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Relations between on-line speech processing measures and Index of Productive Syntax scores in preschool children

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Abstract

This paper explores the possible relations between Reaction Times (RT) and Index of Productive Syntax (IPSyn) scores in preschool children. Nineteen children participated and were categorized into two groups; low and high Mean Length of Utterance (MLU). An auditory plus visual looking-while-listening task was conducted and eye gaze was tracked. Language samples from a previous study collected as children played with their mothers and a standard toy set were used to obtain IPSyn scores. Three hypothesis were tested; children with shorter RT will have higher IPSyn scores regardless of MLU; the noun phrase subscale of IPSyn will be related to RT in the low MLU group and not the high; the verb phrase subscale of the IPSyn will not be related to RT in the low MLU group but will be in the high MLU group. Results revealed no significant relations between RT and IPSyn scores .

Keywords: Reaction Time, Index of Productive Syntax, Mean Length of Utterance

Introduction

Researchers have reported links between online speech processing measures such as reaction time and language for children with typical and atypical development (Fernald, Perfors & Marchman, 2006; Fernald & Marchman, 2012; Nicholas & Geers, 2010; Rescorla, 2011). For example, children with faster reaction times during auditory only looking-while-listening tasks early in the second year of life have bigger vocabularies later in the second year of life (Fernald et al., 2006). Fernald and colleagues evaluated fifty-nine children at 12, 18, 21 and 25 months. The study revealed a developmental decrease in reaction time, which suggests children were developing improved efficiency in processing the speech stimuli. Children with higher rates of change over time in vocabulary size as measured by the MacArthur-Bates Communicative Development Inventory (MCDI; Fenson, Marchman, Thal, Reznick, & Bates, 2007) and accelerated growth in vocabulary had faster reaction times during the looking-while-listening task (Fernald et al., 2006). This is not surprising because this is a developmental time point where children's vocabularies are rapidly expanding and organizing (Goldfield & Reznick, 1990; Nelson, 1973). In addition, they found that children with faster reaction times had higher grammatical complexity scores and longer mean length of utterances (MLU) as reported on the MCDI. These findings have been replicated by others and the positive predictive relation between online-speech processing measures and vocabulary measures is fairly well established for infants and toddlers (Fernald & Marchman, 2008). However, few studies have been completed with preschool

children making it difficult to understand how these relations might change over time.

It is possible that relations between online speech processing measures and language might be especially informative in the preschool years if measures besides vocabulary are used such as measures of morphological and/or syntactic structures. This is reasonable because the preschool years are a time in development when morphological and syntactic development is flourishing and variability in emergence exists (Brown, 2013; Hadley & Short, 2005; Miller & Chapman, 1981; Scarborough, 1990; Nicolas & Geers, 2010; Goffman & Leonard, 2000). Measures like the Index of Productive Syntax (IPSyn; Scarborough, 1990) have been used to differentiate emerging grammatical development in three and four year olds. The IPSyn has four subsections, noun phrases, verb phrases, questions and negations and sentence structure. Children must produce each structure twice in the language sample to receive full credit for each item on the IPSyn. It would be of interest to determine if differences in IPSyn scores are sensitive to variation in reaction time during looking-while-listening tasks. Previous studies have not considered this measure of emergence. Therefore, the current study will use IPSyn scores as the language outcome measure of interest in a group of preschool children.

A final variable to consider is whether or not children have access to auditory and visual stimuli during the looking-while-listening procedure. In the standard looking-while-listening procedure stimuli are presented auditorily. Children cannot see the speaker. Critics of this procedure have pointed out that this does not reflect the natural communication environment where children typically need to integrate

auditory and visual information to make sense of speech (Jerger, Damian, Spence, Tye-Murray & Abdi, 2009; Lewkowicz & Hansen-Tift, 2012). They argue that children's ability to integrate auditory and visual information is important for language learning, however, the relations have not been defined. Therefore, th current study will examine preschool children's reaction times in an auditory plus visual looking-while-listening procedure. Those reaction times will be compared to children's emerging morphosyntactic skills to determine if there are relations.

Hypotheses

1. During an audio-visual looking while listening task, children with shorter reaction times will have higher Index of Productive Syntax total scores regardless of MLU.
2. During an audio-visual looking while listening task, noun phrases will be related to reaction time in children with low MLUs but not for children with high MLUs.
3. During an audio-visual looking while listening task, verb phrases will not be related to reaction time in children with low MLUs but will be related in children with high MLUs.

Method

Participants

Nineteen, three-year-old children, nine boys and ten girls, participated in the current study (mean= 3.17; SD=0.48). All children were reported to be Caucasian and of middle socioeconomic status. Children were further categorized into high and

low mean length of utterance groups using a median split. Five boys and 4 girls were in the low MLU group.

Procedures

Reaction Time

The looking-while-listening task was conducted in a sound treated booth and was videotaped to be coded offline. Participants were seated on their parents' laps while the adults listened to music via headphones. Parents were instructed to reorient their children to the stimuli if they became restless but to talk as little as possible. Each looking-while-listening trial consisted of two digital photographs that corresponded to spoken target labels on a large LCD TV screen. A native English-speaking Caucasian female was used to produce the targeted speech stimuli. The target stimuli were four sentences composed of a carrier phrase ("Look at the…") and one of the four target labels ("doggie", "baby", "shoe", "ball"). The female speaker always appeared in the upper center of the screen as she gave participants a label.

