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Dichotic Speech Recognition Using CVC Word and Nonsense CVC Syllable Stimuli

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Abstract

Background: The effects of stimulus material, lexical content, and response condition on dichotic speech recognition performance characteristics were examined for normal-hearing young adult listeners. No previous investigation has systematically examined the effects of stimulus material with constant phonetic content but varied lexical content across three response conditions typically used to evaluate binaural auditory processing abilities.

Purpose: To examine how dichotic speech recognition performance varies for stimulus materials with constant phonetic content but varied lexical content across the free recall, directed recall right, and directed recall left response conditions.

Research Design: Dichotic speech recognition was evaluated using consonant-vowel-consonant (CVC) word and nonsense CVC syllable stimuli administered in the free recall, directed right, and directed left response conditions, a repeated measures experimental design.

Study Sample: Thirty normal-hearing young adults (15 male, 15 female) served as participants. Participants ranged in age from 18 to 31 yr and were all right-handed.

Data Collection and Analysis: Participants engaged in monaural speech recognition and dichotic speech recognition tasks. Percent correct recognition per ear, as well as ear advantage for dichotic speech recognition, were calculated and evaluated using a repeated measures analysis of variance (ANOVA) statistical procedure.

Results: Dichotic speech recognition performance for nonsense CVC syllables was significantly poorer than performance for CVC words, suggesting that lexical content impacts performance on dichotic speech recognition tasks. Performance also varied across response condition, which is consistent with previous studies of dichotic speech recognition.

Conclusions: Lexical content of stimulus materials impacts performance characteristics for dichotic speech recognition tasks in the normal-hearing young adult population. The use of nonsense CVC syllable material may provide a way to assess dichotic speech recognition performance while potentially lessening the effects of lexical content on performance.

Key Words: Adults, auditory processing, dichotic speech recognition, neighborhood activation model, nonsense CVC syllables

Abbreviations: CV = consonant-vowel; CVC = consonant-vowel-consonant; LEA = left ear advantage; NAM = neighborhood activation model; REA = right ear advantage; SLI = specific language impairment

Dichotic speech recognition has been used to investigate the hemispheric dominance for language (Hugdahl and Andersson, 1986) and auditory processing abilities in adults and children (Musiek, 1983; Bellis, 2002). Dichotic speech recognition involves the presentation of competing stimuli to

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the right and left ears simultaneously. Listeners are typically asked to repeat one or both stimuli presented. In normal-hearing adults, performance on speech materials presented to the right ear is typically better than performance on speech materials presented to the left ear, resulting in a right ear advantage (REA; Kimura, 1961). Difficulty in dichotic speech recognition skills has been correlated with poor speech recognition in adults (Jerger et al, 1995; Bellis and Wilber, 2001) and poor auditory processing in typical classroom environments in children (Bellis, 2002).

The type of stimulus material used in dichotic speech recognition tasks has been shown to impact performance characteristics measured, including individual ear performance and the resultant ear advantage. When comparing performance of listeners across studies that have used a variety of stimulus types, a hierarchy of stimulus difficulty can be established. Overall, performance on simple, highly familiar digit materials yields the highest individual ear performance with relatively small ear advantages (Kimura, 1961; Musiek, 1983; Noffsinger et al, 1994; Strouse et al, 2000). Word and sentence materials that have relatively more lexical content show high performance and moderate ear advantages (Noffsinger et al, 1994; Carter and Wilson, 2001; Roup et al, 2006). Lastly, consonant-vowel (CV) syllables are the most difficult stimulus material with the least amount of lexical content and yield relatively lower levels of performance and larger ear advantages (Studdert-Kennedy et al, 1970; Hugdahl and Andersson, 1986; Wilson and Leigh, 1996; Hugdahl et al, 2001). One variable not considered in previous studies of dichotic speech recognition across different stimulus materials is how the lexical content of the stimulus material impacts performance characteristics given no differences in phonetic content, which varies across digits, words, sentences, and CV syllable materials.

