



Non-Adjacent Dependency Learning in Cantonese-Speaking Children With and Without a History of Specific Language Impairment

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Running head: NON-ADJACENT DEPENDENCY LEARNING IN SLI

Non-Adjacent Dependency Learning in Cantonese-Speaking Children With and Without
a History of Specific Language Impairment

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Abstract

Purpose: This study investigated non-adjacent dependency learning in Cantonese-speaking children with and without a history of Specific Language Impairment (SLI) in an artificial linguistic context.

Method: Sixteen Cantonese-speaking children with SLI history and 16 Cantonese-speaking children with typical language development (TLD) were tested with a non-adjacent dependency learning task using artificial languages that mimic Cantonese.

Results: Children with TLD performed above chance and were able to discriminate between trained and untrained non-adjacent dependencies. However, children with SLI history performed at chance and were not able to differentiate trained versus untrained non-adjacent dependencies.

Conclusions: These findings, together with previous findings with English-speaking adults and adolescents with language impairments, suggested that individuals with atypical language development, regardless of age, diagnostic status, language and culture, showed difficulties in learning non-adjacent dependencies. This study provides evidence for early impairments to statistical learning in individuals with atypical language development.

Keywords: Non-adjacent dependency learning, Statistical learning, Language acquisition, Specific Language Impairment

