

TALKER DISCRIMINATION IN PRESCHOOL CHILDREN WITH AND WITHOUT
SPECIFIC LANGUAGE IMPAIRMENT

by

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ABSTRACT

Variability inherently present between multiple talkers can prove beneficial in the context of learning. However, the performance during learning paradigms by children with specific language impairment (SLI) remains below typically developing peers, even when multiple talkers are used. Preschool children with typically developing language ($n = 17$) and SLI ($n = 17$) participated in a talker discrimination task. Five different pairings of talkers (same male, different males, same female, different females, male + female) were used to present 50 spoken words. Children with SLI were significantly poorer in discriminating same and different male speakers compared to their typical peers. The present findings demonstrate that preschool children with SLI can experience difficulty distinguishing between talkers. Poor sensitivity to variation in talkers may contribute to poor learning in SLI for contexts where multiple talker input should benefit the learner.

Learning Outcomes

The reader will understand that the presence of multiple talkers (voices) can assist or detract from performance on cognitive tasks. Children with specific language impairment are less proficient than their peers in distinguishing the same from different talkers.

INTRODUCTION

As children learn languages, they typically receive language input from a variety of sources. The effect of this talker variability can be either positive or negative, depending on the cognitive task at hand. Previous research posits that talker variability comes at a cost to performance on some cognitive tasks, such as word recognition and item recall (Goldinger, Pisoni, & Logan, 1991; Mullennix, Pisoni, & Martin, 1988). Task performance can decrease when an additional cognitive load is placed on an individual, as with the introduction of multiple talkers, during an already demanding task. Ryalls and Pisoni (1997) investigated the effects of talker variability on word recognition in preschool children. Word lists were constructed using a single male talker or multiple talkers (5 males and 5 females). Children were instructed to point to a picture that corresponded to a spoken word. When the multiple talker word list was presented first, followed by the single talker list, children (ages 3 and 5) correctly identified more words during the single talker list compared to the multiple talker list. Conversely, when the single talker word list was presented prior to the multiple talker word list, no significant difference in word recognition was evident. This suggested that prior practice with the task overcame the disadvantage caused by multiple talkers.

Goldinger et al. (1991) also reported a single talker advantage during an item recall task. Ten word lists were presented either by a single male talker or multiple talkers (5 males and 5 females). In addition, the rate of word presentation for the entire list was manipulated with 250 ms to 4000 ms between each word. Higher word recall scores were observed in all but one condition when lists were presented by a single talker as

opposed to multiple talkers. When items were presented at the slowest speed (4000 ms between words), individuals showed better recall when the list was presented by multiple talkers. One explanation regarding this finding might relate to processing demands. The slower stimulus presentation might have decreased in the cognitive load, resulting in a higher performance during the multiple talker condition.

In other contexts, talker variability can be facilitative. Multiple talkers facilitate learning of sound sequences in typically-developing infants and preschool children (Richtsmeier, Gerken, Goffman, & Hogan, 2009; Singh, 2008). Richtsmeier, Gerken, and Ohala (2010) reported that learning of nonwords was facilitated when multiple talkers presented the nonword tokens. Preschool children listened to novel words paired with novel pictures. Half of the nonwords were constructed to reflect high frequency English phonotactics and half had a low-frequency phonotactic composition. The former condition generally results in better word learning compared to the latter. In one experiment the children heard these words presented by a single talker and in a second experiment, the words presented by multiple talkers. The introduction of talker variability was facilitative even when the sound sequences of the nonword were low frequency relative to English words. Furthermore, increasing the number of times a word was presented within the experiment only benefitted learning when multiple talkers were used. The use of multiple talkers introduces perceptual variability, in that different speakers produce phones with different pitch, resonance characteristics, and speaking rates. Different speakers may also use different allophonic variants of a single phoneme thus introducing phonetic variants of a single phoneme. It is posited that such sources of

talker variation are an important component in perceptual processing for children and infants (Richtsmeier et al., 2010; Singh, 2008). Exposure to multiple talkers may provide sufficient variability to facilitate this type of learning.