Another variable that has been shown to impact dichotic speech recognition performance is the response condition employed. Dichotic speech recognition tasks can be administered in the free recall or directed recall response conditions, including directed recall right and directed recall left. AsbjØrnsen and Hugdahl (1995) demonstrated that young adult listeners yielded a mean REA in the free recall condition, a larger mean REA for the directed recall right condition, and a mean left ear advantage (LEA) for the directed recall left condition for CV syllables. Similar results have been obtained for digit stimuli (Strouse and Wilson, 1999) and monosyllabic words (Roup et al, 2006). Therefore, it appears that both stimulus material and response condition can impact the measurement of dichotic speech recognition performance characteristics. As with studies that specifically examine lexical content effects, investigations that examine the impact of response condition on dichotic speech recognition performance have not been completed for a set of stimuli that have the same phonetic content, which could potentially impact recognition performance across response condition.

One criticism of the current assessment tools used to clinically evaluate dichotic speech recognition skills in young adults and children is the potential impact that lexical content of the stimuli and the cognitive load of the response condition have on individual performance (Cacace and McFarland, 1998; Cacace and McFarland, 2005). This is of particular importance as more children with coexisting language delays or disorders are referred for clinical evaluation for auditory processing disorders. Children with auditory processing disorders require different treatment strategies than children with language delays, and therefore differential diagnosis of these two clinical entities is essential. There is a significant need to examine how lexical and response condition variables impact performance on dichotic speech recognition tasks in order to address current overlapping performance levels in children or adults with differing clinical diagnoses.

The specific aim of the present study was to examine how dichotic speech recognition performance varies for stimulus materials with constant phonetic content but varied lexical content across the free recall, directed recall right, and directed recall left response conditions. Two sets of stimuli with similar phonetic content, including nonsense consonant-vowel-consonant (CVC) syllables with no lexical content and CVC words with relatively more lexical content, were used for evaluating dichotic speech recognition performance in young adult listeners. Nonsense CVC syllables were chosen because they are more numerous and more wordlike than CV syllables. The ability to keep phonetic content constant between the two sets of stimuli also allows for the direct comparison of stimuli that only differ in lexical content, potentially improving differential diagnosis among, for example, auditory processing disorder and language delay. Dichotic speech recognition tasks were completed with both types of stimuli for the free recall, directed recall right, and directed recall left response conditions in order to examine differences in performance across listening modes that attempt to examine the influence of individual variability due to cognitive or attention-based factors (Jerger and Martin, 2006). The primary motivating research question was to determine if performance on a dichotic speech recognition task using nonsense CVC syllables is significantly poorer than performance obtained using CVC words. A significant difference would suggest lexical content impacts recognition performance for dichotic speech recognition tasks. Consequently, a lexical content effect may need to be considered when evaluating performance on dichotic speech recognition tasks used to evaluate auditory processing skills in children and adults.

METHODS

Subjects

Fifteen male and fifteen female young adult listeners between 18 and 31 yr of age (mean = 24.6 yr) participated in the study. Participants were recruited from The Ohio State University Columbus campus and surrounding community, and all listeners reported American English as their native language. None of the listeners reported a significant otologic history or history of language and learning deficits. The Edinburgh Handedness Inventory (Oldfield, 1971) was used to assess handedness, and all participants were identified as right-hand dominant (mean laterality quotient = 85.5). All listeners had normal hearing, defined as air-conduction thresholds of ≤20 dB HL for octave frequencies from 250-8000 Hz with no air-bone gap greater than 10 dB. Thresholds were assessed via conventional pure tone audiometry using a Grason-Stadler (GSI) 61 clinical audiometer and Etymotic ER-3A insert earphones. Normal otoscopic findings and normal middle ear function (Margolis and Hunter, 2000) were also noted for all listeners.

Materials

Speech recognition materials included 100 CVC words and 100 nonsense CVC syllables taken from stimulus lists developed by Boothroyd and Nittrouer (1988). Although the original list from Boothroyd and Nittrouer (1988) contained 120 tokens in each list, some of the nonsense CVC syllables were judged to be actual words by a trained phonetician and were not used in the present study (e.g., /mal/ as *mall,* /kiz/ as *keys*). Therefore, the original list was pared down to 100 CVC words and 100 CVC nonsense syllables with similar phonetic content (see Appendix A for stimulus materials). That is, each list was made up of stimuli consisting of the same initial consonants, medial vowels, and final consonants in order to ensure lists were phonetically balanced. Nonsense CVC syllables followed phonotactic rules of English and as such can be considered "pseudowords." All speech materials were recorded with the same male speaker via a Sennheiser PC 136 USB headset boom microphone routed through a personal computer. A carrier phase of "say the word" was recorded separately in order to avoid coarticulation effects on stimuli. All materials were recorded and edited in Adobe Audition™ 1.5 using a 44.1 kHz sampling rate and 16 bit resolution. All stimuli were normalized for total RMS (root mean square) value and digitally edited to reduce background recording noise via hiss reduction. After editing, the carrier phrase "say the word" was added to each of the stimuli to serve as an onset cue, consistent with other traditional speech recognition tasks. For monaural speech recognition testing, each list of 100 CVC words and 100 nonsense CVC syllables were randomly separated into two lists of 50 words to provide lists for the right and left ears, respectively.