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6 a History of Specific Language Impairment
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8 Language consists of rules and regularities that embed in a continuous sequence.
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10 Extracting these rules and regularities and using them productively are essential for
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12 language acquisition and social communication. Some of these rules and regularities
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14 occur among adjacent elements (e.g., bound-morpheme such as *-s* is added to
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16 unbound-morphemes such as *dog* to illustrate the plural of *dog*) while others exhibit
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18 non-adjacent dependencies (e.g., morphosyntactic rules such as *is X-ing* where the
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20 intervening X is a verb). Much research has been devoted to the investigation of how
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22 English speakers acquire these adjacent and non-adjacent dependencies and a
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24 domain-general statistical learning mechanism was suggested to explain the acquisition
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26 (e.g., Gómez, 2002; Saffran, Aslin, & Newport, 1996). However, there is no study
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28 investigating the acquisition of linguistic dependencies in non-inflectional languages such
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30 as Cantonese which is a Chinese dialect predominantly used as a native language in Hong
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32 Kong, Macau, Guangzhou, and many Chinese communities in other countries. Moreover,
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34 it is found that the features of Cantonese may affect the profile of linguistic deficits in
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36 certain types of language disorders, e.g., Specific Language Impairment (SLI; Leonard,
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38 1998). Given that English speakers with SLI were found to have difficulties in learning
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40 non-adjacent dependencies (Hsu, Tomblin, & Christiansen, 2014), the current study
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42 sought to investigate whether Cantonese-speaking children with a history of SLI would
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44 also show these difficulties when comparing to Cantonese-speaking children with typical
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46 language development (TLD).
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51 In non-adjacent dependencies, there is usually a considerable variation in
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53 intervening elements (e.g., the verb in progressives and perfectives in English, such as *is*
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55 *go-ing*, *is draw-ing*, *has jump-ed*, *has kick-ed*). Therefore, a language learner has to
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57 notice the reoccurring dependencies that surround the variations in order to acquire the
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4 dependencies in a particular language. Gómez (2002) was the first to investigate the
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6 learning of non-adjacent dependencies in typically developing infants and adults. In this
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8 study, participants were exposed to one of two artificial languages that mimic English.
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10 Each of the two languages involved strings of three elements (e.g., *pel wadim jic* or *vot*
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12 *kicey rud*). The strings began and ended with the same elements (e.g., beginning elements:
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14 *pel* and *vot*; ending elements: *jic* and *rud*) but the two languages differed in the
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16 dependencies between the beginning and ending elements (e.g., Language 1: *pel* paired
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18 with *jic*, *vot* paired with *rud*; Language 2: *pel* paired with *rud*, *vot* paired with *jic*). In
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20 other words, if a participant was exposed to Language 1, s/he was trained on the
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22 dependencies of *pel - jic* and *vot - rud*. The intervening elements (e.g., *wadim* and *kicey*)
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24 varied within the dependencies and the same set of intervening elements appeared in both
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26 languages. As a result, participants could only discriminate the two languages in a later
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28 test by noticing the difference in the non-adjacent dependencies between the beginning
29
30 and ending elements.
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34 Gómez (2002) found that a large set size of 24 intervening elements resulted in
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36 excellent discrimination between trained and untrained non-adjacent dependencies. She
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38 explained this finding in terms of statistical learning. When the set size of the intervening
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40 elements was small, the beginning elements were followed by a few possible intervening
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42 elements so the statistical relationship between these adjacent elements was too easy to
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44 notice and participants missed the non-adjacent dependencies between the beginning and
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46 ending elements. In contrast, when the intervening elements were highly variable, the
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48 beginning elements hardly predicted the intervening elements so the non-adjacent
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50 dependencies between the beginning and ending elements became the only reliable
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52 statistical relationship between the elements. Since then, statistical learning has been used
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54 as the main explanation for non-adjacent dependency learning (e.g., Conway &
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56 Christiansen, 2006; Gebhart, Newport, & Aslin, 2009; Newport & Aslin, 2004).
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4 Further studies also applied Gómez's (2002) paradigm to test individuals with
5 language disorders, including adults with language-based learning difficulties (LLD;
6 Grunow, Spaulding, Gómez, & Plante, 2006) and adolescents with SLI (Hsu et al., 2014).
7
8 Both studies showed that individuals with language disorders could not discriminate the
9 trained and untrained non-adjacent dependencies despite a large set size of 24 intervening
10 elements being used. Grunow et al. also tested whether participants were able to
11 generalize the trained non-adjacent dependencies to strings that involved novel
12 intervening elements. Results showed that adults without LLD were able to generalize
13 when the set size of intervening elements was 24 but adults with LLD could not.
14 However, Plante et al. (2014) trained children with language impairment on adjacent and
15 non-adjacent dependencies and generalization was found when training involved
16 variability as high as 24 exemplars. Hence, it is not clear whether impairments to
17 statistical learning underlie individuals with language disorders' difficulties in learning
18 and generalizing non-adjacent dependencies. One possible way to explain this
19 discrepancy in the literature is that Grunow et al. and Hsu et al. tested artificial language
20 learning in an experimental context whereas Plante et al. tested natural language learning
21 in a treatment context. Another possibility is that adults with LLD and adolescents with
22 SLI have been having language disorders for years and that may have contributed to
23 further difficulties in learning and generalizing non-adjacent dependencies. In order to
24 address this discrepancy in the literature, the current study tested children with a history
25 of SLI in similar experimental context. If difficulties in learning and generalizing
26 non-adjacent dependencies were also found in this study, this would suggest that these
27 difficulties may be explained by early impairments to statistical learning rather than long
28 years of language impairments.

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56 In Cantonese, non-adjacent dependencies can be seen in the use of temporal
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4 adverbs when followed by monosyllabic verbs (e.g., 曾經食過 /cang4 ging1 sik6
5 gwo3/ which means ‘*has eaten*’; Ding, 2008) and in anaphoric reference (e.g., 小明打
6 緊波。佢好開心。 /siu2 ming4 daa2 gan2 bo1. keoi5 ho2 hoi1 sum./ which means
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8 ‘*Siu-Ming is playing a ball. He is very happy.*’). Other Chinese languages such as
9
10 Mandarin have similar non-adjacent dependency examples. As there is an increasing
11
12 number of people learning and using Chinese across the world, it is important to examine
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14 non-adjacent dependency learning in an artificial language that mimics Chinese which is
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16 a non-inflectional language and has not been investigated yet. Given that this was the first
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18 study that investigated non-adjacent dependency learning in Cantonese-speaking children,
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20 Gómez’s (2002) design was adopted to develop two artificial languages that mimic
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22 Cantonese and involve non-adjacent dependencies. It was expected that
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24 Cantonese-speaking children with TLD would learn the non-adjacent dependencies
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26 whereas those with SLI history would not. If children with SLI history did not learn the
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28 non-adjacent dependencies in this experimental context, it was likely that they would not
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30 show generalization either. Ethical approval was obtained from the ethics committee in
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32 the University of Hong Kong and parental informed consent was obtained before testing.
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38 **Methods**

