>
<tr>
<td>School</td>
<td>6.43 (2.64)</td>
<td>7.51 (2.7)</td>
<td>3.84 (2.31)</td>
</tr>
<tr>
<td>Home</td>
<td>8.11 (3.76)</td>
<td>.70 (.65)</td>
<td>1.01 (1.72)</td>
</tr>
</tbody>
</table>

Note. Means (SDs) of L1 and L2 used (s/1-min segment) by the participants, adults, and peers across home and school settings.

Figure 6. Audio recording data: the proportion of first language (L1) and second language (L2) use (s/1-min segment) at home and in school settings for each participant.
was only observed in L2 but not in L1. One explanation is that parents and grandparents of the preschool DLLs were in the process of finding a strategy to respond to their children who started to use some L2 at home. According to the ecological perspective on development (e.g., Bronfenbrenner & Morris, 1998), the use of L1 and/or L2 at home may be affected by many interconnected factors such as parents’ L1 and L2 proficiency and family attitude toward L1 and L2 (e.g., Duursma et al., 2007; Luo & Wiseman, 2000). Although the DLL participants, on average, had 11 months of L2 experience in school settings, their MLU in morphemes in L2 was 3.89 at the time of testing (see Table 1). As their L2 skills increase, they are likely to use more L2 at home (Quiroz et al., 2010; Scheele et al., 2010). It is possible that the Cantonese-speaking adults at home used L2 to respond to the L2 used by these children. Another plausible explanation for L2 use at home might be mediated by parents’ attitudes toward L2 and their cultural backgrounds and upbringings (Lee et al., 2015; Luo & Wiseman, 2000; Quiroz et al., 2010; Scheele et al., 2010). For many minority children in the United States, L1 and L2 differ in social status (minority vs. majority). Parental attitude toward the use of minority and majority languages might facilitate differences in using L1 and L2 at home (Luo & Wiseman, 2000; Padmawidjaja & Chao, 2010).

Correlation analyses of the LENA recordings showed that the participants’ L1 use was linked to their peers’ L1 use at home, but no child–peer relationships were found in L2 use. In a study that examined school-age Spanish–English DLLs, Duursma et al. (2007) found that children

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**Figure 7.** Daylong recordings: mean first language (L1) and second language (L2) used (s/1-min segment) by participants, adults, and peers at home and in school settings.
who used more English with their siblings scored lower on
the measure of Spanish. The findings highlight the importance
of sibling interactions at home. In contrast with Duursma
et al., the results in the current study provide some evidence
about the positive aspect of L1 use among siblings. How-
ever, these results should be interpreted with caution due to
the small sample size and the variability of the amount of
language used by peers at home (see Figures 1 and 2).

**L1 and L2 Learning Environments in School Settings**

Participants’ language-learning environments in school
was examined using three types of measures: teacher reports,
classroom visit ratings, and daylong audio recordings
in both languages. The overall results indicated that both L1
and L2 were used in school settings. The teachers reported
that they used 50% Cantonese and 50% English during din-
ing, circle time, and learning activities in school, somewhat
consistent with the classroom visit ratings. The daylong
audio recordings provided more detailed information about
the DLLs’ use and exposure of L1 and L2 in school settings.
Overall, the audio recording data showed that participants
used similar amounts of L1 and L2 in school settings. The
adults in school, who were likely to be the teachers and/or
teaching assistants, used similar amounts of L1 and L2 (L1:
6.43 s/min; L2: 7.51 s/min).

There were several key factors that might have influ-
enced the amount of L1 and L2 used in the Head Start class-
rooms. One crucial factor was the language instructions used
in classroom settings. Although instruction strategies (e.g.,
English-only, dual language) vary across different Head Start
programs, the Head Start program where our participants
were enrolled aimed at promoting a dual language–learning
environment. Multiple strategies were used by teachers,
including using a variety of vocabulary in L1 and L2, blocks
of time using L1 and L2 during teaching activities, and se-
manently contingent responses and encouraging children
to talk during playtime in children’s preferred language. Other
important factors that might have affected the L1 used in
the Head Start classrooms included the teachers’ language
proficiency and the language compositions of DLLs in the
classroom (Collins, 2014; Garcia, 2018). In the Head Start
program where our participants were recruited from, there
were other DLLs who spoke other L1s (e.g., Tagalog,
Spanish, Mongolian) at home. Based on the classroom
observations, we noted that teachers tended to use English
first and then Cantonese when introducing a new topic
or new words in large group activities. However, teachers
used more Cantonese with individual DLLs who spoke
Cantonese as L1 during free-play and small group activi-
ties. In this study, we did not find significant relationships
between adults and children in either language in school
settings (see Table 3). One explanation for the lack of
correlations in adult–child language use in school is that
there are some fundamental differences in adult–child in-
teractions between home and school settings. In classroom
settings, teachers provide instructions to a group of chil-
dren, whereas parents/grandparents might have more di-
rect and personal interactions with the child at home.