There is reason to believe that children with specific language impairment (SLI) may not benefit to the same degree as their typically developing peers from multi-talker input. Although no study has specifically contrasted single and multiple talkers in learning studies involving SLI, previous studies that have used multiple talkers to present stimuli have found that these children show poorer performance than typically developing (TD) peers (Plante, Bahl, & Gerken, 2010; Plante, Bahl, Vance, & Gerken, 2011). Poorer learning may be attributed to poorer attention, memory, or weaker phonological skills. It is also possible that these children fail to receive any benefit from multiple talkers because of a reduced ability to perceive differences in talker characteristics. This possibility has been suggested by a prior study in which children with SLI and their typical peers were asked to discriminate between single talker and talker pairs of German speakers presenting either German or English words (Levi & Schwartz, 2009). Although this study found no overall differences for a group of eight children ages 7–12, the authors suggested a subset of children with SLI showed a weak ability to differentiate between single and multiple talkers presenting word pairs. The current study aims to address whether preschool children with SLI have a reduced sensitivity to differences among talkers. In the present study, we expand upon the Levi and Schwartz study by using a task that explicitly contrasts native English talkers of different genders speaking English words.

METHODS

Participants

Thirty-four native English speaking children participated, half were included in the SLI group and half in the typically developing (TD) group. Seventeen children (10 males and 7 females) were included in each group. Children were matched pair-wise by age and gender. A six-month range was allotted when matching participants, however the majority of participants differed by only 2 months. Ages ranged from 48 to 68 months (SLI, $M = 58.24$ months; TD, $M = 56.0$ months). All participants passed a pure-tone hearing screening of 500, 1000, 2000, and 4000 Hz at 25 dB HL bilaterally (American National Standards Institute, 1996). Children were recruited from local preschools in the Tucson area. Informed consent was obtained and all children provided assent prior to participating.

A battery of standardized tests was administered to assess both cognitive and language functioning. The nonverbal scales of the Kaufman Assessment Battery for Children Second Edition (KABC-II; Kaufman & Kaufman, 2004) were administered to rule out intellectual disability. Children were excluded from the study if their nonverbal standard score was below the cut-off score of 75 ($70 + 1SEM$). The Structured Photographic Expressive Language Test – Preschool Second Edition (SPELT-P2; Dawson, Stout, Eyer, Tattersal, Fonkalsrud, & Croley, 2005) was used to evaluate language status. The SPELT-P2 has been shown to have high accuracy in discriminating between children with SLI and those with typically developing language (Greenslade, Plante, & Vance, 2009). Children were included in the SLI group if their standard scores

were below a cut-off score of 87, which was previously determined to maximally discriminate between children with SLI and their typically developing language peers (Greenslade et al., 2009).

A number of additional tests were administered to describe current language skills. To describe single-word receptive vocabulary knowledge, we administered the Peabody Picture Vocabulary Test-Fourth Edition (PPVT-IV; Dunn & Dunn, 1997). Likewise, to describe receptive grammar skills, we administered the Grammatical Understanding subtest of the Test of Language Development Primary – Third Edition (TOLD-P3; Newcomer & Hammill, 1997). Finally, we administered the Goldman–Fristoe Test of Articulation–Second Edition (GFTA-2; Goldman & Fristoe, 2000) to describe articulation skills.

Stimuli and Procedures

In the experimental task, participants were asked to determine whether an English word was spoken twice by the same talker or once each by two different talkers. For the experiment, 5 male and 5 female young adults (undergraduate and graduate students) who were native speakers of English served as talkers. These individuals were judged by two of the experimenters as speakers of Standard American English, without a distinct regional dialect. Potential talkers with accents or differing dialects (e.g., southern drawl) were excluded.

The talkers recorded a total of 50 two-syllable words. These words are provided in the Appendix. Word characteristics were selected to represent similar levels of concreteness, imageability, familiarity, and age of acquisition using the MRC

Psycholinguistic Database (Coltheart, 1981). Neighborhood density was calculated (Sommers) for all 50 words and ranged from 0 to 12 ($M = 4.31$). Each word was produced using the talker's natural speaking rate and intonation. Additionally, words that were judged as sounding unnatural in any way by two different researchers were re-recorded. The recordings were digitally edited to give approximately equal loudness to all words for all speakers and saved as sound files. Words were presented by either the same talker twice or by pairs of talkers. During the same talker presentations, the same sound file was presented twice.

Talkers were randomly paired to produce the following talker contexts: (a) same male talker for both words in the pair, (b) the same female talker, (c) two different male talkers for each word in the pair, (d) two different female talkers for each word, or (e) a male and female talker for each word (randomly ordered within the pair).

The experiment was administered in the context of a computer program that presented the spoken words along with computer graphics using DirectRT (Jarvis, 2004). Administration of the experiment took place over the course of two days (25 words per day) in order to keep the total length of the experiment to roughly 15 min each day. The stimuli were divided into two sets and these sets were counter balanced across the two days. All stimuli were presented through headphones on a laptop computer. Responses were recorded using a button box.