39 **Participants**

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42 Thirty-two children who had completed a three-year longitudinal project on reading
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44 development were recruited. Figure 1 outlines the recruitment procedure. All children
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46 with SLI scored more than 1.25 *SD* below the mean for age on at least two of the six
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48 subtests in the Hong Kong Cantonese Oral Language Assessment Scale (HKCOLAS;
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50 T’sou et al., 2006) in Year 1 and 2 of the project, despite the absence of cognitive,
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52 peripheral hearing, psychosocial or neurological impairments. All children scored above
53
54 the cut-off of 85 on the Raven’s Standard Progressive Matrices (SPM; Raven, 1986) in
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56 Year 1. They were also tested with the Hong Kong Test of Specific Learning Difficulties
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3 in Reading and Writing for Primary School Students-Second Edition (HKT-P [II]; Ho,
4 Chan, Chung, Tsang, Lee & Cheng, 2007) to rule out dyslexia in Year 2. The HKT-P [II]
5 comprises the literacy composite, phonological awareness composite, phonological
6 memory composite, rapid automatic naming and orthographic skills composite. Dyslexia
7 was defined as a scaled score of 7 or lower in the literacy composite and in one of the
8 cognitive composites (Chan, Ho, Tsang, Lee, & Chung, 2007). All children did not fit
9 with this dyslexia definition. In Year 3, they received an assessment on reading
10 comprehension and the current non-adjacent dependency learning task. Although
11 children's current SLI status was not assessed, it was certain that children in the TD
12 group had TLD whereas children in the SLI-only group had a history of SLI. Participant
13 characteristics are presented in Table 1. The two groups did not differ in chronological
14 age, $t(20.24) = 1.26, p = .22$, and non-verbal intelligence based on earlier Raven's SPM
15 scores, $t(30) = .09, p = .93$. All the other language measures obtained earlier were
16 significantly different between the groups.
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34 ----- Insert Figure 1 and Table 1-----
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36 **Materials and procedure**

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38 Adopting Gómez's (2002) design, children listen to one of two artificial languages
39 that mimic Cantonese. Simple randomization was used to randomly assign children to
40 one of the two languages. The two languages involved strings of three elements and were
41 equivalent in all aspects except the dependencies between the beginning and ending
42 elements. These elements were syllables that have been checked with a database
43 (Humanities Computing and Methodology Programme, 2003) to ensure non-existence in
44 Cantonese (i.e., pseudomorphemes). Besides, Cantonese is not only a non-inflectional
45 language but also a tone language that uses lexical tones to signify meanings. In terms of
46 fundamental frequency patterning, the six contrastive tones in Cantonese can be
47 described as Tone 1 (high level), Tone 2 (high rising), Tone 3 (mid level), Tone 4 (low
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3 falling), Tone 5 (low rising), and Tone 6 (low level). Ching (1981) and Wong, Ciocca,
4 and Yung (2009) reported that Tone 1 and 4 were acoustically most salient and best
5 identified even in difficult listening conditions. Thus, pseudomorphemes in Tone 1 and 4
6 were used (see Appendix A). There were 24 intervening pseudomorphemes in the training
7 phase. In total, 48 strings (2 dependencies \times 24 intervening elements) were generated for
8 the training phase in each of two languages. All strings were recorded by a native
9 Cantonese-speaking female with an inter-string pause of 750 ms and an inter-syllabic
10 pause of 250 ms. After piloting, each string was played four times at a random order to
11 each child using the E-prime software via headphones. Volume was set at a comfortable
12 listening level.
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25 Children were required to listen carefully to strings of syllables that they have never
26 heard before for about 10 minutes and to complete a test later. After training, children
27 were informed that the strings they heard were generated with accord to a set of rules and
28 that they were required to discriminate whether the strings at test followed the rules by
29 pressing a 'yes' or 'no' button. In total, 24 strings were tested: 6 strings with trained
30 intervening elements were taken from each of the two languages and 6 strings with 3
31 novel intervening elements were generated from each language for testing generalization
32 (see Appendix B). Thus, if children have learnt the non-adjacent dependencies in the
33 trained language, they should endorse more strings that involved the trained non-adjacent
34 dependencies than those that did not.
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47 Results

