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ABSTRACT

The ability of 50 kindergarten children to discriminate and produce the phonemes typically used in early phonic-based reading instruction was investigated in matching-to-sample discrimination task and an echoic production task. The phonemes were presented to each child in isolation and in a word context in both tasks. The average time required to teach each subject was twenty minutes per day for five days. It was found that (1) more discrimination than production errors were made, a difference which was reliable only for the vowels; (2) vowels were easier to discriminate and produce than consonants; and (3) phoneme errors were fewer in words than in isolation, a difference which reached significance only in the production data. Most importantly, further data analysis revealed that frequency of a phoneme in the conversational speech of kindergartners and in the lexicon of the Southwest Regional Laboratory (SWRL) First Year Communication Skills program did not predict articulation difficulty of a phoneme either in words or isolation. The implications of the results for reading pedagogy are discussed. (TS)

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KINDERGARTEN CHILDREN'S DISCRIMINATION AND PRODUCTION OF PHONEMES IN ISOLATION AND IN WORDS

George Marsh and Marjorie Sherman

ABSTRACT

Fifty kindergarten children's ability to discriminate and produce the phonemes typically used in early phonics-based reading instruction was investigated in an AB-X discrimination task and an echoic production task. The phonemes were presented in isolation and in a word context in both tasks to each child.

It was found that (1) more discrimination than production errors were made, a difference which was reliable only for the vowels, (2) vowels were easier to discriminate and produce than consonants, and (3) phonemes errors were fewer in words than in isolation, a difference which reached significance only in the production data. Most importantly, further data analyses revealed that frequency of a phoneme in the conversational speech of kindergarteners and in the lexicon of the Southwest Regional Laboratory First Year Communication Skills program did not predict articulation difficulty of a phoneme either in words or isolation

Implications of the results for reading pedagogy are discussed.

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[1]Gary Verna's help with the statistical analyses is greatly appreciated.

KINDERGARTEN CHILDREN'S DISCRIMINATION AND PRODUCTION OF PHONEMES IN ISOLATION AND IN WORDS

Many writers have argued against a phonics approach to teaching reading because it requires children who are just beginning to read to discriminate to produce isolated letters sounds (phonemes). This is seen by linguists (cf, Bloomfield, 1942; Fires. 1963) as a particularly difficult and unnatural task for the beginning reader. The agrument is stated most forcefully by Bloomfield (1961, p. 16):

> English speakers do not separately pronounce the sound of [t] or [p] or [u] as in put, and a succession like [sp], for instance, as in spin, does not occur alone, as a separate utterance. Learning to pronounce such things is something in the nature of a stunt, and has nothing to do with learning to read. We must not complicate our task by unusual demands upon the child's power of pronouncing.

Arguments of this type have been used to support whole word approaches to teaching reading. One type of whole word approach attempts to have the child induce the spelling-to-sound (grapheme-phoneme) correspondences from whole words that contrast in selected letter positions.

> When we present a pair of words like can and fan, a child may have no notion that the words are similar in sound or that a similar spelling indicates a similar sound. It would be a waste of time to try, as do the advocates of "phonic" methods to explain this to him. All we do is to present such words together; the resemblance of sound and spelling will do its work without any explanation from us. Only we must remember that this takes a great deal of time and repetition.

Similarly Fries (1963, p. 204) states:

> Sounds are not given to the separate letters of a spelling pattern. The understanding of the difference that any particular letter makes in the spelling pattern is built up out of the experience of pronouncing a variety of word pairs with minimum differences in their spelling patterns. We avoid completely such a question as, 'What does the letter C say?'

It is probably true, as Bloomfield and Fries claim that many children will eventually induce spelling-to-sound correspondences from whole words, although experiments (cf, Jeffrey & Samuels, 1967) indicate that this will not occur with limited training but indeed will "take a great deal of time and repetition." A child will probably perform this induction only when the memory requirements of storing whole words as visual-auditory pairs become overwhelming and a new strategy is imperative to reduce the memory load.

Arguments against teaching isolated phonemes have recently become more sophisticated. For example, there is considerable debate among experts as whether or not phonemes are "psychologically real" perceptual units or merely fictional abstractions devised by linguists for their own amusement (cf, Neisser, 1968, Chapter 7 for a review of this debate). Psychologists investigating speech perception have found that there is no invariant acoustic stimulus which corresponds to a phoneme. For example, according to Liberman, et al. (1967), the cues necessary to distinguish voiced stops /b/, /d/, and /g/ are contained in the transition of the second formant. However, the acoustic output in the second formant for perception of these consonant phonemes varies widely depending on which vowel the consonant precedes. Thus, there is no invariant acoustic pattern which maps to the perceived consonant. The minimal unit at the acoustic level is a syllabic-type unit. Presumably on this basis, many reading programs use syllabic units as the basic unit (cf, Rodgers, 1966).

This fact has also led Gibson (1969) to conclude that a phonics reading program would be untenable, even granting one-to-one grapheme-phoneme correspondences. Since Gibson's (1969) theory requires an invariant stimulus pattern in the distal stimulus she concludes phonemes cannot be psychologically "real" units of perception. However, this is not proper deduction from the evidence presented by the Haskin's Laboratory group.

According to the Haskin's group, phonemes are psychologically real units of perception even though there is no invariant distal stimulus because the variant acoustic stimulus is synthesized in the listener's head and phonemes are recognized because the acoustic stimulus corresponds to the listener's own articulatory rules. Such an "analysis by synthesis" approach does not necessarily require an invariant external stimulus for speech perception. Indeed, one of the major sources of evidence for such a theory is the fact that no such external stimulus exists.