Children were seated in front of a button box and were able to comfortably reach the buttons, and see the computer screen. One button had a cartoon picture of one person and the other button had a cartoon picture of two people. For each trial, children saw a

cartoon of a tree in the center of the computer screen and heard a single word spoken twice. Children were instructed to press the button with one person, if the word was spoken each time by the same talker, and the button with two people if the word was spoken each time by two different talkers. The assignment of buttons to responses (one or two talkers) was counter balanced across children.

Three training trials were used to help teach the nature of the task prior to the experimental task. A visual aid, in the form of a cartoon picture of the talker, was presented simultaneously with the presentation of each sound file. After the two identical cartoon pictures were presented, the two pictures merged into one in order to help solidify the meaning of ‘same talker’. In contrast, during ‘different talker’ trials two different cartoon pictures were presented on the screen in conjunction with the sound files. Presentation of the pictures and sound files was followed by computerized instructions of which button to push (e.g., “That was two talkers, push the button with two talkers”). Children received auditory and visual feedback after each response using the same cartoon pictures. Training trials used talker combinations of male + female, two different males, and same female. Therefore, not all possible trial types were presented during the training phase. Instead, the goal of the training portion was to ensure that children understood the concept of ‘same talker’ versus ‘different talker’. These three trials were designated as training trials because the experimenter actively trained children on the needed response.

Next, participants completed 10 practice trials. Visual feedback was provided following each response during practice trials. When the participant correctly identified a

single talker for both word pairs, a cartoon character peaked out from behind a tree. If the participant correctly identified two talkers, two cartoon characters peaked out from behind the tree. However, when the participant was incorrect, a red “X” appeared on a black background. Two examples of all talker type combinations (same male, different male, same female, different female, and male vs. female) were presented during the practice section, for a total of 10 trials. The experimenter provided verbal support and feedback as needed during practice trials. Because of this additional feedback, performance on the practice trials was not included with the experimental trials (described below) for statistical analysis. Lexical items for training and practice trials were different than the lexical items used in the experimental task. Thus, children were unable to rely on lexical information presented during the training and practice phases to aid in performance on the experimental task.

A minimum score of 8 correct practice trials out of 10 was needed before advancing to the test items. If participants did not meet criterion after three practice sets, they were excluded from the study. Two potential SLI participants were unable to reach the criterion and were therefore excluded.

The experimental trials were identical in format to the practice trials. However, the experimenter only provided general encouragement (e.g., “I like how you are listening”) during these trials. Children continued to receive differential visual feedback via computer concerning their button-press selections.

RESULTS

To ensure there were no practice effects across the two days of the experiment, a dependent samples *t*-test was conducted for each group separately, comparing the mean for day 1 ($M = 19.12$, $SD = 4.39$; $M = 15.41$, $SD = 4.58$) to the mean for day 2 ($M = 19.06$, $SD = 3.85$; $M = 17.12$, $SD = 4.90$) for typically developing children and children with SLI, respectively. As predicted, there was no difference between day 1 and day 2 for the TD group [$t(1,16) = 0.07$, $p = 0.94$, $d = 0.01$] or the SLI group [$t(1,16) = -1.74$, $p = 0.10$, $d = 0.35$]. Therefore, data were collapsed across days for each group. We also examined the distribution of responses for both the TD and SLI groups to assure a relatively normal distribution occurred (see Fig. 1). This was done both to satisfy the assumptions of parametric statistics and because it had been suggested previously that talker differentiation may be a bimodally distributed skill for children with SLI (Levi & Schwartz, 2009). Figure 1 displays a histogram of the distributions for the TD and SLI groups. The overall distribution for either group did not differ significantly from a normal distribution (Kolmogorov–Smirnov $d = 0.16$ for the TD group and $d = .20$ for the SLI group) and the distribution variances did not differ between groups ($F = 1.30$, $p = 0.61$).