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49 No significant difference was found between Language 1 and 2 so data for the two
50 languages were averaged in the following analyses. Effect sizes were calculated using
51 Cohen's d and partial eta-squared (η_p^2). In general, an effect size of .20 is a small
52 effect, .50 is a medium effect and .80 is a large effect (Cohen, 1992). Children's
53 performance based on accuracy was first examined against chance level (i.e., .50) using a
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4 one-sampled *t*-test. Children with TLD performed above chance on the test items
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6 (Min-Max = .50 – 1, *M* = .60, *SD* = .13), $t(15) = 3.18$, $p < .01$, $d = .80$, but not on the
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8 generalization items (Min-Max = .33 – .92, *M* = .56, *SD* = .15), $t(15) = 1.69$, $p = .11$, d
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10 = .42. Children with SLI history performed at chance on both test (Min-Max = .25 – .75,
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12 *M* = .49, *SD* = .15) and generalization items (Min-Max = .33 – .75, *M* = .51, *SD* = .12),
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14 $ts(15) < .34$, $ps > .74$. D-prime (d') was also calculated on the test and generalization
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16 items for each group. Based on signal detection analysis (Green & Swets, 1966/1974), the
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18 parameter d' is distributed around 0 and a value of 0 means no discrimination between
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20 items. Children with TLD obtained a large d' , indicating that they were able to correctly
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22 discriminate between the trained and untrained test items (Min-Max = 0 – 8.60, *M* = 1.14,
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24 *SD* = 2.21), however, their discrimination between the trained and untrained
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26 generalization items was less successful (Min-Max = -9.7 – 5.27, *M* = .73, *SD* = 1.69). By
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28 contrast, children with SLI history obtained a small d' for both test items (Min-Max =
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30 -4.30 – 4.30, *M* = -.40, *SD* = 2.09) and generalization items (Min-Max = -3.87 – 4.30, *M*
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32 = .05, *SD* = 1.58), suggesting that they were not able to discriminate between the trained
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34 and untrained items.
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39 Given that literature in this area has compared correct accepts against false
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41 positives (Gómez, 2002; Grunow et al., 2006; Hsu et al., 2014), the same analysis was
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43 carried out to allow comparison between studies. Figure 2 presents the mean scores for
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45 correct accepts and false positives for test and generalization items in each group. To
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47 support the hypothesis that children with TLD would learn the non-adjacent
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49 dependencies whereas those with SLI history would not, the correct accepts should be
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51 significantly more than the false positives in the TLD group but not the SLI-history group
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53 for both test and generalization items. A 2x2x2 3-way mixed ANOVA with group as
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55 between-subjects variable and grammaticality (correct accepts vs. false positives) and
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57 item type (test items vs. generalization items) as within-subjects variables resulted in a
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main effect of grammaticality, $F(1, 30) = 4.71, p < .05, \eta_p^2 = .14$, and a main effect of item type, $F(1, 30) = 40.94, p < .001, \eta_p^2 = .58$, but more importantly, a significant grammaticality x group interaction, $F(1, 30) = 4.15, p = .05, \eta_p^2 = .12$. There were no other main effects or interactions, $F_s < 1.05, p_s > .31, \eta_p^2_s < .03$. Post hoc tests further indicated that the grammaticality effect was significant for children with TLD ($p < .01, d = 1.49$) but not for children with SLI ($p = .92, d = .05$), suggesting that the correct accepts were significantly more than the false positives in the TLD group but not the SLI-history group. Furthermore, the item type effect suggested that performance on test items was significantly better than for generalization items.

