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Syntactic Bootstrapping in Children with Mental Retardation

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Abstract

The ability to learn novel verbs in the context of familiar syntactic frames was examined in 10 children with mild-grade mental retardation (MR) and 10 typically developing (TD) children who were matched on receptive language. The children were asked to select the appropriate toy animals and to act out 18 sentences that they heard. The sentences were constructed from one of the three syntactic frames that were expected for both groups of children, and each sentence contained a pseudo-verb. Both the TD children and children with MR were able to use syntactic cues to learn novel verbs. The performance of both groups of children was affected by the length and syntactic complexity of the sentences in which the novel verbs occurred. However, children with MR performed less successfully than the TD children. Error analysis indicated that verb learning of children with MR was constrained by processing limitations.

Introduction

In a typical assessment, speech therapists usually examine how much a child knows about his or her language. However, it is important that clinicians also find out how well the child uses his or her current knowledge to learn new language forms. The reason is that children with the same knowledge may show different abilities in learning new language forms.

A child who fails to learn new language forms may be due to his/her lack of the knowledge that is needed for learning, or due to his/her inability to use the acquired knowledge for learning. Children's learning of new language forms in the former case can be facilitated by teaching the knowledge required. The second case requires investigation on what affects the children's application of acquired knowledge for learning new language forms. It is worth studying why some children can apply their acquired knowledge to learn new knowledge, but some children are less able to do so.

It has been found that children use a number of strategies for learning new words. Some of these strategies depend on the properties of the referents like mutual exclusivity (Merriman & Stevenson, 1997), while other strategies depend on the language input and the linguistic knowledge of the listeners, such as syntactic bootstrapping (Tomasello, 1995). The latter kind of strategies takes an important role when the referents are out of sight. Many studies tried to explain how language input affects the learning of new words. Therefore, syntactic bootstrapping would be studied in this article.

Syntactic Bootstrapping: the use of syntax for prediction of verb meanings

Landau & Gleitman (1985) studied the development of comprehension in a blind child during her first six years of life. Given that this child was not able to see, and hence could not take advantage of the extralinguistic context, she was still able to learn many verbs including sighted verbs like see. Landau & Gleitman (1985) suggested that some support for

verb learning came from linguistic context. They first proposed the use of syntactic bootstrapping for verb meaning in young language learners.

Syntactic bootstrapping refers to the strategy for learning new words by inferring the meaning of a novel word from the syntactic frame in which the word occurs. In the learning of verbs, the syntactic frame constrains the meanings of the verb it contains. A transitive verb frame, as illustrated in "the duck grops the cat", is related to causative actions, and an intransitive verb frame, as illustrated in "the duck grops", is related to non-causative movements (Bloom, 2000). Therefore, a novel verb occurring in a transitive verb frame is often interpreted as carrying a causative meaning, whereas the same novel verb occurring in an intransitive frame is often interpreted as describing self-initiated actions.

The Importance of Syntactic Bootstrapping for verb Learning

Many researchers (e.g. Gleitman, 1990; Naigles, 1996; Lidz, Gleitman & Gleitman, 2003) pointed out that syntactic bootstrapping is important for learning in several ways. First, there can be a number of plausible interpretations about the meaning of a novel verb if it is given in isolation, and only the extralinguistic scene is available (Naigles, 1996; Lidz et al., 2003). Imagine a child watching a man bringing a doll towards a baby. The novel verb "bring" that the child heard during the scene may be interpreted as walk, play, or other verbs, as there are more than one possible ongoing and future actions that can be associated with the scene. Actually, the novel verb "bring" can even be interpreted as man, baby, or other objects that are present in the scene as the child did not have the linguistic context to identify the novel word as a verb. In this situation, the child is very unlikely to correctly infer the meaning of the novel verb. On the other hand, if syntactic cue is provided, the situation will be different. In the above example, if the child heard "Daddy is bringing a doll to baby", and if he knows that this ditransitive frame is often semantically associated with transfer action, the meaning of the novel verb "bring" can be narrowed down sharply. The position of the

novel verb in the sentence excluded all the objects as possible meanings of the novel verb. Moreover, each syntactic frame carries with it semantic implications, which restrict the meanings of the verbs that appear in it (Naigles, 1996). Actions that cannot fit into the transfer syntactic frame, for example walking, can be eliminated. Therefore, syntactic frames facilitate learning of the meaning of novel verbs where extralinguistic context showed too many plausible interpretations.

The second reason why syntactic bootstrapping is important for novel verb learning is that some verbs are different only in the perspectives the action is perceived and encoded (Gleitman, 1990). Let's take the verbs chase and flee for an example. Observation of the extralinguistic scene alone cannot help to identify the meaning of these verbs if they are novel to the child. By using knowledge of syntactic frames, this kind of ambiguity can be avoided. The sentence "The robbers are chased by the police" is a transitive verb frame with a prepositional phrase signaling passive voice agent. Together with information from the extralinguistic scene, the child is likely to interpret the meaning of "chase" as action that the police did towards the robbers. On the other hand, the sentence "All the robbers fled" is an intransitive verb frame. The novel verb "fled" in this linguistic context is more likely to be interpreted as an action that the robbers are doing alone, that is running away. In short, the sentence structure bounded the possible state of actions of the verbs.