In order to pair stimuli for dichotic presentation, CVC word stimuli were rated for word frequency and neighborhood density according to the neighborhood activation model (NAM) of speech perception (Luce and Pisoni, 1998). Ratings were taken from the English Lexicon Project (Balota et al, 2007), and each CVC word was defined as having high or low word frequency and high or low neighborhood density. "High" frequency words were those having a frequency rating greater than the median word frequency for this specific list of words while "low" frequency words were those words having a rating less than the median word frequency. Ratings for neighborhood density were also defined in reference to the median neighborhood density for this specific list, with "high" density words having ratings greater than the median density rating and "low" density words having ratings less than the median density rating. The "high" and "low" ratings for word frequency and neighborhood density yielded four different groups of CVC words: high frequency–high density words, high frequency–low density words, low frequency–high density words, and low frequency–low density words. For the dichotic speech recognition stimuli, CVC word tokens were paired to generate three lists of 50 dichotic word test stimuli, and the nonsense CVC syllables were paired to generate three lists of 50 dichotic syllable test stimuli. Word pairings for dichotic tasks involving CVC words included only words with the same NAM ratings to ensure paired words were similar in recognition difficulty. Nonsense CVC syllables did not undergo the same pairing scheme, since all syllables are equally infrequent and density ratings for nonsense CVC syllables could not be obtained. When pairing both the CVC words and nonsense CVC syllables, the following rules were used: (1) pairs did not consist of stimuli with the same initial consonant; (2) pairings with the same medial vowel and/or final consonant were avoided in order to decrease the possibility of perceptual fusion of stimuli; (3) both the 100 CVC word and 100 nonsense CVC syllable stimuli were paired three times to provide three different 50 token test lists for CVC word and CVC syllable stimuli, respectively, in order to be administrated in the free recall, directed right recall and directed left recall response conditions; and (4) no pair was repeated across lists in order to avoid the possibility of a learning effect increasing recognition on subsequent trials. All dichotic pairs were temporally aligned at onset for simultaneous presentation, and total duration differences between stimuli within a pair did not exceed 50 msec. The presentation of stimuli was counterbalanced across both channels so that no word was presented only to one ear across lists.

Procedures

All procedures for the present study were approved by The Ohio State Behavioral and Social Sciences Institutional Review Board. Listeners participated in two experimental tasks: (1) monaural speech recognition and (2) dichotic speech recognition. Monaural speech recognition was completed for both ears for CVC words and nonsense CVC syllables in order to establish whether differences in monaural speech recognition performance could impact dichotic speech recognition performance. Dichotic speech recognition was completed with both CVC words and nonsense CVC syllables under three response conditions: free recall, directed recall right, and directed recall left. In the free recall response condition, participants were free to repeat the two stimuli in any order. In the directed recall response conditions, participants were instructed to repeat the stimulus in their directed ear first and then repeat the stimulus in their opposite ear. Presentation of stimulus lists was randomly assigned across subjects for both the CVC word and nonsense CVC syllable stimuli. The order of presentation of CVC words and nonsense CVC syllables was counterbalanced across participants. Listeners were seated in an IAC sound attenuated testing booth for all experimental tasks. All stimuli were delivered at 50 dB HL via ER-3 insert earphones from a CD player routed through an audiometer (Grason-Stadler 61) calibrated using a 1000 Hz calibration tone. A trained examiner familiar with both lists of CVC word and nonsense CVC syllable stimuli recorded verbal repetition responses from participants. Percent correct recognition for each of the experimental tasks was derived from listener verbal responses. All testing equipment (audiometer and tympanometer) was calibrated according to the appropriate American National Standards Institute (ANSI) standards (1987, 2004).