----- Insert Figure 2 -----

Discussion

This was the first study that investigated non-adjacent dependency learning in Cantonese-speaking children with and without SLI history in an artificial linguistic context. Although the task appeared to be difficult given children's accuracy was not high, children with TLD did perform above chance on the test items and were able to differentiate trained versus untrained non-adjacent dependencies. However, those children with SLI history performed at chance and were not able to differentiate trained versus untrained non-adjacent dependencies. These findings were consistent with those found in Grunow et al. (2006) and Hsu et al. (2014) although they tested adults with LLD and adolescents with SLI respectively. Therefore, individuals with atypical language development, regardless of age, diagnostic status, language and culture, showed difficulties in learning non-adjacent dependencies in artificial languages. This study thus provided stronger evidence for early impairments to statistical learning rather than long years of language impairments in explaining non-adjacent dependency learning in individuals with atypical language development.

However, the current study was not a longitudinal study and the sample size was

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3 small. Further longitudinal investigation with a much larger sample is needed to clarify
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5 whether early impairments to statistical learning has an impact on non-adjacent
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7 dependency learning and language acquisition. Currently, there is no longitudinal data
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9 available in either typical or atypical developing populations (Arciuli & von Koss
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small. Further longitudinal investigation with a much larger sample is needed to clarify whether early impairments to statistical learning has an impact on non-adjacent dependency learning and language acquisition. Currently, there is no longitudinal data available in either typical or atypical developing populations (Arciuli & von Koss, 2012). Although Kerkhoff, De Bree, De Klerk, and Wijnen (2013) found an early difference between infants at familial risk of dyslexia and typically developing infants in non-adjacent dependency learning, there was no longitudinal follow-up on the infants' language development. Besides, this early difference in non-adjacent dependency learning between the two groups of infants may be due to attention during the training phrase. They indicated that the familial risk infants showed shorter looking times and higher degree of restlessness during the training phrase. Given that attention could be a factor affecting non-adjacent dependency learning and evidence has been found in adults (Pacton & Perruchet, 2008), attention may explain the current findings in both children with and without SLI history. Although no obvious inattentive behaviour was observed during testing, attentive listening could not be assured. Children with SLI history could fail to learn any non-adjacent dependencies due to lack of attention whereas children with TLD may attend well to the dependencies in relation to the intervening elements and thus performed better on the test items than the generalisation items. There is also evidence showing that children with SLI have deficits in auditory attention (Finneran, Francis, & Leonard, 2009; Spaulding, Plante, & Vance, 2008). Future research may therefore investigate to what extent attention may affect children's non-adjacent dependency learning and whether attention may be better than statistical learning in explaining language impairments.

In addition to attention, exposure duration could be another factor that affects non-adjacent dependency learning. Although this effect was not found in adults (Romberg & Saffran, 2013), it was found in children with SLI who showed sensitivity to transitional