Despite the long continuing debate concerning the use of isolated phonemes in beginning reading, no empirical evidence exists (to the author's knowledge) which compares children's articulation and discrimination of isolated phonemes with their ability to articulate and discriminate the same phonemes in words. The present study was designed to provide such evidence.

Previous work on phoneme discrimination. A good review of phonological discrimination is contained in a technical report by Rudegeair and Kamil (1969). An early study using children, by Travis and Rasmus (1931), involved 366 pairs of phonemes; 300 involving consonants and 66 involving vowels. There were few errors in contrasts involving manner of articulation. Another pilot study by Tikofsky and McInish (1968), presented all 105 possible contrasting pairs of 15 consonants in the context of words and nonsence syllables to four seven-year-old children. Again errors occurred only on pairs differing in one distinctive feature and of the five feature differences studied only place of articulation and voicing contrasts produced errors. The above findings with children are consistent with the classic Miller and Nicely (1955) study in which adults discriminated consonants in a CV context with the acoustic stimilus reduced either by frequency attenuation or a noise background. Most errors occurred only in contrasts between minimal pairs differing in place or voicing. Cole, Haber, and Sales (1968), suggest that manner of articulation contrasts may be implicated in confusibility in short-term memory but these investigators classed voicing as a manner feature and voicing contrasts actually account for most of their subjects' errors.

In general, then, of all possible pairs of consonants, only those involving one feature differences in either place or voicing appear to be difficult for both children and adults. Most recent tests and experiments on phoneme discrimination use minimal pairs differing in the above two contrasts. Of the tests, the most frequently used are the Wepman (1958) and Templin (1957) tests. The Templin test (for 3-5 year olds) is somewhat unsystematic in its choice of contrasts: it is a picture test and only pairs that are easily pictured are presented. The Wepman test uses 13 consonant contrasts differing in place of articulation only, which are presented in a word context.

Two recent studies by the group at the Wisconsin Research and Development Center for Cognitive Learning, have also investigated children's ability to discriminate consonants. The first of these (Skeel, Calfee, and Venezky, 1969) tested preschool children on a set of six fricatives (excluding /h/) in the context of three different vowels in a CV or VC order. The second study (Rudegeair and Kamil, 1969) testes kindergarten and first grade children on 13 consonant contrasts involving place of articulation and eight contrasts involving the voicing feature. The contrasts were made in the context of CVC nonsense syllables contrasting either initially, terminally, or both a redundant condition).

Rudegeair and Kamil (1969) point out the methodological difficulties associated with the same-different (A-X) technique, sometimes used to test children's phoneme discriminations (e.g., in the Wepman test).

The Wisconsin studies used a delayed matching-to-sample forced choice discrimination (A-B-X) procedure, which appears to be more satisfactory for young children. Since a procedure is also used in the present study.,

There appears to be less systematic evidence available on the discrimination of vowels in young children. Experiments with synthetic speech (Liberman, et al., 1967) suggest that when vowels are articulated in a consonantal context, adults show the same type of categorical perception for vowels as for consonants. However, vowels articulated slowly in isolation show graded discriminability functions similar to nonspeech sounds. Menyuk (1967) similarly found that children (aged 4 and 7) showed categorical perception of the vowel set (/i/, /I/, and /./) in a consonantal context. But it is not clear whether children would recognize vowels articulated in isolation as speech sounds.

Previous work on phoneme production. As is the case with discrimination, most work on phoneme production has been obtained in the context of other phonemes. The most comprehensive published norms for production were collected by Templin (1957), who used a word context. Templin's techniques for collecting her data were somewhat unsystematic. She mixed data from conversational speech, direct echoic imitation and so on. There is reason to believe that children who misarticulate in conversational speech may be able to articulate the same phonemes correctly in an echoic task, or vice versa, so that a mixed task procedure is not very satisfactory. Venezky and his colleagues at the Wisconsin Research and Development Center, have collected normative articulation data on over 600 Ss in a systematic fashion. This data is unpublished but a preliminary tabulation was available for comparison with the data collected in this study. Venezky's responses were also collected in the context of words.

According to Templin's data, almost all three-year-olds can articulate the vowel sounds in words correctly and most four-year-olds can pronounce single consonant sounds used in the SWRL First Year Communication Skills Program (cf, Cronnell, 1969 for a summary of Templin's data). However, it has been noted by many persons involved in the SWRL reading program that ability to pronounce a phoneme in a word does not guarantee ability to pronounce the same or a similar sound in isolation, thus casting some doubt on the usefulness of word articulation scores as a data base for a phonics reading program. The present study investigates the relationship between pronouncing phonemes in words and phonemes in isolation.

Relationship between discrimination and production. Gibson's (1969) theory posits a hierarchical arrangement of cognitive-perceptual skills starting with differentiation, and going to recognition, identification, abstraction, and production. This theory and most others assumes that discrimination is a necessary prerequisite skill for production. There is some evidence which supports this view. Menyuk and Anderson (1969), for example, found that children could discriminate the semi-vowels w, r, and l at a high accuracy level but could not necessarily produce them correctly. Skeel, Calfee, and Venezky (1969), found that intrusion errors in production tended to maintain either the same place or voicing features as the correct response and, as discussed previously, place and voicing are the hardest features to discriminate. There was also a significant correlation ($r = .62$ $p < .01$) between overall number of errors in articulation and discrimination. On the other hand, Blank (1968) found that children could produce sounds in an echoic imitation task which they could not discriminate correctly on the Wepman test. This is probably due to the methodological flaws embodied in the Wepman test. While production can be assessed more or less directly, discrimination requires some sort of choice task in which response bias, the type of distractors, etc., can play an important role.