RESULTS

Statistical Analysis

For all statistical analyses, raw scores for each test in each response condition were converted using Studebaker's (1985) rationalized arcsine transform. Although statistical analyses were completed using rau scores, all tables and figures present the percentage data for discussion purposes. For all statistical analyses, an a priori alpha level of 0.05 was used to evaluate significance. The Greenhouse-Geisser correction was used in evaluating significance because the homogeneity of covariance, or sphericity assumption, can be violated when data are obtained in a repeated measures fashion with factors that have more than two levels.

Monaural Speech Recognition

Statistical analysis for monaural speech recognition performance was performed using a two-factor repeated measures analysis of variance (ANOVA) using a two *stimulus material* by two *ear* factorial design. A main effect for *stimulus material* ($F_{1,28} = 19.49$, $p < 0.05$) revealed a significant difference between CVC words and nonsense CVC syllables. Post hoc comparisons using paired-samples *t*-tests with Bonferroni correction revealed poorer performance for nonsense CVC syllables than CVC words for both ears. Performance levels for both ears for both stimuli, however, fell above 88%, with a mean of 98.7% and 96.2% for CVC word and nonsense CVC syllables, respectively, when the data were collapsed across ears. Therefore, the difference in monaural recognition performance between CVC word and nonsense CVC syllables was not clinically significant for a speech recognition task using 50 stimulus items (Thornton and Raffin, 1978). The lack of a clinically significant difference is most likely due to monaural speech recognition in quiet being a relatively easy task for normal-hearing young adults resulting in high performance levels.

Dichotic Speech Recognition

Mean dichotic speech recognition scores and standard deviations in percent correct for the right and left ears are presented on Table 1 for both stimulus material types in each response condition. Ear advantage scores were derived by subtracting the performance on materials presented to the left ear from performance on materials presented to the right ear. Positive ear advantage scores indicate an REA while negative ear advantage scores indicate an LEA.

Statistical analysis for overall performance was performed using a three-factor repeated measures analysis of variance (ANOVA) using a two *stimulus material* by three *response condition* by two *ear* factorial design. A main effect for *stimulus material* ($F_{1,28} = 222.83$, $p < 0.05$) revealed a significant difference between CVC words and nonsense CVC syllables. Overall, performance for nonsense CVC syllables was significantly poorer than performance for CVC words.

A main effect for *response condition* ($F_{2,56} = 4.10$, $p < 0.05$) revealed that performance changed as a function of response condition. For both stimulus material types, performance for materials presented to the right ear was better than performance for materials presented to the left ear in the free recall and directed right response conditions, resulting in REAs for both response conditions. For the directed left response condition, however, mean performance for materials presented to the left ear was better than performance for materials presented to the right ear, resulting in an LEA for both

Table 1. Mean Dichotic Speech Recognition Performance (in percent correct) and SDs per Ear for Each Stimulus Material for Free Recall, Directed Right, and Directed Left Response Conditions

Response condition/stimulus material		Right ear (%)	Left ear (%)	RE − LE (%)
Free recall				
CVC words	Mean	94.5	91.3	3.2
	SD	3.8	6.3	5.4
Nonsense CVC syllables	Mean	83.2	75.4	7.8
	SD	8.8	12.5	11.3
Directed recall right				
CVC words	Mean	96.7	90.3	6.4
	SD	3.5	6.1	6.0
Nonsense CVC syllables	Mean	88.9	74.6	14.3
	SD	7.5	11.6	7.8
Directed recall left				
CVC words	Mean	93.3	94.9	−1.6
	SD	5.2	3.7	5.2
Nonsense CVC syllables	Mean	79.9	83.3	−3.4
	SD	8.0	10.3	9.6

stimulus materials. Post hoc comparisons using paired-samples t-tests with Bonferroni correction were used to evaluate the main effect for *response condition*. Performance per ear was paired within each response condition (e.g., the right ear score of the CVC words in the free recall response condition was contrasted with the right ear score of the nonsense CVC syllables in the free recall response condition). This same comparison was repeated for the left ear scores and across each response condition. Results showed that mean performance on tasks using CVC words was significantly better than mean performance on tasks using nonsense CVC syllables for both ears across all response conditions.