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4 probabilities when the exposure duration was doubled (Evans, Saffran & Robe-Torres,
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6 2009). It is therefore possible that children with SLI history in the current study might
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8 learn the non-adjacent dependencies and children with TLD might consolidate and
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10 generalise better if the exposure duration was extended. However, keeping children
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12 engaged with a longer task and ensuring they paid attention throughout would be a
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14 challenge. This was one of the reasons why the current study presented each string of
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16 syllables four times only. Comparing to previous studies which found successful
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18 generalization in children with language impairments (Plante et al., 2014) and adults
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20 without LLD (Grunow et al., 2006), their exposure durations were obviously longer.
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22 Plante et al.'s (2014) "treatment sessions lasted 30 min and occurred daily for as many as
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24 25 sessions" (p. 534) whereas Grunow et al. (2006) seemed to follow Gómez (2002) in
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26 presenting each string of syllables six times. Although Hsu et al. (2014) did not look at
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28 generalisation, they also followed Gómez's (2002) design and found successful
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30 non-adjacent dependency learning in adolescents without SLI but not in adolescents with
31
32 SLI. Taking these findings together, one may suggest that a presentation of six times may
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34 be sufficient for typically developing individuals (including adults, adolescents and
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36 children) to learn and generalise non-adjacent dependencies whereas individuals with
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38 language impairments may need a more extended exposure of multiple presentations.
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40 However, the 18-month-old infants in Gómez (2002) could discriminate the trained and
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42 untrained non-adjacent dependencies with only one presentation in the training phase.
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44 Hence, how exposure duration may affect non-adjacent dependency learning across the
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46 lifespan in both typical and atypical development needs further investigation. If typically
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48 developing infants were more sensitive to statistical features despite low exposure
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50 whereas infants at risk of language disorders were not, then early identification and
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52 extended exposure throughout development may be beneficial for those who were in need
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54 to learn non-adjacent dependencies.
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4 Finally, variability needs to be considered. All of the studies discussed above have
5 used 24 exemplars as high variability conditions in comparison with lower variability
6 conditions (Gómez, 2002; Grunow et al., 2006; Hsu et al., 2014; Plante et al., 2014).
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8 They all suggested that high variability is the key for learning non-adjacent dependencies.
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10 Therefore, extended exposure needs to be paired with high variability in order to facilitate
11 non-adjacent dependency learning in both typically and atypically developing individuals.
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13 High variability was also found to be important for atypically developing individuals in
14 learning different grammatical structures (Plante et al., 2014; von Koss Torkildsen,
15 Dailey, Aguilar, Gómez, & Plante, 2013) and for typically developing adults in learning
16 noun gender subcategories in a foreign language (Eidsvåg, Austad, Plante, & Asbjørnsen,
17 2015). All these studies suggest a link between statistical learning and language
18 acquisition and disorders although longitudinal evidence is still warranted.
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30 In sum, the current study showed that Cantonese-speaking school-aged children
31 with TLD were able to learn non-adjacent dependencies in non-inflectional artificial
32 languages whereas children with SLI history were not. Taken together with findings from
33 previous studies, this difficulty in individuals with atypical language development seems
34 to be universal, regardless of age, diagnostic status, language and culture. Given that
35 non-adjacent dependencies do not only occur in artificial and natural languages but also
36 in other contexts (e.g., music, mathematics and science all involve abstracting
37 long-distance relationships; Marcus, 2001), it is critical to investigate non-adjacent
38 dependency learning in different contexts with relevance to other factors such as attention
39 and exposure duration. Moreover, its longitudinal relationship with language acquisition
40 and development in a much larger sample has to be determined in order to advance our
41 understanding of language acquisition and language disorders and to provide implications
42 for intervention and educational strategies.
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Table 1

Demographic information and language mean scaled scores and standard deviations in the SLI-history and TLD Groups