The third reason explaining the importance of syntactic bootstrapping is that the verb class is too abstract to be induced solely from extra-linguistic information (Gleitman, 1990; Lidz et al., 2003). For instance, novel verbs that refer to mental states such as think refer to states that are not observable. Children will never be able to infer the meaning of the verb from information in the extra-linguistic context alone as no cue can be provided. Children need cues from other sources, for example from linguistic context. Syntactic bootstrapping is one of the possible sources. Take the sentence "He daydreams about the holiday" in which

the verb "daydream" is novel to the listener. The novel verb is followed by a prepositional phrase which indicated that the action should be related to the event "holiday". The frame helps the listener to infer the meaning of the novel verb should be action or mental state that the subject can do towards the object.

Conditions for Success in Syntactic Bootstrapping

Success in linguistic performance requires linguistic knowledge and information processing skills. Obviously, children must acquire the sentence structures before they can apply the structures for learning. In addition, syntactic bootstrapping requires some processing ability, including attention and perception of the input. Without getting the input, it is impossible to map the verb. In addition to these peripheral processing, the general information processing mentioned by Baddeley (1997) is also necessary for syntactic bootstrapping task. Maintaining the input in short-term memory is important. As before and during processing, children should be able to retain the information received. Otherwise, the signal fading away and further processing becomes unachievable. After that, children have to retrieve information on sentence structures and word meanings from long-term memory. Finally, they have to make use of the syntactic cues to successfully bootstrap the novel verbs.

As mentioned at the beginning, children with the same language knowledge may show different abilities to learn new words, which was evidenced in O'Hara & Johnston's (1997) study. Two groups of children, children with specific language impairment (SLI) and typically developing children (TD), were matched on sentence comprehension ability in their study. Yet, children with SLI showed more errors than the matched TD children on a task which required them to use toys to act out sentences containing novel verbs.

The lack of syntactic knowledge may lead to children with SLI's relatively poorer performance in the task. However, the linguistic knowledge was controlled by matching on sentence comprehension ability in the two groups of children. O'Hara & Johnston (1997)

completed an error analysis in which they categorized the errors. Each category pointed to a breakdown or a problem at different levels of processing. For example omission errors were argued to relate to limitations in short term memory. Because children could not retain in their short term memory the objects involved in the action to be acted out, they left out one or more of the objects. O'Hara & Johnston (1997) concluded that children with SLI had processing difficulties and therefore failed the syntactic bootstrapping task.

Processing difficulties of children with SLI have been reported in the literature (Leonard, 1998; Montgomery, 2002). Although the specific relationship between processing difficulties and language problems in this group of children is not yet known, the presence of processing limitation in children with SLI is well documented. The literature support O'Hara & Johnston's (1997) claim that language learning difficulties are present in children with SLI even in situations where linguistic knowledge is available.

Processing Limitations in children with MR

Similar to children with SLI, children with mental retardation (MR) are believed to have processing limitations. Sabsay & Kernan (1993) suggested that language deficits in children with MR can be due to a number of processes difficulties, including overall reduction in processing capacity, and a deficit in memory. Seung & Chapman (2000) studied digit spans in children with MR, and they reported that children with MR showed a shorter digit span than the mental-age-matched control group. However, these children showed similar performance as the MLU-matched control group. Seung & Chapman (2000) concluded that language production problems and short-term memory deficit are related in children with MR.

It was hypothesized that children with MR may face similar difficulties as did children with SLI in the task of syntactic bootstrapping. Therefore, the performance of children with MR in the syntactic bootstrapping task was examined in this study. First, the investigator

examined whether children with MR were as successful as TD children with comparable language skills in using their syntactic knowledge to learn new verbs. Second, the effect of sentence types on syntactic bootstrapping was also studied. Third, the investigator examined whether children's performance would improve when the stimuli were repeated once when needed. Fourth, the errors on the syntactic bootstrapping task were analyzed to see if any processing limitations led to the errors. Information on the underlying causes for failure of the syntactic bootstrapping task was considered as guidelines for better intervention planning.

Method

Participants

Two groups of Cantonese-speaking children were recruited, the typically developing children (TD) and the children with mental retardation (MR). There were 10 children in each group.

Children with MR were recruited from two schools for children with mild grade mental retardation in Hong Kong. All of the children were reported to have normal hearing and no socio-emotional problems by the speech therapists in the schools. Children in these schools were diagnosed as having mild mental retardation. Mild mental retardation was defined as having an IQ score between 55 and 70 (Batshaw & Shapiro, 1997). However, neither the IQ scores nor the details of the IQ tests of each individual child were available to the investigator.

Children in the TD group were recruited from one kindergarten and one primary school in Hong Kong. All of the children were reported to have normal hearing and no socio-emotional problems by the school administrators. Children in this group had average academic performance from school report and no report of language problems.