The participants' eye gaze was tracked with a digital video recorder at 30 frames/sec and coded offline. Trained observers coded the digitally stored videos of the sessions. The observers coded eye gaze as toward the left object, the right object, the center video; away from visual stimuli; or as shifting their eye gaze. Reaction time was calculated using the eye gaze data in the 300- 2000ms window after the onset of the target label. Reaction time was defined as the first eye shift following the duration of time between the target label onset and a child's first eye shift *away* from the center video. (Grieco-Calub & Olson, under review).

Language sampling

A language sample collected as part of a larger study was used for the current study. To collect the samples, the children and their mothers were videotaped while playing for 15 minutes with a set of toys. The toy set included a feeding set, balls, toy animals and vehicles. The mothers were asked to play as they would at home. Experimenters watched from an observation room. The sessions were audio-video recorded and transcribed offline by pairs of transcribers and analyzed using Systematic Analysis of Language Transcripts software (SALT; Miller & Iglesias, 2008). SALT was used to calculate mean length of utterance in morphemes for each child and to obtain IPSyn scores.

Index of Productive Syntax

The 15 minute language samples were used to obtain IPSyn scores (Scarborough, 1990). Total IPSyn scores, Noun Phrase and Verb Phrase scores were calculated for the current study. A coder with a linguistics background was the primary coder and a second, independent coder with a background in speech-language pathology coded thirty percent of the samples. Interrater reliability was obtained for total, noun phrase and verb phrase IPSyn scores.

Results

Descriptive statistics were obtained for reaction time, total IPSyn scores and IPSyn noun phrase and verb phrase scores. See Table 1.

Table 1

Means and (standard deviations) for MLU, RT and IPSyn scores

Group	Low MLU	High MLU	Total
MLU	2.70 (.27)	3.66 (.34)	3.20 (.58)
Reaction Time	606.09 (228.57)	819.08 (360.31)	718.19 (316.34)
IPSyn Noun Phrase	20.22 (3.11)	22.50 (1.08)	21.42 (2.50)
IPSyn Verb Phrase	18.55 (3.91)	24.70 (2.87)	21.79 (4.56)
IPSyn Total	67.67 (13.01)	86.60 (8.49)	77.63 (14.34)

To test hypothesis 1, a Pearson *r* correlation was obtained to determine if children with shorter reaction times had higher total IPSyn scores regardless of MLU group. The resulting correlation was not significant (r= 0.21, p= 0.389).

To test hypothesis 2, a Pearson *r* correlation was obtained to determine if noun phrase scores were related to reaction time in the low MLU group and another was obtained to determine if reaction time was related to noun phrase scores in the high MLU group. It is predicted that reaction times will predict noun phrase scores in the low MLU group but not the high MLU group. Neither correlations were significant (low MLU: r= -0.048, p= 0.902; high MLU: r= -0.391, p= .264).

To test hypothesis 3, a Pearson *r* correlation was obtained to determine if verb phrase scores were related to reaction time in the low MLU group and another Pearson r correlation was obtained to determine if verb phrase scores were related to reaction time in the high MLU group. It is predicted that reaction times will predict verb phrase scores in the high MLU group but not in the low MLU group. The resulting correlations were not significant (low MLU, $r = 0.117$, $p = 0.764$; high MLU, $r = 0.048$, $p = 0.894$).

Discussion

Many studies have been conducted predictively linking online-processing measures and vocabulary in children with typical and atypical development (Fernald, Perfors & Marchman, 2006; Fernald & Marchman, 2012; Nicholas & Geers, 2010; Rescorla, 2011). It has been found that higher rates of change in vocabulary and more complex grammatical scores were positively related to faster reaction times in looking-while-listening tasks (Fernald et al., 2006). However, all of these studies examined children between one and two years of age. Few studies have been done that investigated preschool children so it is not known how reaction times are related to language measures in preschool. The current study is designed to examine preschool children to determine if the maturing of the grammatical systems is related to reaction times during looking-while-listening tasks.

Contrary to expectations, total IPSyn scores were not related to reaction time nor were noun phrase and verb phrase subscales of the IPSyn. This is despite previous findings that children with faster reaction times scored higher on grammatical complexity and had longer MLUs at later ages (Fernald et al., 2006). It

was hoped that using the IPSyn, a robust measure of grammatical development would reveal concurrent relations with reaction time during a period of rapid morphosyntactic development (Goldfield & Reznick, 1990; Nelson, 1973) that previous studies have not considered. This was not the case.

There are several possible explanations for why IPSyn scores were not related to reaction time in the current study. One possibility is that the standard looking-while-listening task might have been too easy for the preschool students. The pictures presented to the children included a dog, baby, shoe and ball. These are familiar entities and were selected because they are familiar but because the children in the current study were older than in previous studies, the targets could have been too easy. Using familiar but more difficult pictures might result in more variability in RT scores.

The current study also only considered RT and IPSyn scores in one snapshot of time. Previous studies finding predictive links between RT and language scores were longitudinal in design whereas the current study was not. Therefore, only concurrent relations could be explored. Tracking the preschoolers over a couple months and comparing future IPSyn scores to RT at earlier ages would be necessary to explore predictive relations in preschoolers.

Finally it is possible that the current study did not find predictive relations because it added a visual cue to the looking-while-listening protocol. In standard looking-while-looking tasks participants only hear the spoken stimulus item. The do not see the person speaking as in the current study. This difference in methodology could have played a role in the current study's nonsignificant findings.

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