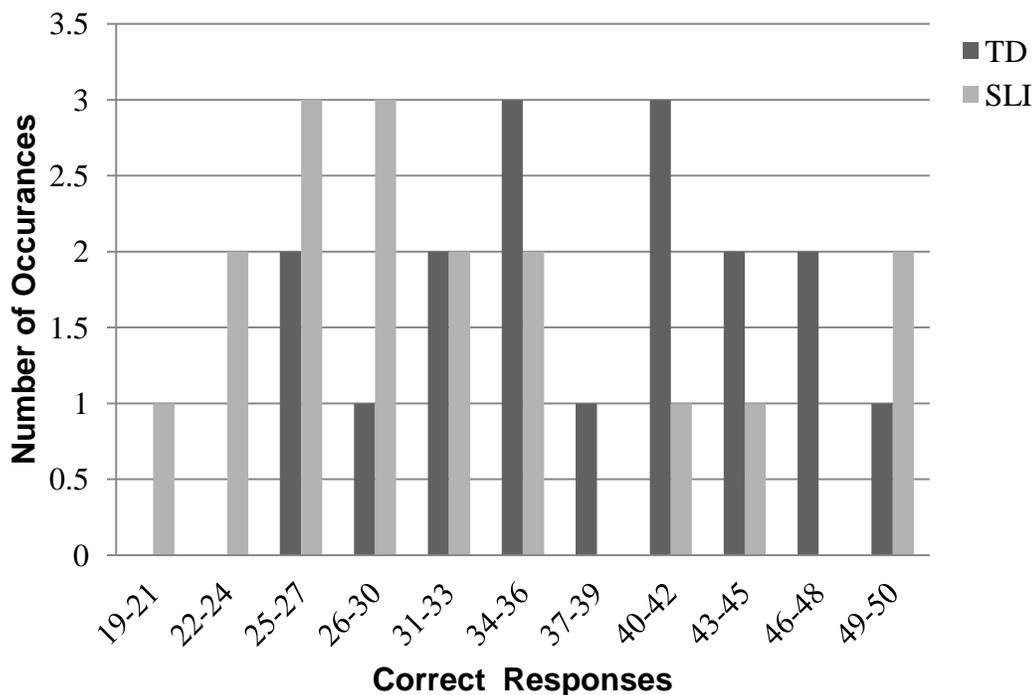


Figure 1. Response distribution for children on the multiple talker task. Bars indicate the number of children in each group who correctly identified different numbers of talker pairs (out of 50 possible pairs).

In order to assure that the SLI group understood the task, we analyzed the responses to items in which a male voice was paired with a female voice. This talker condition was intended to be the easiest and most salient talker condition. If children understood the task, they should indicate that these items represented different talkers approximately as well as their normal peers. Typically developing children ($M = 8.86$; $SD = 1.54$) and children with SLI ($M = 7.59$; $SD = 2.62$) showed the most accurate performance during the male + female condition. An independent sample t -test was performed on the male + female items. As expected, no significant group effect was found for this condition [$t(2, 32) = -1.44, p = 0.16, d = 0.40$]. This supports the

conclusion that both groups were able to perform the experimental task. Thus, the following analyses were carried out on the remaining four conditions.

As Figure 1 indicates, no child performed perfectly on the task. A one-sample *t*-test was conducted to ensure that performance on the experimental task was not at or near ceiling. Performance was significantly below ceiling for each of the four item types for both the TD and SLI groups ($p < .002$ for all comparisons).

The responses for the remaining conditions were analyzed using signal detection approach to determine whether children with SLI showed a decreased ability to discriminate among talkers. Trials of multiple talker stimuli for which the child responded that multiple talkers had spoken were coded as hits. Trials of multiple talker stimuli, for which the child responded that a single talker had spoken were coded as misses. Trials of single talker stimuli, for which the child responded that a single talker had spoken were coded as correct rejects. Finally, trials of single talker stimuli for which the child responded multiple talkers had spoken were coded as false alarms.

The number of correct responses for each of the five item types during the experimental task is reported in Table 2. The d' statistic corresponding to discrimination of all item types (male + female, same male, different male, same female, different female) was calculated for each child. All male talker conditions were combined to calculate discrimination of male talkers. The same was done for female talkers. This resulted in two different combined d' statistics (see Table 2). Group differences in the d' values corresponding to discrimination of male and female talkers was tested using independent sample *t*-tests. Results indicate that TD children were significantly more

accurate compared to SLI children in correctly differentiating between same and different male talkers [$t(2,32) = -1.76, p < .05, d = 0.58$] but no difference was apparent for female talkers [$t(2,32) = -1.01, p = .32, d = 0.32$].