As this study aimed to assess children's ability to use existing syntactic knowledge to acquire new verbs, it is necessary to ensure that the participants have knowledge of the

syntactic structures used in this study. The syntactic structures used in this study are three-and four-element structures, including simple active transitive, active transitive locative, and active transitive with conjoined object noun phrases (refer to stimuli section for details). All of the participants were screened by comprehension section of *Reynell Developmental Language Scale—Cantonese version* (RDLS) (Reynell, 1987) to ensure they are at a level of language development where the three- and four-element sentences required for the task was expected to be available. In comprehension section of RDLS (Reynell, 1987), some items were questions with simple active transitive (e.g. 邊隻馬食緊草?), some were statements and questions concerning transitive locative (e.g. 擺一隻豬喺個人後便), and some were statements with conjoined object noun phrases (e.g. 擺個農夫同埋一隻豬喺農場裡便). The items were similar to structures used in the present study. The RDLS (Reynell, 1987) could be used to ensure that the participants had the knowledge required in the syntactic bootstrapping task.

Since there was no developmental information in Cantonese on the specific syntactic structures used in this study, the age of acquisition of these structures was deduced from studies on the general development of 3-element and 4-element sentences.

Mok (1995) conducted a research studying children's knowledge of different sentence types. Mok (1995) tried to reveal children's knowledge by two different tasks, comprehension and production tasks. According to Mok (1995), children comprehended both three-element structures with or without expansion, and four-element structures with 75% accuracy between 5;00-5;06. In the production task in Mok's (1995) study, the children were required to imitate immediately after the investigator's production. Sentences that are longer and syntactically more complex emerged in children's sample earlier than some shorter and less complex ones in the production task. For example children as young as 3;06-3;11 could produce one of the 5-element sentence types with 75% accuracy while the one of

the 2-element sentence types could only be produced with 75% accuracy by children aged 4;06 or above. The imitation nature of the production task may explain why result did not consistent with the comprehension task. The result of production task in Mok's (1995) study may not best reflect the children's knowledge of different sentence types.

One other study was employed to deduce the age at which children have knowledge of 3- and 4-element sentences. Fletcher, Leung, Stokes, & Weizman (2000) constructed a profile about language development in typically developing Cantonese-speaking children from two to five years of age. The development of syntactic structures was derived from the language samples of the participants, which were collected during conversation with an adult. Fletcher et al. (2000) reported that children in the five-year-old group produced three-element sentences with SVO, SVC, and VOO syntactic structures, and four element sentences with SVOO structure. Children in the 5-year-old group received a raw score between 55 and 61 (except one with 48) in the comprehension section of the RDLS (Reynell, 1987). The age equivalent to this range of raw scores was from 5;00 to 6;11 years.

The two studies are consistent about the age at which 4-element sentences are present, which is around five to six years old. Considering results of the two studies, it is estimated that children receiving a raw score in the comprehension section of RDLS (Reynell, 1987) from 55 to 61 are likely to have the syntactic structures required in the present study. TD children who received this range of scores would fall in the age range of 5;00-6;11. But because of the documented effect of cognitive deficit on language development, children with MR show language skills below their chronological ages (Owens, 2002). To achieve the same range of scores, children with MR would be older than children in the TD group as indicated in Table 1.

The 10 children in the TD group received the raw scores between 55 and 63 in the comprehension section of RDLS (Reynell, 1987). The raw scores lie within ± 1.0 S.D., which

confirmed that the children in the TD group had normal language development. The 10 children in the MR group scored between 54 and 63 in the comprehension section of RDLS (Reynell, 1987). Each child in the MR group will be individually matched with one child in the TD group within one raw score point in the comprehension section of RDLS (Reynell, 1987) to ensure comparability. Information about the RDLS scores of each group was presented in Table 1 below.

Table 1: Chronological Age and RDLS scores by group

	MR		TD	
	Mean	SD	Mean	SD
Chronological Age	10.0	1.8	5.8	0.5
RDLS's comprehension scores	58.7	3.1	59.1	2.6

Stimuli

Eighteen sentences were constructed based on the following three types of syntactic frames:

Type 1: Reversible active transitive (NP + V + NP) (for example "The pig /p^{h}iŋ55/ the cow."). In this frame, the verb is often interpreted as referring to causative action.

Type 2: Reversible active transitive locative (NP + V + NP + "to" + NP) (for example "The horse /wɔk5/ the turtle to the pig."). In this frame, the verb is often interpreted as referring to action involved movement.

Type 3: Reversible active transitive with conjoined object noun phrases (NP + V + NP + "and" + NP) (for example "The sheep /lyn33/ the zebra and the cow."). In this frame, the verb is often interpreted as referring to causative action on two objects.

These three types of sentences allow the investigation of the effects of length and syntactic complexity on syntactic bootstrapping. Both Type 2 and Type 3 sentences carried one more noun phrase than Type 1 sentences. Moreover, Type 2 and Type 3 sentences are

expansion of Type 1 sentence structures at clause and phrase levels respectively. Therefore, Type 2 and Type 3 sentences are longer in length and syntactically more complex than Type 1 sentences.