The relationship between discrimination and production is of some practical importance because assumptions concerning it determines remediation strategies. For example, one program (Holland & Mathews, 1968) for improving articulation involves no practice in articulation per se. The entire program is devoted to discrimination. In contrast, other programs (cf, Mowrer, Baker, & Schutz, 1968) prescribe direct articulation training. Discrimination of phonemes is probably a necessary but not sufficient condition for production. If so, a program should diagnose the area of the individual child's difficulty and give appropriate training. The present study is designed to throw some light on the relationship between discrimination and production by having each child perform both tasks with the same phonemes.

Method

Subjects

The Ss were fifty kindergarten children from a local school, ranging in age from 5 yrs. 6 mos. to 6 yrs. 7 mos. with a mean age of 6 yrs. 3 mos. There were twenty-eight girls and twenty-two boys. The Ss were all Caucasian and speakers of Anglo English. Children whose parents spoke a foreign language (e.g., Spanish) to them at home were excluded. The Ss mean IQ on the Peabody test was 103.

Apparatus

The apparatus for presenting the discrimination test consisted of an Ampex Micro 88, two channel stereo cassette recorder with two

Electro-voice "Sonocaster" extended range speakers. The responses in the production test were recorded on an Ampex Micro 20 monophonic cassette recorder using a Sennheiser Dynamic microphone. The sound form the stimulus recorder illuminated pictures of animals over the two speakers.

Materials

All the consonants and vowels used in the SWPL FYCSP were used in both the production and discrimination tasks. In additional several phonemes introduced in the second year programs were included.

The sounds used included all the single consonant sounds except /ž/ and twelve vowel sounds (i.e., the ten long and short vowels and two additional vowels /ʊ/ and /ɔ/). The consonant sounds in words were all in the initial position (except /ŋ/). The vowel sounds in words were in medial position; in most cases in the consonant environment b_t. Most of the words used were found in a kindergarten lexicon either the SWRL lexicon, that of Rinsland (1945) or Kolson (1960). The frequency of each word used is shown in Appendix I

The pronunciation of the consonant sounds in isolation were those recommended by Russell and Pfaff (1969). The stops were followed by a voiceless schwa (/ə/). The discrimination task primarily used minimal contrasts involving place of articulation or voicing. In addition there were a few contrasts in manner of articulation. These included /θ/- /t/ and /θ/- /d/ because they are often collapsed by foreign speakers and in some English dialects. The triad /š/ /t/ and /č/ was also included because according to some linguists the latter phoneme contains the other two phonemes as components. All possible contrasts of the long and short vowels were included. In addition, the contrast between /ʊ/ and /u/ and /ɔ/ and /a/ were investigated.

The entire set of discrimination contrasts used in this study are shown in Appendix II.

Procedure

The Ss were tested individually in a room provided by the school. The order of phonemes within a given test was determined randomly, as was the order of the correct and incorrect exemplars. The order of the tests (e.g., consonant words, vowel words, etc.), and the discrimination and production task were counterbalanced over Ss. Prior to phoneme tasks each child was given the Peabody picture vocabulary test.

At the out set of each testing session in which a new task was introduced, the child was given an opportunity to familiarize himself with the testing procedure by responding to five items which, while employing elements found within the subsequent task, were not presented in that task.

In the discrimination task a matching-to-sample procedure (A-B-X) similar to that employed by Rudegeair and Kamil (1969) was used. On each trial a phoneme or word came over the left and simultaneously a picture of an animal over the speaker was illuminated; one half second later the other exemplar sound (and animal picture) was presented on the right speaker: one-half second later the sentence "Who said X?" (the exemplar sound) came over both speakers. The child responded by saying the name of the appropriate animal (e.g., the duck or the bear). In the production test the child was instructed to repeat exactly what the tape said. The production stimuli were presented over both speakers. Each child was given two series of each task, one shortly following the other. The two word production series alternated both words used in the discrimination task (cf, Appendex II). The average time required to teach each S was 20 minutes per day for five days.

Results and Discussion

In order to get an overall look at the relationships between task factors, a 2 x 2 x 2 within Ss analysis of variance was run on the percent errors (transformed to arc sines). The factors were: production vs. discrimination; vowels vs. consonants; and phonemes in words vs. phonemes in isolation. The mean percentage of errors in each of these cells is shown in Table 1.

There was a significantly larger proportion of errors in discrimination than in production ($F = 60.28$, $df = 1/392$, $p < .001$). The vowels were significantly easier to discriminate and produce than the consonants ($F = 88.68$, $df = 1/392$, $p < .001$) and there was a smaller proportion of errors when the phonemes were in words than when they were in isolation ($F = 17.46$, $df = 1/392$, $p < .01$).

In addition to the above main effects, two of the four interactions between factors were significant at the .01 level. There was a significant interaction between the production vs. discrimination factor and vowels vs. consonants factor ($F = 9.09$, $df = 1/392$, $p < .01$). The cell means of this interaction were further evaluated with Duncan Multiple Range Test. Vowel production performance was significantly superior to vowel discrimination performance but consonant production performance was not significantly different from consonant discrimination performance.