Due to the large spread of scores on the experimental task, we asked whether differences in speech, language, or cognitive skills might account for individual differences in task performance, as measured by d' for the male talker conditions and d' for the female talker conditions. To this end, we correlated each of the measures, based on standard scores, found in Table 1 with task performance. Significant correlations were observed between task performance for male talkers and the KABC-2, PPVT-IV, and the TOLD-P3-GU, but only for the TD group. Task performance for female talkers was correlated significantly with the KABC-2, SPELT-P2, and the PPVT-IV for the TD group (see Table 3). No measures were significantly associated with the task for the SLI group (Tables 2 and 3).

Table 1
Means and standard deviations for typically-developing (TD) and specific language impairment (SLI) groups on standardized tests

	<i>TD Group (n=17)</i>		<i>SLI Group (n=17)</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
KABC-II	109.82*	11.88	98.65	8.12
SPELT-P2	108.71*	6.76	69.88	9.33
TOLD-P3-GU	11.41*	2.24	9.41	1.80
PPVT-IV	105.24*	12.44	89.71	12.63
GFTA-2	108.18*	6.11	86.24	18.05

Note : TD = typically developing, SLI = specific language impairment
 KABC-II: *Kaufman Assessment Battery for Children Second Edition*, SPELT-P2: *Structured Photographic Expressive Language Test – Preschool Second Edition*, TOLD-P3-GU: *Test of Language Development Primary – Third Edition- Grammatical Understanding* subtest, PPVT-IV: *Peabody Picture Vocabulary Test- Fourth Edition*, GFTA-2: *Goldman-Fristoe Test of Articulation – Second Edition*

* Significant group difference at $p < .01$

Table 2

Means and standard deviations for items correct and d' values for typically-developing (TD) and specific language impairment (SLI) groups on experimental task

	<i>TD Group (n=17)</i>		<i>SLI Group (n=17)</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Male and Female Talker	8.86	1.54	7.59	2.62
Same Male Talker	7.47	2.63	6.00	2.81
Different Male Talker	7.29	2.05	6.06	2.51
Same Female Talker	7.12	2.62	6.35	2.52
Different Female Talker	7.65	1.54	6.53	1.70
d' Male Talker	2.74*	2.79	1.13	2.53
d' Female Talker	2.56	2.31	1.66	2.83

Note : TD = typically developing, SLI = specific language impairment

* Statistically significant (between-group t-test) at $p < .05$ (1-tailed)

Table 3

Pearson product-moment correlations for behavioral measures and talker discrimination for typically-developing (TD) and specific language impairment (SLI)

	<i>TD Group (n=17)</i>		<i>SLI Group (n=17)</i>	
	<i>d'</i> male talkers	<i>d'</i> female talkers	<i>d'</i> male talkers	<i>d'</i> female talkers
KABC-II	0.48*	0.50*	98.65	8.12
SPELT-P2	-0.21	6.76	69.88	9.33
TOLD-P3-GU	0.45*	2.24	9.41	1.80
PPVT-IV	0.50*	12.44	89.71	12.63
GFTA-2	0.43	6.11	86.24	18.05

Note : TD = typically developing, SLI = specific language impairment

* Significant correlation at $p < .05$

DISCUSSION

The current findings show that typically developing preschool children were better able to discriminate between multiple talkers when compared to age-matched children with SLI. The current results stand in contrast to a previous study by Levi and Schwartz (2009), who reported no overall group differences for school-aged children with and without SLI. Levi and Schwartz found group differences only after breaking the SLI group into high and low performers. These authors suggested that performance differences within a subset of the SLI group might reflect heterogeneity in the presentation of specific language impairment. The present findings were more robust, in that group differences were detected for the full sample of children with SLI. In addition, our data did not suggest a clear bimodal distribution within the SLI group. Neither group included children who performed at ceiling, and there was considerable overlap between the two participant groups. A small number of children with SLI (4 out of 17) demonstrated relatively strong performance (42 or more correct out of 50 trials) on the experimental task, and the remaining children with SLI performing in the low normal to below normal range (34 or fewer correct, see Fig. 1). However, the overall distribution did not differ significantly from normal.

Task performance was correlated with both receptive and expressive language measures and nonverbal IQ, but only for the TD group. There was no strong relation between language profile and task performance for the SLI group.

Based on the current findings, children with SLI may be less likely to benefit from the variability provided by multiple talkers for word learning tasks. This may

explain why learning is often poorer for children with SLI compared to their age-matched peers, even when multiple talkers are used in an experiment (Alt & Plante, 2006; Plante et al., 2011). A weaker ability to perceive the talker variations related to differences in articulation, speaking rate, voice pitch, and vocal resonance that characterize individual talkers may well reduce the benefit that multiple talkers confer during word learning.