The nouns in each of the sentences were chosen so that all were common animals that young children normally know (refer to appendix A). The verb in each of the 18 sentences was constructed from novel sequences of consonants and vowels in the typical CVC or CVV syllabic structure, which followed the phototactic rules of Cantonese. So these novel verbs all sound like Cantonese.

The novel verbs created should have no equivalent meanings in Cantonese in order to prevent the facilitation on the performance of the learning task from existing knowledge of verbs. To ensure that the novel verbs were not associated with any existing Cantonese verbs, the experimenter carried out an adult judgment task to test how much the novel verbs were like existing verbs in Cantonese. Ten adults were recruited to make independent judgments on the stimuli items using a six-point (0-5) scale. "0" represented that the novel verb did not sound like any real verb in Cantonese. "1" means the novel verb sounds a little bit like a Cantonese verb. The listener could think of a real verb but it is very unlikely that one would regard it as a real verb. "5" means the novel verb is a real verb in Cantonese. "2" to "4" are categories falling between 1 and 5, where "2" is closer to "1" and "4" is closer to "5". Six of the original 18 novel verbs received a score of 3 or above from more than four adult judges. The experimenter replaced these novel verbs. The amended list of stimuli was screened by an adult once.

Procedures

The children were tested individually in a quiet room in their schools. The experimenter first asked the children to name the set of 12 animals included in the study. This step could

eliminate the possibility that children failed the task because they did not know the name of the animals.

The experimenter then gave the following instruction to the children: "I have some animals here. We will hear some sounds. You use the animals to make an action according to what you heard."

Three trials were carried out. The purpose of these trials was to make sure that the children understood the requirements of the task. The experimenter did the first trial, which contained a real verb. Then, the experimenter presented another two trial sentences (one with a real verb, one with a novel verb) and asked the children to select animals to act out the utterance. If the children could not act out the action, the experimenter would demonstrate once and then ask the children to imitate. After the trials, the experimenter presented the experimental items and children were asked to act out the experimental items. No feedback was given to children's actions for experimental items. In case the children did not select any animals or did not perform any action, the investigator would invite the children to do so by saying "Can you act out for me". In case the children told the experimenter that they finished the action, no repetition would be provided even if no action was preformed. The experimenter would repeat the items immediately if the children failed to select any animals, failed to act out any event with the selected toy animals or when the children told the experimenter that they did not remember the sentence.

The 18 sentences, each with a novel verb, were randomized and were recorded on a Mini-Disc. The sentences were presented to the children in the same order. The task was videotaped for scoring by a second judge.

The above procedure was piloted with four adults and two children aged 6;6 and 8;7 before carrying out for the participants. All of the adults scored 100% accuracy and both

children scored above 80% accuracy. The piloting was successful and no modification was needed for the procedure.

Scoring

The scoring scheme included two parts. The first part was rating on the correctness of the responses. A correct response would include the correct selection of the objects involved and the creation of actions that are consistent with the syntactic frame. Type 1 sentences (reversible active transitive) should involve a causative event. Type 2 sentences (reversible active transitive locative) should be a causative action involving movement of the second NP to or towards the third NP. Type 3 sentences (reversible active transitive with conjoined object noun phrases) should involve causative event acting on both the second and third NPs.

The second part was error analysis. Incorrect responses were categorized into one of the following categories. The error pattern analysis allowed the investigator to examine in detail the underlying reason for poor performance. This error analysis was similar to the one used in O'Hara & Johnston's (1997) study with one category modified, which was Intransitive. The Intransitive errors in O'Hara & Johnston's (1997) study were referred to trials that children acted out an intransitive event for novel verbs in a causative syntactic frame. In the present study, some actions created did not consistent with the sentence frames in which the novel verbs occurred, but were not intransitive. For example a causative action on conjoined NPs was made when given a verb in a reversible active locative frame. These errors were combined with Intransitive errors to form a boarder category called Inappropriate Syntactic Frame, as Intransitive is actually a subtype of Inappropriate Syntactic Frame. Inappropriate Syntactic frame was especially important as it indicated whether a child could use the syntactic cue or not.

One new category was added to O'Hara & Johnston's (1997) classification of errors, which was Reduction. Reduction errors were not reported in O'Hara & Johnston (1997)'s

study but were seen in the present study. Reduction was an indicator of short-term memory limitations.

1. **Inappropriate Syntactic frame**: Child could select the correct objects, but created an event that was not consistent with the syntactic frame. Reduction, role assignment, coordination, or addition error would not be scored separately. For example the child made the horse kick the turtle and the pig, which is a causative action on conjoined NPs, when given a sentence in the reversible active locative frame "The horse /wɔk5/ the turtle to the pig.".

2. **Reduction**: Child could pick out all the animals involved correctly, but did not use all of the animals selected. Role assignment would not be scored separately. For example the child took out the penguin, pig and turtle, but made the penguin hit the pig only when given the sentence "The penguin /tsap5/ the pig and the turtle".