TABLE 1

PERCENT ERRORS IN THE EIGHT GROUPS

		Production	Discrimination
Consonants	isolated	13.29	12.54
	words	6.98	12.10
Vowels	isolated	5.96	9.31
	words	3.75	10.21

The other significant interaction was between the production vs. discrimination factor and the words vs. isolation factors ($F = 27.66$, $df = 1/392$, $p < .01$). Again the locus of the interaction was evaluated by a Duncan Multiple Range Test. There was no significant difference between isolated phonemes and phonemes in words in discrimination but there was a significant difference on this factor in production.

The remaining interaction between consonants vs. vowels and words vs. isolation factors was marginally significant ($F = 6.37$, $df = 1/392$, $p < .05$). A Duncan test showed that consonant phonemes were discriminated and produced significantly better in words than in isolation, while this factor did not produce a significant difference with the vowels. The interaction between all three factors, however, was not significant ($F = < 1$).

<u>Discrimination of consonant phonemes.</u> A breakdown of the percentage of discrimination errors within each consonant pair is shown in Table 2 for phonemes in isolation and in Table 3 for phonemes in words. Comparing these tables it can be seen that although the word vs. isolation factors was not significant overall as stated previously, there was a large reduction (approximately 50%) in the number of errors in some consonants (e.g., nasals-- /n/, /m/, and /ŋ/) when they were presented in words.

A Spearman rank order correlation (rho) was computed between the rank order of difficulty of discrimination phoneme pairs in the present experiment and those of Skeel, Calfee, and Venezky (1969), and Rudegeair and Kamil (1969). Neither the word or isolation data correlated significantly with the rank order difficulty of Skeel, <u>et al</u>. (rho = .43, $df = 7$, $p > .05$ for isolated phonemes and rho = .55, $df = 7$, $p > .05$ for words). The same lack of significance was true for the correlation of the present isolated phoneme data with that of Rudegeair and Kamil (rho = .28, $df = 14$, $p > .05$). However, the present data with phonemes in a word context correlated significantly with the Rudegeair and Kamil data (rho = .43, $df = 14$, $p < .05$).

The lack of a significant correlation in most cases indicates that the rank difficulty of phoneme pairs in a discrimination task may be a function of methodological factors. Since the procedures in all three studies were similar (e.g., A-B-X paradigm, etc.), the most likely factor producing the discrepancy is phonemic context.

Skeel, <u>et al</u>., used a CV or VC context while Rudegeair and Kamil used a CVC context (a number of their CVC's were real words). The Skeel, <u>et al</u>., data does not correlate significantly with that of Rudegeair and Kamil (rho = .43, $df = 7$, $p > .05$). However, correlations with the Skeel, <u>et al</u>., data will probably be understimated because of the relatively small number of phoneme pairs used in their study. Most importantly, the correlation between rank order of difficulty in the word and isolated conditions of the present study is very low and not significant (rho = .17, $df = 32$, $p > .05$). This means that tests involving either word pairs or nonsense CVC's will not accurately

TABLE 2

CONSONANT DISCRIMINATION ERRORS IN ISOLATION

Phoneme Pair	Percent Errors	Phoneme Pair	Percent Errors
v ð	53	d b	21
m ŋ	52	t p	20
s f	48	s z	19
f θ	46	b p	18
m n	45	t č	18
ɲ ŋ	43	k g	17
š č	39	l r	17
s [illegible]	34	b g	17
t θ	26	ð θ	16
g d	26	f h	16
ǰ č	25	w̃ l	15
f v	24	ð d	15
v θ	22	l y	14
t k	22	š θ	14
t d	22	h θ	13
k p	21	r w	12
w y	21	r ɣ	8
s š	21		

TABLE 3

CONSONANT DISCRIMINATION ERRORS IN WORDS

Phoneme Pair		Percent Errors	Phoneme Pair		Percent E
that (ð)[1]	vat (v)	43	wet (w)	yet (y)	25
fin (f)	thin (θ)	39	chin (č)	tin (t)	24
sip (s)	zip (z)	36	done (d)	gun (g)	23
thigh (θ)	thy (ð)	36	map (m)	nap (n)	23
chin (č)	shin (š)	32	fin (f)	sin (s)	23
bit (b)	pit (p)	30	shin (š)	sin (s)	22
fat (f)	hat (h)	29	thin (θ)	tin (t)	22
thick (θ)	[illegible]ic (v)	29	pin (p)	tin (t)	22
kin (k)	tin (t)	28	high (h)	thigh (θ)	21
led (l)	wed (w)	27	rim (m)	ring (ŋ)	20
cap (k)	gap (g)	27	die (d)	thy (ð)	19
shin (š)	thin (θ)	27	dip (d)	tip (t)	18
fat (f)	vat (v)	26	red (r)	wed (w)	16
sin (s)	thin (θ)	26	led (l)	red (r)	15
chest (č)	jest (ǰ)	25	sin (n)	sing (ŋ)	14
bun (b)	done (d)	25	bun (b)	gun (g)	14
let (l)	yet (y)	25	kin (k)	pin (p)	13
rung (r)	young (y)	25			

[1]The phonemes given in parentheses are those which are involved in the contrast.

accurately predict p[illegible] ce on discrimination of pairs of phonemes in isolation.

Discrimination of vowel pairs. The mean percentage of errors for each vowel phoneme pair in the isolated condition is shown in Table 4 and in the word condition in Table 5. The greatest number of errors in both words and isolation is the contrast between /ɔ/ and /a/ (cot and caught). This contrast is not normally made by speakers who speak the standard dialect of Southern California. It was included to see if a person who does not have a particular vowel discrimination in his dialect can discriminate the distinction in another speaker's dialect. This is possibly an important question when the pupil speaks one dialect and the teacher speaks another. The answer to this question from the very limited data of this study is negative. Both word and isolation performance is at the chance level.