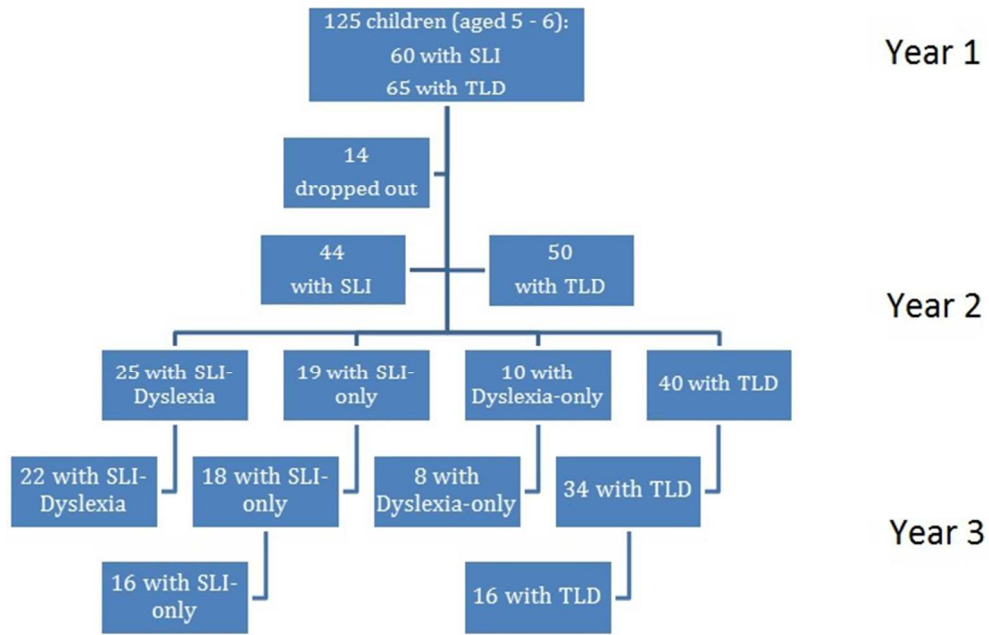
Characteristic	SLI-history (<i>n</i> = 16, 10 males)			TLD (<i>n</i> = 16, 7 males)		
	<i>M</i>	<i>SD</i>	Min - Max	<i>M</i>	<i>SD</i>	Min - Max
Chronological age (months)	119	3.43	111 - 127	116.25	8.06	100 - 126
Age 5 – 6						
NVIQ	109.25	8.60	91 - 127	109	7.61	94 - 121
Age 6 – 7						
HKCOLAS						
Vocabulary	5.13*	1.71	2 - 8	11.50	2.97	6 - 16
Grammar	4.81*	2.29	0 - 9	11.12	2.50	6 - 15
Textual Comprehension	7.50*	1.71	5 - 11	11.56	3	6 - 17
Narrative Retelling	5.75*	3.49	1 - 12	11.38	2.92	7 - 17

Note. NVIQ = Non-verbal intelligence quotient; HKCOLAS = Hong Kong Cantonese Oral Language Assessment Scale; * Significant difference (t-test) from TLD at $p < .001$

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14 *Figure 1.* Flow chart showing participant recruitment from a three-year longitudinal
15 project to the current study.
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26 *Figure 2.* Mean Scores for Correct Accepts and False Positives for Test and
27 Generalization Items.
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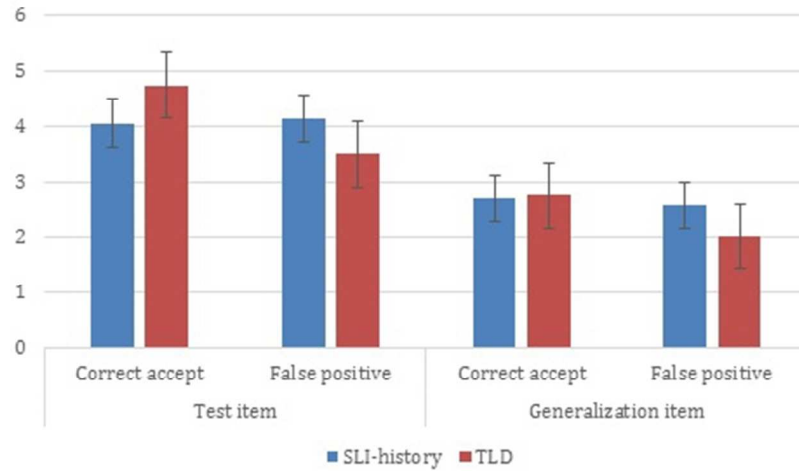
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Flow chart showing participant recruitment from a three-year longitudinal project to the current study.

186x122mm (96 x 96 DPI)

Review



Mean Scores for Correct Accepts and False Positives for Test and Generalization Items.