A main effect for *ear* ($F_{1,28} = 20.56$, $p < 0.05$) revealed a significant difference between performance for materials presented to the right ear versus performance for materials presented to the left ear. The mean performance on materials presented to the right ear was significantly better than mean performance on materials presented to the left ear for both stimulus material types across most response conditions.

Additionally, a significant interaction effect for *stimulus material* × *response condition* ($F_{2,56} = 3.79$, $p < 0.05$) and a significant interaction effect for *response condition* × *ear* ($F_{2,56} = 21.79$, $p < 0.05$) suggests that performance on materials presented to the right ear versus performance on materials presented to the left ear is dependent on stimulus type and response condition. The interaction of *response condition* × *ear* was due to better mean performance for materials presented to the right ear for the free recall and directed right response conditions and better mean performance for materials presented to the left ear for the directed left response condition.

Figure 1 includes bivariate plots of individual subject data that allow for the examination of variability in individual performance for each stimulus material type across the three response conditions. In each plot, performance on materials presented to the right ear is plotted on the abscissa, and performance on materials presented to the left ear is plotted on the ordinate. All three response conditions are depicted on separated plots, and the diagonal represents equal performance per ear. Points that fall below the diagonal line indicate an REA while points that fall above the diagonal line indicate an LEA. The majority of data points for each stimulus material type suggest an overall REA for the free recall and directed right response conditions, and an LEA for the directed left response condition. Observation of individual performance, however, suggests that not all listeners followed that specific pattern of performance. Also, overall performance for nonsense CVC syllables is more variable than CVC words, evidenced by the larger spread of data in each response condition.

Dichotic Speech Recognition—Ear Advantage

Statistical analysis of ear advantage was also completed to determine if significant differences existed between stimulus materials across response condition. A two-factor repeated measures ANOVA was completed using a two *stimulus material* by three *response condition* factorial design. A main effect for *response condition* ($F_{2,56} = 21.79$, $p < 0.05$) was also significant. Post hoc comparisons using paired-samples t-tests with Bonferroni correction were used to evaluate ear advantage across *response condition* within each stimulus material type. For both CVC words and nonsense CVC syllables, results showed statistically significant ear advantage differences for the free recall versus directed left response conditions and the directed right versus directed left response conditions.

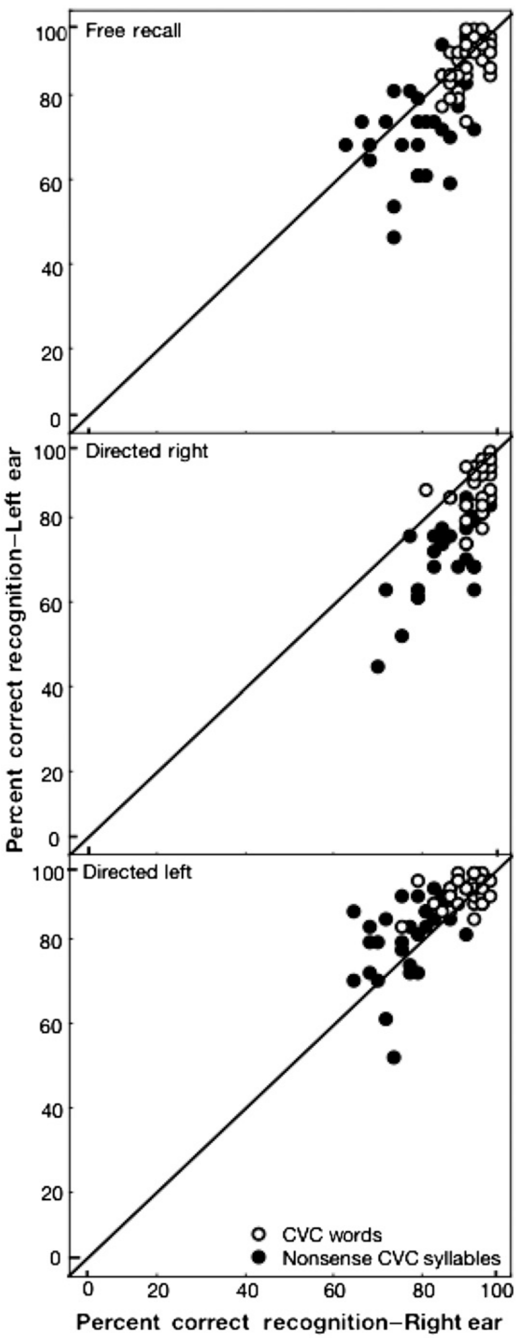

Figure 1. Bivariate plots of individual subject performance for the right ear (abscissa) and left ear (ordinate) for dichotic speech recognition. Data points that fall below the diagonal line indicate a right ear advantage while points that fall above the diagonal line indicate a left ear advantage. Data points falling on the diagonal line indicate equal performance for both ears.