As stated previously, vowel discrimination performance was found to significantly inferior to vowel production performance, which was not true for consonants. Part of the difficulty in discriminating vowels in words may be due to the fact that until the listener is familiar with a speaker's entire set of vowels, he may have difficulty deciding how high a given vowel is in that speaker's dialect. In addition, as stated in the introduction, vowels pronounced slowly in isolation may not even be recognized as speech sounds by children. Unfortunately to the authors' knowledge there are no good recent data on children's vowel discrimination to compare with the present study with the consonants.

Methodological factors in discrimination task

The fact that there are, in general, more errors on discrimination tasks than production tasks appears contrary to the hypothesis that discrimination precedes and is necessary for production. However, since discrimination requires some sort of choice task, there is more room for methodological factors to influence performance. Briere (1967) has pointed out that a recency bias operates in the A-B-X paradigm. That is, there tends to be more errors on a pair in which the exemplar sound occurs first (i.e., A-B-A) than in a pair in which the exemplar sound occurs second (A-B-B). Rudegeair and Kamil (1969) reported a significant recency bias of this type on the first day of testing in their study, however this bias disappered by the second day. Skeel, et al., (1969) did not evaluate the presence or absence of this bias.

A second possible source of variance is a series or practice effect. Skeel, et at., gave six series of the same lists over a period of six weeks (each child being tested once per week) but found no significant practice effect. Rudegeair and Kamil also tested their Ss

TABLE 4

VOWEL DISCRIMINATION ERRORS IN ISOLATION

Phoneme Pair	Percent Errors	Phoneme Pair	Percent Errors	Phoneme Pair	Percent Errors
ɔ a	42	ey uw	19	I iy	15
ɛ æ	34	æ ə	19	ay uw	14
ɛ iy	27	æ o	18	o ə	14
a ay	24	o ay	18	ə uw	14
ɛ ay	24	iy ay	18	o uw	13
ɛ I	24	o ɛ	18	I æ	12
a ə	24	a I	17	a iy	12
ay ey	24	o ey	17	I ey	11
ə ay	24	ɛ ə	17	o I	08
a uw	23	æ uw	17		
ə iy	22	iy uw	16		
a ɛ	22	æ iy	16		
I ə	22	ɛ ey	16		
[illegible] uw	22	iy ey	16		
a ey	21	I uw	16		
I ay	20	ə ey	15		
æ a	20	o a	15		
ɛ uw	19	o iy	15		
æ ey	19				

TABLE 5

VOWEL DISCRIMINATION ERRORS IN WORDS

Phoneme Pair		Percent Errors	Phoneme Pair		Percent Errors	Phoneme Pair		Percent Errors
caught (ɔ)[1]	cot (a)	48	bot (a)	but (ə)	21	beet (iy)	bot (a)	19
bet (ɛ)	bit (ɪ)	32	bait (ey)	boot (uw)	21	beet (iy)	boot (uw)	18
bit (ɪ)	bait (ey)	29	bet (ɛ)	beet (iy)	20	bat (æ)	bite (ay)	18
bite (ay)	boat (o)	28	but (ə)	bet (ɛ)	20	bit (ɪ)	boot (uw)	17
pull (ʊ)	pool (uw)	27	but (ə)	boot (uw)	20	bat (æ)	but (ə)	17
bat (æ)	bit (ɪ)	27	bat (æ)	bait (ey)	20	bot (a)	boat (ɔ)	17
bet (ɛ)	bite (ay)	25	bait (ey)	bite (ay)	20	bait (ey)	boat (ɔ)	16
bit (ɪ)	boat (o)	25	bot (a)	bait (ey)	20	bit (ɪ)	bite (ay)	15
but (ə)	bait (ey)	24	bat (æ)	bot (a)	20	but (ə)	bite (ay)	15
bat (æ)	boat (o)	23	bat (æ)	boot (uw)	20	bit (ɪ)	bot (a)	15
bot (a)	bite (ay)	23	bet (ɛ)	boat (o)	19	bet (ɛ)	bot (a)	14
bit (ɪ)	but (ə)	22	bat (æ)	beet (iy)	19	bet (ɛ)	boot (uw)	13
bit (ɪ)	beet (iy)	21	bite (ay)	boot (uw)	19	boat (o)	boot (uw)	13
bet (ɛ)	bait (ey)	21	bot (a)	boot (uw)	19	but (ə)	beet (iy)	12
bait (ey)	beet (iy)	21	bat (æ)	bet (ɛ)	19	but (ə)	boat (o)	11
			beet (iy)	boat (o)	19	bot (a)	beet (iy)	10

[1] The phonemes given in parentheses are those which are involved in the contrast.

six times on each test pair, but on a once per day basis instead of once per week. They reported a significant practice effect only between the first and second days.

In order to evaluate the recency and practice effects in the present study a 2 x 2 analysis of variance was run with series (1 and 2) and order (ABA and ABB) as variables. Neither the main effects for series ($F = 1.75$, $df = 1/196$, $p > .05$) or order ($F = 2.23$, $df = 1/196$, $p > .05$) were significant. Apparently the present procedure of running the series sequence without breaks lessens practice and order effects.

The third methodological factor is the position of the consonant phonemes in a word or CVC. Skeel, et al., (1969) point out that vowel duration is longer before some final consonants (fricatives) than others thus possibly facilitating discrimination of these phonemes in the final position. In their study there were significantly fewer errors in discriminating consonants in a VC order than in a CV order. The position variable was not a factor in the present study because all consonant phonemes (except /ŋ/) occurred in the initial position.