3. **Role assignment**: Child could create the correct event but mis-assigned the semantic roles. For example the child used the kangaroo as the agent and hit the giraffe given the sentence "The giraffe /fun3/ the kangaroo" in which the giraffe should be the agent.

4. **Coordination**: Child created more than one event as a response, but none was correct. Role assignment or Reduction error would not be scored separately. For example the child made the penguin run and the panda jump given the sentence "The penguin /jɛŋ35/ the panda to the lion".

5. **Addition**: Child created an event in addition to the correct response. Role assignment or Reduction error would not be scored separately. For example the child made the cow push the elephant to the sheep and then the elephant kick the cow given the sentence "The cow / syt6/ the elephant to the sheep".

6. **Object selection**: child selected incorrect objects. For example the child selected the pig and the sheep given the sentence "the pig /pʰiŋ1/ the cow".

7. **Object omission**: Child chose fewer objects than required for the event. For example the child selected only the elephant and the cow given the sentence "The cow /nɐp3/ the elephant and the kangaroo".

8. **Unclear event**: the event created was unclear. For example the child put the pig facing the cow given the sentence "The pig /pʰiŋ55/ the cow".

9. **No event**: Child selected the object(s) but did not create any events. For example the child selected the pig and the cow but performed no action given the sentence "The pig /pʰiŋ55/ the cow".

All the error categories were mutually exclusive to each other except object selection and object omission. Object selection and Object omission could co-occur with each other and other error categories.

Result and Analysis

The mean raw scores on correctness of each group across different sentence types were summarized in Table 2 below:

Table 2: Mean (standard deviation) scores of correct responses by sentence type and by group

Sentence type	MR	TD	overall
Type 1: Reversible active transitive (max=6)	3.5 (1.8)	5.8 (0.4)	4.65 (1.7)
Type 2: Reversible active transitive locative (max=6)	1.5 (1.6)	4.4 (1.1)	2.95 (2.0)
Type 3: Reversible active transitive with conjoined object noun phrases (max=6)	1.6 (1.7)	4.8 (0.8)	3.2 (2.1)
Overall	2.2 (1.9)	5 (1.0)	

Accuracy of Reponses across groups and sentence types

The first analysis compared the overall correctness on the three sentence types by the two groups. A two-way repeated measures ANOVA, 2 (group) X 3 (sentence type), was

used. The sentence type was the within-subject factor and the number of correct responses was the dependent variable.

The analysis indicated that the main effect for group was significant [F (1,18) = 35.20, $p<0.01$, $d = 1.88$]. An effect size of 0.5 can be said as medium and an effect size of 0.8 should be large (Shaughnessy & Zechmeister, 2000). So, the effect size for group was large. The typically developing children preformed better than the children with MR.

A significant main effect was also found for sentence type [F (2,36) = 16.45, $p<0.01$]. The main effect for sentence type was further analyzed by Post hoc comparisons. Children preformed Type 1 sentences better than Type 2 sentences ($p<0.01$, $d = 0.94$); and preformed Type 1 sentences better than Type 3 ($p<0.01$, $d = 0.79$). The effect sizes were large. Interaction effect was not significant.

Analysis of Error Patterns

The incorrect responses were further analyzed according to the scoring scheme described in the method section. The result was summarized in Table 3.

The TD group made fewer incorrect trials, and so they made less error instances. TD group made a total of 36 error instances while MR group made 167 instances.

Error types that made up more than 10% of the total errors in each group were considered significant and were mentioned below. The four categories that TD group made the highest percentage of errors were Object Selection, Role Assignment, Object Omission, and Addition. The five categories that children with MR made the highest percentage of errors were Inappropriate Syntactic Frame, Object Omission, Object Selection, No Event, and Role Assignment.

The two groups showed some similarities and differences in the error analysis. Both groups made a large proportion of Object Omission, Object Selection, and Role Assignment errors.

Table 3: Error Pattern Analysis by group

Error type	TD	MR
Inappropriate Syntactic Frame	3 (8.3%)	36 (21.6%)
Role Assignment	6 (16.7%)	21 (12.5%)
Coordination	2 (5.5%)	2 (1.2%)
Addition	4 (11.1%)	7 (4.2%)
Reduction	1 (2.8%)	5 (3.0%)
Object Selection	14 (38.9%)	29 (17.4%)
Object Omission	5 (13.9%)	35 (21.0%)
Unclear Event	0 (0%)	3 (1.7%)
No Event	1 (2.8%)	29 (17.4%)
total	36 (100%)	167 (100%)

However, the two groups also showed a different pattern. MR group made a large percentage of Inappropriate Syntactic Frame and No Event errors, but the TD only made small percentage of both categories. One child in the MR group created no event for 37.9% of total trials made by the MR group (11 out of 29 trials). After she selected the animals, she told the investigator that she finished making the action. Without counting trials of this particular child, the MR group still made No Event error 17 trials more than TD group.