Figure 2 depicts mean ear advantage scores for both stimulus material types across each response condition, with error bars representing 1 SD. Overall, ear advantages were larger and more variable for the nonsense CVC syllables when compared to CVC words. The pattern of performance, however, remains the same across stimulus material, with a mean REA for the free recall response condition, a larger mean REA for the directed right response condition, and a mean LEA for the directed left response condition.

DISCUSSION

The aim of the present study was to compare dichotic speech recognition performance for tasks using stimulus materials with no lexical content (nonsense CVC syllables) versus stimulus materials that have relatively high lexical content (CVC words). Results from dichotic speech recognition tasks completed in the free recall, directed recall right, and directed recall left testing paradigms in the present study revealed that overall performance on tasks using nonsense CVC syllables was significantly poorer and more variable than performance on tasks using CVC words. These results are consistent with previous findings from Noffsinger et al (1994) that compared meaningful digit and synthetic sentence stimuli with nonsense CV syllable stimuli. Phonetic content was not controlled in previous studies, however, and digit material greatly differs from CV syllable material in both the duration and the phonetic content across the two sets of stimuli. One advantage of the stimuli used in the present study is that the set of CVC word and nonsense CVC syllables have similar phonetic content. That is, across both lists of stimuli, the same consonants and vowels appear in initial, medial, and final position with the same frequency (Boothroyd and Nittrouer, 1988). Therefore, the only variable remaining between the two lists is the presence of more lexical content in the CVC words as opposed to the nonsense CVC syllables. Because performance was significantly poorer for nonsense CVC syllables, the results of this study suggest that lexical content impacts recognition performance in dichotic speech recognition tasks in the young adult population. This is consistent with the findings of Carter and Wilson (2001) and suggests that young adult listeners use lexical cues when processing speech in complex listening situations.

For both stimulus material types, performance on materials presented to the right ear was better than performance on materials presented to the left ear in most response conditions, resulting in the expected REA for speech material in a dichotic speech recognition paradigm. The magnitude and direction of ear advantage, however, was dependent on the response condition employed as well as the stimulus material used. As seen in Figure 2, for both stimulus materials, the free recall and directed right recall response conditions yielded a mean REA, whereas the directed left recall response condition yielded a mean LEA. For the present study, the use of the free recall, directed recall right, and directed recall left response conditions served to allow for the examination of the influence of individual variability due to cognitive or attention-

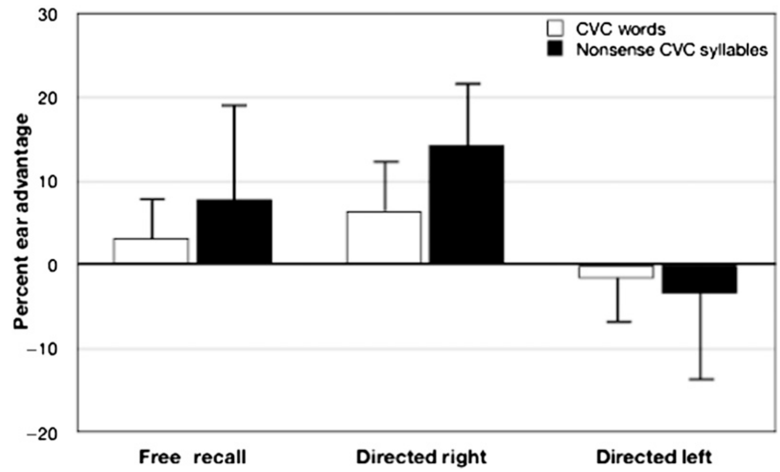

Figure 2. Mean ear advantage (%) for CVC word and nonsense CVC syllables for the free recall, directed right, and directed left response conditions. Error bars represent 1 SD.