Rudegeair and Kamil (1969) report a significant decrease in errors by the use of redundant minimal pairs (e.g., bib-did). Their concern was to devise an optimal test procedure because previous studies have found the error rate to be considerably higher on discrimination than on articulation. As discussed previously, this doesn't make sense if one believes discrimination precedes production. The present study was more concerned with relative error rates than absolute error rates since the latter tend to be based by methodological factors. However, as noted previously, even the relative error rates seem to vary considerably as a function of the method of measurement, particularly phonemic context.

Production of consonants. The error rates in production for the consonants used in this study are shown in Table 6. In contrast to the lack of significant differences in the word and isolation conditions in the discrimination task, production errors are decreased substantially in the word condition as compared with the isolation conditions. Spearman rank order correlation was computed between the isolated and word production conditions of the present experiment and was not significant (rho = .34, $df = 35$, $p > .05$). The data from the word and isolation data in this experiment were compared with the rank difficulty reported by Venezky for 661 children (unpublished) and Templin (1957). As seen in Table 2, both correlations were significant.

TABLE 6

CONSONANT PRODUCTION ERRORS

Phoneme	Isolation Percent Errors	Word Percent Errors
θ	93	59
ŋ	90	0
l	81	1
ð	79	52
f	54	12
n	38	2
v	38	12
m	35	1
č	34	6
ǰ	19	18
y	8	0
v	5	11
z	5	6
w	4	5
s	3	4
b	2	7
p	2	0
d	1	4
š	0	10
k	0	3
g	0	14
t	0	0
h	0	0

TABLE 7

RANK ORDER CORRELATIONS FOR PRODUCTION BETWEEN PRESENT STUDY AND OTHER STUDIES

Present Study	Venezky	Templin (Gyvs)	Carterette and Jones	SWRL FYCSP	Coleman
Isolation	.47*	.52*	.24	.33	--.17
Words	.58**	.46*	.40	.31	---

*Significant at p < .05
**Significant at p < .01

In order to see if difficulty of articulation is related to frequency of phonemes, a rank order correlation was run between the present data and the frequency of phonemes in conversational speech of children in this age range as reported by Carterette and Jones, (1968). Table 7 shows that the correlation was not significant. The same was true when the present data was compared with the frequency of these phonemes in the SWRL FYCSP[1] (see Table 7).

A rank order correlation coefficient was also run between the present production data and the difficulty of learning these phonemes in a paired-associate task as reported by Coleman (unpublished). The correlation as shown in Table 7 is negative and nonsignificant. Although ability to articulate a phoneme would seem to be an index of response availability, this factor alone does not seem to account for the rank difficulty of learning various phonemes as reported by Coleman. Other factors such as list similarity undoubtedly play an important role. Since Coleman does not report list composition--and it apparently varied from one subject to another--little can be determined from his report concerning this factor. However, it is evident from the verbal learning literature that response similarity can have a powerful effect on learning difficulty. List similarity should therefore be studied with reference to the phonemes involved in beginning reading since it would have important implications for sequencing materials. For example, it would probably be wise to avoid puting phonemes which are difficult to discriminate (e.g., /m/ and /n/ etc.) in the same instructional block unless procedures are instituted for maximizing their discriminability.

Production of vowels. The data on vowel production is shown in Table 8. In contrast to the consonants, there was no significant difference between the word and isolation conditions with the vowels. In line with previous research (e.g., Templin, 1957), vowels are considerably easier to produce and discriminate than consonants. As in the case of vowel discrimination data, there is also little recent data available in the literature with which to compare the vowel production data in the present report. Templin (1957) reports almost perfect vowel production performance from the ages 3 through 8 years.

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[1]The Carterette and Jones (1968) frequency count is a type/token count, while the SWRL count is only a type count.

TABLE 8

VOWEL PRODUCTION ERRORS

Phoneme	Isolation Percent Errors	Words Percent Errors
ʊ	35	2
ɔ	32	37
ɛ	28	12
ɪ	12	1
a	10	13
ə	9	2
æ	2	2
o	1	0
ay	1	1
u	1	2
e	0	1
i	0	0

Methodological factors in production task

As noted previously, there are fewer opportunities for methodological factors to influence performance in an echoic production task than in various discrimination tasks. All the children in the present study seemed to understand the task of repeating back the sounds played to them over the tape recorder. Methodological factors do, however, come to bear in the analyses of the production data. In the Templin (1957) study the responses were recorded on the spot by the experimenter (Templin) but were not tape recorded, nor was a reliability check made. In the present study, the production errors were recorded on the spot by the two experimenters, who were not trained in phonetics. The responses were tape recorded and a reliability check on errors between the experimenters and a trained phonetician was above 90% overall cases. This level of agreement was highly significant (phi = .58, p < .001).

Relation between discrimination and production

If discrimination were a necessary prerequisite to production, it would be logical to find fewer discrimination errors than production errors. This is usually not the case in either the present study or other studies concerned with this problem. However Rudegeair and Kamil (1969) have shown that with optimal testing procedures (i.e., repeated testing and redundant minimal pairs) children's discrimination performance will approach levels commonly reported for articulation performance. Therefore, the higher error rates for discrimination than production can probably be viewed as due to methodological factors rather than as a refutation of the accepted beliefs concerning the relationships between discrimination and production.