Appropriateness of Event Types

In addition to correctness and error type analysis, the appropriateness of the event types preformed by the children was analyzed. Children who were able to make use of the syntactic cues would not create an action that violated the sentence frame which the novel verb appeared, even the response was incorrect in some way, such as inappropriate selection of animals. In order to study how well each group of children could make use of the syntactic cues, appropriateness of the event types was counted in which other errors were not

considered. Only trials with Inappropriate Syntactic Frame errors would be counted as incorrect in this analysis. The result on appropriateness of event types was shown in Table 4:

Table 4: Mean (standard derivation) of appropriate event types by sentence type and by group

	MR	TD	overall
Type 1: Reversible active transitive (max=6)	5.5 (0.7)	6.0 (0.0)	5.8 (0.6)
Type 2: Reversible active transitive locative (max=6)	3.7 (1.8)	5.9 (0.3)	4.8 (1.7)
Type 3: Reversible active transitive with conjoined object noun phrases(max=6)	5.2 (1.2)	5.8 (0.4)	5.5 (0.9)
Overall	4.8 (1.5)	5.9 (0.3)	

The ANOVA revealed a significant group and sentence type interaction [$F_{(2, 36)}$ = 4.18, p = 0.02]. Children in MR group preformed poorer than children in TD group in Type 2 sentence. The main effects for group and for sentence types were not significant.

Both groups of children acted out with appropriate syntactic frame with over 80% accuracy, although the typical developing children preformed with higher accuracy.

Effect of Repetition

The fourth area of interest was the effect of repetition. Repetition of the sentence may reactivate the fading information about the sentence heard due to short-term memory limitation. The result could provide evidence for the hypothesis that the performance of children with MR would be affected by processing difficulties as mentioned in the introduction section.

The clinician repeated the sentences for trials that the children failed to select any animals, failed to act out any event with the selected toy animals or when the children told the experimenter that they did not remember the sentence.

None of children in TD group required repetition. Seven children in the MR group required repetition. On average, each child in the MR group required 1.7 times of repetition. The percentage of correct responses after repetition was 64.71% (11/17).

Inter-judge reliabilities

A second judge was recruited to score the children's responses for inter-judge reliability. She re-scored three children (30%) in the MR group and two children (20%) in TD group from the videotapes. The inter-rater reliability on correctness and error patterns were calculated.

The second judge first rated the responses as correct or incorrect. The reliabilities are 94.4% and 100% on MR and TD groups respectively. The overall reliability on correctness is 96.67%. The second judge then rated the incorrect items according to the error scheme (referred to method section). The reliabilities on error pattern are 86.21% and 100% on MR and TD groups respectively. The overall reliability on error type is 88.06%. Since all the reliabilities calculated were over 85%, it was believed that the judgment of the first judge is reliable.

Discussion

Most studies on syntactic bootstrapping were in English (e.g. Naigles & Hoff-Ginsberg, 1995). However studies on syntactic bootstrapping in other languages began to appear in recent years, for example Kannada mentioned in Lidz, Gleitman, & Gleitman (2003). But to the knowledge of the author, there was no study on syntactic bootstrapping in Chinese or Cantonese until now. The present study provided evidence that, like children learning other languages, Cantonese-speaking children also used syntactic bootstrapping for verb learning. All the typically-developing children achieved above 70% accuracy in the task and the overall accuracy for TD group was 83% (5/6).

Cantonese-speaking children with MR, were also able to use linguistic structures they had for learning new verbs. Children with MR could act out sentences that carried novel verbs successfully. The MR group scored about 37% (2.2/6.0) on average for all sentence types. The group scored 58% (3.5/6.0) for Type 1 sentences, 25% (1.5/6.0) for Type 2 sentences, and 26% (1.6/6.0) Type 3 sentences. Individually speaking, all the children got raw scores higher than zero for Type 1 sentence. Seven and six children got non-zero raw scores for Type 2 and Type 3 sentences respectively. Despite the fact that the children with MR could use the syntactic cues, they were less successful than the TD group on the syntactic bootstrapping task. This finding was not unexpected. Attention would be put on the underlying causes for children with MR's relatively poorer performance in syntactic bootstrapping task.

Factors affecting the performances

Children's comprehension ability may affect the task performance. However, the children with MR had comparable language skills with TD children, as indexed by their matched scores in the comprehension section of RDLS (Reynell, 1987). Moreover, the appropriateness of event type analysis indicated that the children with MR had the syntactic knowledge and were able to apply them most of the time. They could act out an appropriate event types with 80% (4.8/6.0) accuracy. They should have knowledge of the syntactic frames, as the TD children did, and make use of this knowledge to interpret the action type (for example simple transitive or locative). These two pieces of evidences ruled out the possibility that the children did not have knowledge about syntactic frames necessary for the learning of new verbs in this task. Other factors would have to account for the discrepancy in the performance of the two groups of children.