based factors on performance. Differences in performance across response condition show that biasing attention to one ear versus the other had an impact on ear advantage, and that impact was different across stimulus types. Overall, performance for the directed ear improved for both stimulus types, which in turn impacts the magnitude and direction of ear advantage. Further, when examining differences in ear advantage across stimulus types for the directed left response condition, it is evident that the magnitude and variability of the LEA is larger for the nonsense CVC syllables than for the CVC words. This may be explained by the fact that nonsense CVC syllables are harder to perceive than CVC words and that the directed left LEA would be attenuated relative to the LEA for CVC words because the left ear is at a disadvantage for recognition of dichotically presented stimuli.

The ear advantages obtained with the nonsense CVC syllable stimulus material were larger and more variable than those obtained with the CVC word stimulus material. As seen in Figure 1, however, individual data indicates great variability in ear advantage even within a specific recall response condition. That is, not all participants showed an REA in the free recall and directed right recall response conditions and an LEA in the directed left recall response condition. This is also consistent with previous findings in young adults using speech materials in a dichotic speech recognition paradigm (Shinn et al, 2005). The larger individual variability seen for the nonsense stimulus material across listening conditions suggests that the limiting of lexical content in complex listening situations impacts individuals differently. However, the fact that the performance of some individuals on the nonsense CVC syllable stimulus tasks overlapped considerably with their performance on the CVC word stimulus tasks suggests that some listeners are not as affected by the lack of lexical cues. A majority of the data for the nonsense CVC syllables, however, is quite disparate and much more variable than performance on tasks using speech stimuli with lexical content. This suggests that listeners who are faced with speech recognition in complex listening situations will have varying degrees of difficulty with speech understanding when lexical cues are lacking.

Overall the results of the present study suggest that lexical content impacts recognition performance in dichotic speech recognition tasks in the young adult population. An advantage of using nonsense CVC syllables versus CVC words in a speech recognition task is that the lexical content is reduced and equalized across stimuli. Since all nonsense stimuli are equally infrequent in the English language, differences in recognition across stimuli attributed to word frequency are diminished. Therefore, differential effects of lexical content previously reported by Dirks et al (2001) and Takayanagi et al (2002) for monaural speech recognition, and by Carter and Wilson (2001) for dichotic speech recognition are avoided.

Another advantage of using nonsense CVC syllable material versus CV syllables is that nonsense CVC syllables have greater ecological validity. Because nonsense CVC material is more wordlike in nature, performance measures would yield a more realistic measure of dichotic speech recognition abilities while potentially lessening differential effects of top-down processing introduced by lexical content present in the stimulus material. Therefore, a possible future use of nonsense CVC syllables in a dichotic speech recognition paradigm would be for assessing auditory processing skills in a population who have coexisting language issues, such as children with specific language impairment (SLI). Although one clinical marker of SLI is poor nonsense word repetition (Gathercole and Baddeley, 1990), children with SLI can typically repeat one-syllable nonsense words with similar accuracy to age-matched peers (Archibald and Gathercole, 2006). Therefore, a potential advantage for using nonsense

Table 2. Mean Dichotic Speech Recognition Performance (in percent correct) for the Present Study and a Sample of Dichotic Speech Recognition Studies Using Various Stimulus Material Types for the Free Recall Response Condition

Study	Stimulus material	Right ear (%)	Left ear (%)	RE − LE (%)
Noffsinger et al (1994)	Digits (1 pair)	≥94.0	≥94.0	0.0
Musiek (1983)	Digits (2 pair)	97.8	96.5	1.3
Kimura (1961)	Digits (3 pair)	92.3	90.3	2.0
Noffsinger et al (1994)	Sentences	≥90.0	≥90.0	0.0
Present Study	*CVC words*	*94.5*	*91.3*	*3.2*
Roup et al (2006)	Words	86.9	84.4	2.5
Present Study	*Nonsense CVC syllables*	*83.2*	*75.4*	*7.8*
Noffsinger et al (1994)	CVs*	75.0	76.0	−1.0
Wilson and Leigh (1996)	CVs*	72.8	56.5	16.3

*Both the Noffsinger et al (1994) and Wilson and Leigh (1996) studies required two responses per stimulus pair for the CV task.