The composition of DLLs in the classroom is another
important factor that contributes to the language environ-
ments at school (Garcia, 2018). In this study, there was
great variability in L1 used by peers in classroom settings,
ranging from 0.97 to 7.34 s/min. This suggests a more com-
plex composition of DLLs in the classroom. Participants’ L1
use was found to be positively related to their peers’ L1 use.
The findings indicated that DLLs who spoke Cantonese pro-
vided opportunities for Cantonese use in school settings.
Few studies have directly examined the links between DLLs
and their peers’ L1 use in school settings. However, several
studies have examined the association between peers’ L2
skills and DLLs’ growth in L2. For example, in a series of studies
that examined Spanish–English DLLs, Palermo et al. (2014)
found that peers’ English exposure was positively associated
with children’s English receptive and expressive vocabulary

**Table 3. Correlations: first language (L1) and second language (L2) used by participants, adults, and peers across
home and school settings.**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Adult L1</th>
<th>Adult L2</th>
<th>Child L1</th>
<th>Child L2</th>
<th>Peer L1</th>
<th>Peer L2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult L1</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult L2</td>
<td>.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child L1</td>
<td>.38</td>
<td>-.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child L2</td>
<td>.17</td>
<td>.80*</td>
<td>-.27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer L1</td>
<td>.21</td>
<td>-.24</td>
<td>.76*</td>
<td>-.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer L2</td>
<td>.41</td>
<td>-.03</td>
<td>-.08</td>
<td>-.32</td>
<td>-.18</td>
<td></td>
</tr>
<tr>
<td>School</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult L1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult L2</td>
<td>-.50</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Child L1</td>
<td>.15</td>
<td>-.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child L2</td>
<td>-.04</td>
<td>.01</td>
<td>-.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer L1</td>
<td>.54</td>
<td>-.72*</td>
<td>.71*</td>
<td>-.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer L2</td>
<td>-.05</td>
<td>.29</td>
<td>-.58</td>
<td>.39</td>
<td>-.59</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05.
skills (Palermo et al., 2014; Palermo & Mikulski, 2014). Future investigations with a larger sample of participants may provide more evidence about how interactions among peers in school might affect children’s L1 proficiency and maintenance as well as their L2 growth.

**Limitations of This Study**

There were some important limitations noted in this study. First, although we recruited participants from a relatively large pool of Cantonese–English DLLs, only nine participated in this study. The results should be interpreted with caution as the small sample size ($n = 9$) may have masked significant effects. Additionally, the participants lived in a community where the minority language, Cantonese, is used and supported, and they attended a Head Start program that emphasized dual language learning. Although the Head Start program had teachers from monolingual and bilingual backgrounds, the teachers of the participants were Cantonese–English bilinguals. The current findings might not be representative of those DLLs who are from less linguistically diverse areas. A larger and more representative sample is needed for future research. Second, the success of obtaining daylong audio-recording data depends on the participation of teachers. In this study, the teachers at the Head Start program were very engaged in the teacher interviews, observations, and audio-recording process. However, previous research has shown that Head Start teachers have tremendous challenges (e.g., limited resources) in supporting students and their families (e.g., Harding et al., 2019; Jeon & Wells, 2018). It is unclear whether such barriers could affect the participation of teachers from other Head Start programs. We hope that this research could facilitate the communication between researchers and the minority communities in future studies. Third, the analysis of the daylong recordings in this study was based on the temporal units (seconds/minutes) of L1 or L2 used by adults, peers, and DLL participants. Although temporal units (e.g., 8 hr/day) have been used in previous studies to characterize bilingual children’s language exposure, it did not provide specific linguistic information in the input or the quality of teacher–child interaction (Carroll, 2017). More linguistic information (e.g., number of words, types of words used, sentence length, interactions) could provide specific information about children’s language environment. Future research is needed to examine the fine-grained details of DLLs’ language-learning environments that facilitate children’s dual language development.

**Conclusion and Clinical Implications**

The main goal of the current study was to examine the bilingual language-learning environments of Cantonese–English DLLs using both direct and indirect measures. These measures are not mutually exclusive and can be used to complement each other. It is also important to note that our findings uncovered strengths and limitations of each measure. Parent and teacher reports can be used to obtain general information about relative L1 and L2 use in an environment, whereas daylong audio recordings, along with a reliable coding scheme, can provide detailed information about DLLs’ language environments in both languages. Despite having a small sample size, the results of the manually coded daylong audio recordings helped reveal the amount of L1 and L2 used by DLLs, adults, and peers during school and home settings. The visual display of distributed L1 and L2 use across settings in Figures 1 and 2 could be informative for educators to plan classroom instructions and home programs that support children’s dual language learning. An additional consideration in using the daylong recordings is that there are limited resources in many preschool programs, and teachers are under pressure to meet the needs of students (e.g., Jeon & Wells, 2018). Although teacher questionnaires have been commonly used in the school settings, it remains unclear whether the use of daylong audio recordings to examine DLLs’ language environments is feasible in many preschool programs. Future studies should continue to refine the class-recording methodology that meets the needs of the educators.

The results of this study provide important information about the relationships among L1 and L2 used by DLLs, adults, and peers. DLLs’ L2 use was found to be associated with their caregivers’ L2 use at home. DLLs’ L1 use was linked to their peers’ L1 use in both home and school settings. Home language skills are an essential foundation for DLLs’ development and their academic growth (Durán et al., 2016; Hammer et al., 2007). However, many DLLs are at increased risk of losing their L1 due to less supportive learning environments (Guardado, 2002; Proctor et al., 2010). This study provides some preliminary evidence about the role of Cantonese (L1) use among peers at home and in school settings. We hope that this research, as well as other future studies, will continue to broaden our understanding of the language-learning environments of DLLs.

**Acknowledgments**

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