The analysis of error patterns was one way to understand what affected the children's performance. Inappropriate Syntactic Frame errors made up the largest proportion of errors

in MR group. Errors in Inappropriate Syntactic Frame category involved the creation of a wrong event type. To succeed in this novel verb learning task, the children must consider the sentence in which the novel verb appeared. The sentence type provided information about the nature of the action encoded by the novel verb. In cases where children made use of the syntactic cue, they would show actions with appropriate event type, even other errors may still occur. On the other hand, without considering or unable to use the syntactic cue, the children would perform an action that does not fit with the syntactic frame of the utterance, for example an intransitive action for a transitive sentence, or perform a locative sentence as simple transitive action. O'Hara & Johnston (1997) claimed that children's misuse or neglect of the syntactic cues would create an action that was not consistent with the syntactic frame. The children with MR must be affected in some way so that they could create appropriate event types with 80% accuracy but misuse or neglect the syntactic cues in the 20% trials left. Poor short-term memory may result in forgetting of the syntactic cue and so the children randomly selected a frame to create the action, leading to an impression that they misused or neglected the syntactic cues.

Some errors were common in both groups. They were Object Selection, Role Assignment, and Object Omission. The errors were interpreted as consequences of short-term memory limitations (O'Hara & Johnston, 1997). The children forgot which animals were involved or the role of each animal, so they omitted an animal or selected them wrongly. They may allocate an animal's role incorrectly as they forgot the animals' roles once they had selected the animals. The TD children achieved high overall accuracy but still made these errors. Their attention and memory affected their performance.

Children with MR acted out correctly after repetition with more than 60% accuracy. This effect of repetition is an additional piece of evidence that processing limitation constricted children with MR's performance in the syntactic bootstrapping task.

O'Hara & Johnston (1997) further suggested that lexical misinterpretation could lead to Object Selection errors. However, all the children in this study were asked to name the animals, or were at least able to comprehend all the animal names. It was unlikely that problem of lexical interpretation could explain the findings here.

Effect of Sentence structures on task performance

When considering the effect of sentence types, both groups of children preformed better on Type 1 sentences (Reversible active transitive) than Type 2 (Reversible active transitive locative) and Type 3 sentences (Reversible active transitive with conjoined object noun phrases). Type 2 and Type 3 sentences contained three noun phrases which were syntactically more complex and longer in length than Type 1 sentence. Type 1 sentence carried fewer noun phrases and therefore required less memory load (Carpenter, Miyake, & Just, 1994). The children benefited from remembering one noun phrase less. Besides, children learned simple transitive sentence earlier than transitive locative or transitive with conjoined noun phrases (Paul, 2001). They had more exposure to this sentence type from the environment. With increased familiarity, the activation level for that particular sentence type would be lower and so the demand would be lower. The children can access this sentence type faster. More importantly, the children have more chances to use those early-learnt syntactic structures, and so have a better retrieval of these frames resulting in improving the performance when using the knowledge.

Overall speaking, length effect and effect of syntactic complexity on the syntactic bootstrapping task are suggested by the result.

Implication

Result of the present study confirmed that Cantonese-speaking children with MR or those developing typically used sentence structures they have to learn new verbs. Speech therapists may introduce new verbs to children in different sentence structures to facilitate

the children's learning. Obviously, a pre-requisite for success in verb learning is knowledge of the syntactic frames in which the new verbs occur. Before the introduction of the novel verbs, the speech therapists should make sure the children have acquired the sentence structures used to present the novel verbs.

The children with MR were found less able to learn new verbs than their language-matched TD peers, even when they had the linguistic frames necessary. Therefore, clinicians should aim to facilitate their learning. First, the clinicians should increase the children's number of encounters of the novel verbs. Referred to the result section, children's performance improved over repeated exposure to the sentence carrying the novel verbs. The new verb can be presented many times in different sentences constructed from the same syntactic frame. Recurrence of the same sentence frame increases one's activation for the frame and so increases the likelihood of successful bootstrapping.

Second, the clinicians should reduce overall processing demands of the novel verb learning task. In the information processing system described by Just & Carpenter (1992), information needs to be computed and stored. The whole system is capacity limited. The computation and storage would be degraded if the total demands exceed the available capacity. Just & Carpenter (1992) found that both the speed and accuracy for comprehension and other language tasks will be decreased when the demand increases. Therefore, it is suggested that clinicians allow the children to learn under less demanding environment. This is especially true for learning novel verbs as children would have a higher threshold for retrieval of unfamiliar task/element. Higher the threshold, higher activation is required for operating that task.

Third, the clinician must carefully choose the syntactic frame in which the novel verb appears. As Goldberg (1995) pointed out, verbs can appear in frames that do not necessarily reflect the meaning of the verb. An example given in Goldberg (1995) was "kick", which

can appear in di-transitive sentence but does not carry a transfer meaning. The children may mis-interpret the meaning of the novel verb in this way. Clinicians should select a sentence frame that best reflects the meaning of the verb.

Fourth, most of the verbs are used in more than one sentence structures (Naigles, 1996). The exposure to a single syntactic frame does not allow children to understand a new verb's complete meaning and use. New verbs should be introduced in all possible sentence types. This helps the children to constrain the verb meaning and finally acquire the full meaning of the verb.