A second source of evidence concerning the relationship between discrimination and production are correlational studies. For example, two studies by Kronvall and Diehl (1954), and Cohen and Diehl (1963), report that children with articulatory defects have lower scores on the Templin test for discrimination than normal (control) children. Rudegeair and Kamil (1969) point out the difficulties in using gross correlations between discrimination and articulation as evidence concerning the relationships between discrimination and production. Templin (1957), for example, shows many significant correlations between various tests of language ability. It is possible that these correlations are due to some factor analogous to Spearman's G and thus represent some general language processing ability.

A confusion matrix of intrusion errors in production in the present study is shown in Table 9 for consonants and Table 10 for vowels. Contingency coefficients were run on both matrices and were significant (C = .93 for consonants, p < .01 and 89 for vowels, p < .01). This means

TABLE 9

INTRUSION ERRORS IN PRODUCTION (CONSONANTS)

RESPONSES

STIMULI	θ	ŋ	l	o	f	n	v	m	č	ǰ	y	r	z	w	s	b	p	d	š	k	g	t	h
θ	-			1	82	1	1							1	54				2			2	
ŋ		-				24		65															
l			-																				
o				-	8	2	103	2					13			1		1	1				
f	8			2	-		2		1	1			1		43				8				
n						-	2	33							2	1							
v	2			11	2		-				1		29			1		1					
m						29	2	-				1	2										
č									-	3					1		4		32				
ǰ									17	-	1		4								5		
y											-												
r												-		10				1					
z	1			1		1				1			-		5								
w							1					2		-									
s	4												3		-								
b					3		3									-		2					
p																	-						
d																		-			3		
š									8						2				-				
k									1						1					-		1	
g																		5		5	-	2	
t																						-	
h																							-

TABLE 10

INTRUSION ERRORS IN PRODUCTION (VOWELS)

RESPONSES

STIMULI	ʊ	ɔ	ɛ	I	a	ə	æ	o	ay	u	e	i
ʊ					2	7		7		21		
ɔ					63	7		6				
ɛ				15		2	9				3	
I												
a		15					1	1	2			
ə	2				5		1	1				
æ			2			1						
o						1						
ay						1		1				
u	1							1				
e				1								
i												

that the hypothesis that the confusion errors are distributed randomly can be rejected. The contingency coefficient for consonants is similar ($C = .90$) to that reported by Bricker (1967) in his study of echoic production in preschool children.

A rank order correlation was run between the frequency of intrusion errors in production and the frequency of errors for that phoneme pair in the discrimination task. The correlations were significant both for consonants (rho = .88, df = 33 $p < .01$) and vowels (rho = .90, df = 45 $p < .05$). These results are in agreement with the results of Skeel, Calfee, and Venezky (1969), who reported a marginally significant rank order correlation (rho = .34 $p < .10$) between difficulty of discrimination and production.

Pedagogical Implications

The results of the present experiment have several pedagogical implications for the teaching of reading by the phonics approach.

a) The use of discrimination and production tests employing a word context such as the Wepman and Templin tests as well as other data using words does not form an appropriate data base for predicting the difficulty of discrimination and producing phonemes in isolation as required by phonics reading programs. Although there is no significant difference between overall discrimination of phonemes is isolation and phonemes in a word context, the rank order fiddiculty of individual item pairs varies considerably as a function of these two factors. Production of consonant phonemes in isolation is significantly more difficult than production in a familiar word context. This fact casts some doubt on the assumptions of many articulation programs (e.g., Holland and Mathews, 1968; Mowrer, Baker, and Schutz, 1968) which assume that consonant phonemes in words. However, since the above mentioned programs are designed for children with speech articulation defects, it may be necessary to break the phoneme from its habitual context in order to correct misarticulation of the phoneme.

b) A second pedagogical implication is the apparent necessity to institute special procedures for facilitating discrimination of difficult phoneme pairs. Several such procedures come to mind, but all should be first investigated empirically. In the absence of such information, it would probably be wise not to introduce highly confusible phoneme pairs (e.g., some fricatives and nasals) in the same instructional block. However, this may only postpone the problems particularly if the program is cumulative (i.e., includes material from previous lessons) as is the case in the SWRL FYCSP.

c) A third pedagogical implication concerns the use of frequency as the major criterion for introducing phonemes. This has a long tradition in teaching reading going back to Thorndike. It is ironic that Thorndike, a psychologist, had such a significant impact on the linguistic aspects of reading, while Bloomfield, a linguist, had his major impact on the psychology or pedogogy of teaching reading. The SWRL FYCSP follows both the Thorndikean and Bloomfield traditions quite closely. Both the present study and that of Skeel, et al., (1969) show that ease of production is not significantly related to frequency of a phoneme in children's conversational speech. The present study further demonstrates that difficulty of articulation is not significantly related to frequency of a phoneme in the SWRL FYCSP lexicon. Introducing the most frequent phonemes first and less frequent phonemes later will not insure an easy to hard progression in terms of discriminability or difficulty of articulation. However there are other advantages to using frequency of phonemes as a criterion for sequencing instruction. One of the obvious ones is "productivity" (i.e., the number of potential words a child should be able to read given that he knows only N grapheme-phoneme pairs). This factor however assumes that a child can read new words made up of familar letters a program objective that is often difficult to achieve. In the original Thorndike approach the frequency principle was applied to words in a sight word approach where probably it can be justified. The same frequency principle applied to phonemes in a phonics approach is may have less justification.