CVC syllables for dichotic speech recognition assessment in children with SLI suspected as having an auditory processing disorders is the ability to equalize difficulty for children with SLI when compared to their peers. Equalizing difficulty for this population could potentially lessen the likelihood that deficits in higher-level language processing are impacting assessment. This, in turn, could add to a clinician's ability to differentially diagnose auditory processing from language processing deficits.

One last advantage of using nonsense CVC syllables is that it lessens the likelihood that normal performance will reach ceiling, as has been shown with digit material and some word material (Musiek, 1983, Noffsinger et al, 1994). Table 2 presents a summary of selected dichotic speech recognition results from studies that have used a variety of types of speech stimuli, including the results of the present study. The data presented in this table includes the performance of normal-hearing young adult listeners performing dichotic speech recognition tasks in the free recall response condition across different speech material typically used for dichotic speech recognition assessment. As can be seen, performance on nonsense CVC syllables does not approach ceiling even in the normal-hearing young adult population, but performance is also not as poor as seen with CV syllables. Therefore, using nonsense CVC syllables for dichotic speech recognition assessment could lessen the likelihood that listeners, especially those with dichotic speech recognition deficits, will approach chance levels of performance.

One disadvantage that must be noted is that overall performance for nonsense CVC syllables in the present study was more variable than performance using CVC words. These results are most likely due to two reasons: (1) performance for CVC words approached ceiling due to the task being relatively easy for normal-hearing, typically developing young adults, and (2) the sample size of this study does not represent a normative data sample. Further investigation of the use of nonsense CVC syllable material should include more listeners to determine if variability is inherent in the task itself or just a by-product of a relatively low subject number.

CONCLUSION

The primary motivating research question for the present study was to determine if recognition differences existed between CVC word and nonsense CVC syllable stimuli that had similar phonetic content but differed in the amount of lexical content present in the stimuli. As such, this study attempted to isolate the impact of lexical content on dichotic speech recognition while controlling for phonetic content of speech stimuli. Without controlling for phonetic content, it cannot be established whether lexical content alone can impact performance measures in dichotic speech recognition. Results showed that mean dichotic speech recognition for tasks using nonsense CVC syllables were significantly poorer than mean performance for tasks using CVC words. Current dichotic speech recognition assessment tools for adults and children use speech stimuli with various amounts of lexical content. The results of this study suggest that the possibility of a lexical content effect needs to be considered when evaluating performance on dichotic speech recognition tasks used to evaluate auditory processing skills in young adults. Further investigation is needed to establish the usefulness of nonsense stimuli in a dichotic speech recognition paradigm for different populations to assess auditory processing skills.

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Appendix A: CVC Word and Nonsense CVC Syllable Stimuli

CVC Words			
bag	dip	loon	rice
bed	dot	lose	rid
beg	doze	made	rig
bell	hag	maim	rod
big	hall	make	room
boom	ham	mall	root
boss	heat	mean	rose
buys	heel	meek	rot
call	hem	miss	rule
cat	hid	mock	same
caught	hide	moon	seal
cause	hiss	mop	sick
coat	hog	pack	sip
cod	hoop	pad	soap
comb	hope	pal	soon
come	keep	pass	sought
cop	keys	peace	suit
dad	league	peck	tag
date	lean	pen	take
dawn	let	pep	tame
dean	lice	pick	time
deep	like	pig	toes
dial	load	pope	tomb
dies	loan	race	toss
dike	log	rake	tote

Nonsense CVC Syllables			
bach	hoon	mim	rouk
bape	hoss	moge	rousse
bawn	kaid	moke	sanne
beeg	kaze	mool	sayz
bep	kazz	mott	seeg
bim	kell	pake	seg
bipe	kezz	paz	sem
bool	kig	peem	sig
dack	kip	pem	sile
dap	kipe	pid	soge
dass	koom	pim	some
dez	koss	pite	soom
dit	lal	pone	sote
dizz	lape	pook	taid
doke	leem	pote	tal
donne	leet	rall	tane
doog	len	rame	tat
doss	lep	rayg	tate
hame	lole	reet	tazz
hap	lyle	reeze	teed
heese	meck	rem	teeg
hez	meese	rige	tem
hice	meeze	rike	tice
hime	mide	rin	took
hod	mige	roasse	toop