152x98mm (96 x 96 DPI)

Review

Appendices

Appendix A

Beginning, ending and intervening elements for both Language 1 and 2

The 2 beginning and 2 ending elements were in the form of consonant-vowel-consonant (CVC) pseudomorphemes: /tam⁴/, /fɔn⁴/, /pɛk¹/ and /hɪp¹/ respectively. The intervening elements were in the form of CV+CVC pseudomorphemes as follows:

<i>X</i> ₁	/ja ¹ p ^h ɛt ⁴ /	<i>X</i> ₁₀	/p ^h œ ¹ k ^h ɪm ¹ /	<i>X</i> ₁₉	/tsu ⁴ tsm ¹ /
<i>X</i> ₂	/jɛ ¹ k ^h ɛn ⁴ /	<i>X</i> ₁₁	/fœ ¹ ɪm ¹ /	<i>X</i> ₂₀	/fy ⁴ mɛp ¹ /
<i>X</i> ₃	/fi ¹ pɛm ⁴ /	<i>X</i> ₁₂	/kœ ¹ jɪp ¹ /	<i>X</i> ₂₁	/lu ⁴ sɪp ¹ /
<i>X</i> ₄	/tɪ ¹ jɛm ⁴ /	<i>X</i> ₁₃	/pɛ ⁴ tɔn ⁴ /	<i>X</i> ₂₂	/hu ⁴ kɔt ¹ /
<i>X</i> ₅	/t ^h ɪ ¹ pan ⁴ /	<i>X</i> ₁₄	/ta ⁴ fɛm ⁴ /	<i>X</i> ₂₃	/py ⁴ hɔn ¹ /
<i>X</i> ₆	/k ^h ɪ ¹ ts ^h ap ⁴ /	<i>X</i> ₁₅	/tsa ⁴ kan ⁴ /	<i>X</i> ₂₄	/my ⁴ lap ¹ /
<i>X</i> ₇	/wɪ ¹ lak ¹ /	<i>X</i> ₁₆	/kɔ ⁴ sam ⁴ /		
<i>X</i> ₈	/pœ ¹ fɛk ¹ /	<i>X</i> ₁₇	/pɔ ⁴ jɛm ⁴ /		
<i>X</i> ₉	/mœ ¹ pɛm ¹ /	<i>X</i> ₁₈	/fɔ ⁴ tɪm ⁴ /		

Appendix B

Test strings used in testing phase

Item	Language 1	Language 2
Test	/tam ⁴ ja ¹ p ^h et ⁴ hip ¹ /	/tam ⁴ ja ¹ p ^h et ⁴ pek ¹ /
	/tam ⁴ wi ¹ lak ¹ hip ¹ /	/tam ⁴ wi ¹ lak ¹ pek ¹ /
	/tam ⁴ hu ⁴ kot ¹ hip ¹ /	/ tam ⁴ hu ⁴ kot ¹ pek ¹ /
	/føn ⁴ ja ¹ p ^h et ⁴ pek ¹ /	/føn ⁴ ja ¹ p ^h et ⁴ hip ¹ /
	/føn ⁴ wi ¹ lak ¹ pek ¹ /	/føn ⁴ wi ¹ lak ¹ hip ¹ /
	/føn ⁴ hu ⁴ kot ¹ pek ¹ /	/føn ⁴ hu ⁴ kot ¹ hip ¹ /
Generalization	/tam ⁴ wœ ¹ fɔk ¹ hip ¹ /	/tam ⁴ wœ ¹ fɔk ¹ pek ¹ /
	/tam ⁴ hy ⁴ fak ¹ hip ¹ /	/tam ⁴ hy ⁴ fak ¹ pek ¹ /
	/tam ⁴ k ^h i ¹ lən ⁴ hip ¹ /	/tam ⁴ k ^h i ¹ lən ⁴ pek ¹ /
	/føn ⁴ wœ ¹ fɔk ¹ pek ¹ /	/føn ⁴ wœ ¹ fɔk ¹ hip ¹ /
	/føn ⁴ hy ⁴ fak ¹ pek ¹ /	/føn ⁴ hy ⁴ fak ¹ hip ¹ /
	/føn ⁴ k ^h i ¹ lən ⁴ pek ¹ /	/føn ⁴ k ^h i ¹ lən ⁴ pek ¹ /

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