It is also possible that the results obtained are related less to perception of voice differences than to sustained attention. Previous studies have found a deficit in sustained attention in the auditory domain for children with SLI (Spaulding, Plante, & Vance, 2008; Finneran, Francis, & Leonard, 2009). The present experiment required children to sustain attention during the presentation of 25 word pairs per session, for roughly 15 min.

Therefore, it is possible that the group difference could have occurred because of weaker sustained attention on the part of the SLI group. However, sustained attention cannot account for the full pattern of results. Task accuracy varied with different talkers. In particular, children with SLI were no different than their peers when responding to male vs. female talker trials.

Given that the different types of items were administered in a computer-generated random order, attentional breaks would not be expected to affect one class of item more than another.

This study provides an extension of the earlier study by Levi and Schwartz (2009) that found typically developing children between 7 and 12 years of age were able to differentiate between various talkers. However, in the present study, even the typically

developing children were not at ceiling performance for the easiest contrast in the present study (male vs. female).

This may relate to the task demands rather than to the children's true ability to discriminate between talkers. In addition to sustained attention, the task required children to selectively attend to talker information and to disregard the lexical information. It may be that that children were unable to suppress the task-irrelevant lexical information contained in each trial and this made talker discrimination more difficult for them. However, in every day contexts, discriminating between voices typically does occur in the context of linguistic content. Therefore, this aspect of the task used reflects real-life demands.

APPENDIX A – LIST OF AUDITORY STIMULI

Talker combination	Lexical item
M2F4	Cover
M5M5	Teacher
M5M5	Apple
M5M3	Hammer
M5M1	Football
M4M5	Money
M4M5	Butter
M4M4	Pocket
M4M4	Blanket
M3M4	Water
M3M3	Puppy
M3M3	Daddy
F3F3	Oven
F3F2	People
F2M5	Mother
F2M4	Breakfast
F2F3	Penny
F2F2	Marble
F2F2	Letter
F2F1	Summer
F1M4	Insect
F1F4	Honey
F1F4	Clothing
F1F1	Garden
F1F1	Butter
F5F5	Weather
F5F5	Circle
F5F3	Gravy
F5F1	Singer
F4F5	Mirror
F4F4	Kitten
F4F4	Body
F4F2	Bubble
F3M5	Berry
F3M3	Lemon
F3F5	Window
F3F3	Rabbit
M3M2	Pepper
M2M3	Building

APPENDIX A – LIST OF AUDITORY STIMULI - *Continued*

Talker combination	Lexical item
M2M2	Lion
M2M2	Lady
M2M1	Sunshine
M2F5	Onion
M1M4	Robin
M1M2	Coffee
M1M1	Fairy
M1M1	Bedroom
M1F5	Baseball
M1F4	Chicken
M1F3	Pillow

Note: M = male, F = female. Numbers designate different talkers.

APPENDIX B – CONTINUING EDUCATION QUESTIONS

1. Presentation of materials by multiple talkers
 - a. Aids performance compared with presentation by a single talker.
 - b. Inhibits learning compared with presentation by a single talker.
 - c. Neither enhances or inhibits learning
 - d. Can enhance learning or inhibit learning, depending on the task.

2. Children engaged in word learning
 - a. Benefit from multiple talkers presenting new words.
 - b. Find word learning harder when multiple talkers are used.
 - c. Do not notice whether words are presented by multiple talkers.
 - d. Benefit most with single talkers when words are less English-like.

3. When male and female talkers presented word pairs
 - a. The normal but not the SLI group correctly identified these items as involving different talkers.
 - b. The SLI group could identify these as different talkers about as well as their normal peers did.
 - c. Both the normal and SLI groups always correctly identified these items.
 - d. Neither group recognized that different talkers had presented the word pairs.

4. Compared with their typical peers, children with specific language impairment
 - a. Were significantly less able to identify when two different female talkers presented word pairs.
 - b. Were significantly less able to identify when two different male talkers presented word pairs.
 - c. Were significantly less able to identify when different talkers presented word pairs, regardless of gender.
 - d. Were significantly as proficient on the task as a whole, regardless of talker gender.

5. Compared with an earlier study of sensitivity to differences in talkers by children with SLI, this study showed
 - a. Difficulty in talker differentiation was not limited to speakers of a foreign language.
 - b. Difficulty could be detected in younger children than were studied previously.
 - c. Difficulty varied with the gender of the talkers.
 - d. All of the above.

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