As suggested by Naigles (1996) and O'Hara & Johnston (1997), a typical verb-learning situation for young children involves the use of extralinguistic context. The present study did not consider the children's use of the extralinguistic context for learning. In a clinical situation, extralinguistic context may help children to learn new verbs as well. Further study may focus on how extralinguistic context assist children in syntactic bootstrapping task.

Although the result turned out as expected, there are some limitations in the present study. First, IQ scores of the children were not available. The correlation between IQ scores and the performance on the task has not been considered in the present study. The cognitive ability may affect children's performance in the syntactic bootstrapping task. It is recommended that children's IQ scores should be included as a factor if this study is replicated in the future. Second, RDLS (Reynell, 1987) may not be the best screening tool for the present study. The stimuli used in this study all begin with subject noun phrase, but most of the items in the comprehension section of RDLS (Reynell, 1987) are commands without subjects. The presence of 3- and 4-element sentences in the children is inferred from their RDLS scores. The test itself may not reflect the children's knowledge of the syntactic structures required for this study. More direct assessment of this knowledge should be considered in future studies.

Conclusions

Syntactic bootstrapping was used by Cantonese-speaking children for learning novel verbs. Children with MR were matched on language comprehension abilities with their typically-developing peers. Yet, they were less successful than the TD children on syntactic bootstrapping task. Processing limitation was suggested by the result as a factor affecting their performance. Length and syntactic complexity of the sentences, in which the novel verbs appeared, affected the performance of the TD children and children with MR.

Acknowledgements

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Appendix A—Stimuli

The set of animals included in the study:

(i)   Giraffe 長頸鹿

(ii) Lion 獅子

(iii) Pig 豬

(iv) Elephant 大笨象

(v)   Horse 馬

(vi) Kangaroo 袋鼠

(vii) Cow 牛

(viii)Zebra 斑馬

(ix) Penguin 企鵝

(x)   Turtle 烏龜

(xi) Sheep 羊

(xii) Panda 熊貓

Set of stimuli:

Trial item done by clinician:

  i. 隻長頸鹿 咬 隻獅子 (The giraffe bites the lion)

Trial items done by child:

  ii. 隻豬 踢 隻大笨象去隻馬度 (The pig kicks the elephant to the horse)

  iii. 隻大笨象 /tsʰip5/ 隻袋鼠同埋隻牛 (The elephant /tsʰip5/ the kangaroo and the cow.)

Experimental items:

(a) Type 1: Reversible active transitive (NP + V + NP)

1. 隻豬 /pʰiŋ55/ 隻牛 (The pig /pʰiŋ55/ the cow.)

2. 隻長頸鹿 /fun33/ 隻袋鼠 (The giraffe /fun33/ the kangaroo.)

3. 隻大笨象 /kœŋ22/ 隻獅子 (The elephant /kœŋ22/ the lion.)

4. 隻斑馬 /fau23/ 隻企鵝 (The zebra /fau23/ the penguin.)

5. 隻熊貓 /hɛŋ33/ 隻馬 (The panda /hɛŋ33/ the horse.)

6. 隻烏龜 /kɐi22/ 隻羊 (The turtle /kɐi22/ the sheep.)

(b) Type 2: Reversible active transitive locative (NP + V + NP + "to" + NP)

7. 隻馬 /wɔk5/ 隻烏龜去隻豬度 (The horse /wɔk5/ the turtle to the pig.)

8. 隻企鵝 /jɛŋ35/ 隻熊貓去隻獅子度 (The penguin /jɛŋ35/ the panda to the lion.)

9. 隻袋鼠 /tsai23/ 隻羊去隻馬度 (The kangaroo /tsai23/ the sheep to the horse.)

10. 隻豬 /tʰa33/ 隻長頸鹿去隻大笨象度 (The pig /tʰa33/ the giraffe to the elephant.)

11. 隻獅子 /kwʰik2/ 隻斑馬去隻企鵝度 (The lion /kwʰik2/ the zebra to the penguin.)

12. 隻牛 /syt2/ 隻大笨象去隻羊度 (The cow / syt2/ the elephant to the sheep.)

(c) Type 3 : Reversible active transitive with conjoined object noun phrases (NP + V + NP + "and" + NP)

13. 隻羊 /lyn33/ 隻斑馬同埋隻牛 (The sheep /lyn33/ the zebra and the cow.)

14. 隻烏龜 /tøn35/ 隻袋鼠同埋隻熊貓 (The turtle /tøn35/ the kangaroo and the panda.)

15. 隻企鵝 /tsap5/ 隻豬同埋隻烏龜 (The penguin /tsap5/ the pig and the turtle.)

16. 隻馬 /pi35/ 隻獅子同埋隻長頸鹿 (The horse /pi35/ the lion and the giraffe.)

17. 隻牛 /nɐp3/ 隻大笨象同埋隻袋鼠 (The cow /nɐp3/ the elephant and the kangaroo.)

18. 隻長頸鹿 /kɐi21/ 隻熊貓同埋隻斑馬 (The giraffe /kɐi21/ the panda and the zebra.)