d) The fourth pedagogical implication is that children apparently will have difficulty discriminating and producing phonemes in the speech of others which do not occur in their own dialect. This conclusion is very tentative, of course, since it rests only on the vowel pair /ɔ/ and /ɑ/ used in the present study. If true, however, it may have important implications for teaching reading to Spanish speaking and Black dialect speaking children. Most writers (cf, Fasold, 19) who have considered problems of the teaching reading to speakers of nonstandard dialects have implicitly assumed the use of a whole (sight) word approach. In this case the problems may be so minimal as to be nonexistant as claimed. However, a whole new set of problems may exist in a phonics reading approach where the child is required to deal with individual phonemes which he may not have in his repertoire as in the Spanish spea er case, or may use only in certain environments as in the Black dialect speaker case. Even more severe difficulties may arise when such a child has to "blend" these fractionated phonemes into words and recognize these distorted words as the same as those in his own dialect.

e) A fifth pedagogical implication is provided by the close relationships found in the present study between difficulty of discriminating a phoneme pair and the frequency of intrusion errors between the same phonemes in the production task. This suggests that discrimination factors are implicated in production performance. It is unlikely that such a direct relationship would be produced by some third factor such as general ability. The correlations of the discrimination and production performance with IQ in the present study are not significant ($r = .04$ $p > .05$ for discrimination and $r = .29$ $p > .01$ for production). It is logical that if a phoneme is not discriminated properly it will be given incorrectly on a production task, but the converse does not follow. Thus it will be necessary to diagnose the source of difficulty in production before proper remediation procedures can be instituted.

f) The sixth pedagogical implication is contained in the detailed data on specific phoneme pairs shown in the tables of this report.

In general, the results of this study can be useful by indicating to program developers and teachers which phonemes kindergarten children may have difficulty discriminating and producing in phonics-based reading programs.

APPENDIX I

Letters	Words	Kolson		Thorndike		Rinsland		SWRL	
p - b	pit - bit	14	89	29	AA	2	75	*	*
t - d	tip - dip	19	--	A	34	6	2	*	*
k - g	cap - gap	29	--	A	17	137	--	*	*
f - v	fat - vat	35	--	AA	5	78	--	*	
θ - ð	thigh - thy	--	--	13	A	--	--		
s - z	sip - zip	50	--	8	--	3	--	*	
č - ǰ	chest - jest	16	--	41	20	9	--		*
d - g	done - gun	835	72	AA	A	75	104		*
t - p	tin - pin	13	78	36	43	28	31	*	*
p - k	pin - kin	18	--	43	13	28	--	*	*
k - t	kin - tin	--	13	13	36	--	28	*	*
b - d	bun - done	9	835	4	AA	5	75	*	*
b - g	bun - gun	9	72	4	A	5	104	*	*
f - θ	fin - thin	--	35	6	AA	3	5	*	*
f - h	fat - hat	35	407	AA	AA	78	212	*	*
v - ð	vat - that	35	7,899	AA	AA	78	3,146	*	*
θ - h	thigh - high	--	626	13	AA	--	64		*
s - š	sin - shin	--	--	A	5	1	--	*	*

-- = No count is given for this word at the K-1 level.

AA = The observed frequency of this word is at least 100 per 1,000,000

A = The observed frequency of this word is at least 50 but less than 100 per 1,000,000.

* = This word is found in the SWRL FYCSP lexicon.

* 2nd = This word is found in the SWRL SYCSP lexicon.

Letters	Words	Kolson		Thorndike		Rinsland		SWRL	
v - θ	Vic - thick	--	18	--	A	--	16		
s - f	sin - fin	--	--	A	6	1	3	*	*
š - θ	shin - thin	--	35	5	AA	--	5	*	*
s - θ	sin - thin	--	35	A	AA	1	5	*	*
m - n	map - nap	--	29	A	15	3	15	*	*
m - ŋ	rim - ring	--	128	12	AA	--	31	*	
n - ŋ	sin - sing	--	202	A	AA	1	152	*	
w - r	wed - red	--	369	5	AA	1	883	*	*
w - l	wed - led	--	--	5	AA	1	5	*	*
r - l	red - led	369	--	AA	AA	883	5	*	*
y - w	yet - wet	461	105	AA	A	72	28	*	*
y - l	yet - let	461	1,609	AA	AA	72	478	*	*
y - r	young - rung	1	9	AA	6	10	2		
t - č	tin - chin	13	8	36	27	28	3	*	
š - č	shin - chin	--	8	5	27	--	3	*	
ð - d	thy - die	--	26	13	AA	--	19		
θ - t	thin - tin	35	13	35	13	5	28	*	*
iy	beet	--		11		1		*2nd yr	
ɪ	bit	89		AA		75		*	
ey	bait	--		14		6			
ɛ	bet	68		23		105		*	
æ	bat	17		19		57		*	
ay	bite	72		33		56		*2nd yr	
a	bot	--		--		--			

Letters	Word	Kolson	Thorndike	Rinsland	SWRL
uw	boot	9	37	1	2nd yr
u	put	5,714	AA	1,104	2nd yr
o	boat	341	AA	166	
ɔ	bought	286	A	93	
ə	but	607	AA	700	

APPENDIX II

Test Series for Vowel Discrimination Task

Pre-Test

ɛ - æ[1]
uw - ey
ɪ - ay
a - o
iy - ə

Series 1

iy - ɪ
ɪ - ey
o - ɪ
æ - ɛ
a - æ
uw - iy
ay - o
iy - a
a - uw
o - æ
iy - ə
ey - ay
ey - uw
a - ɛ
ɪ - ay
iy - ɛ
ay - a
æ - uw
ey - a
iy - æ
ɛ - o
uw - ə
ɛ - ɪ
ey - æ
o - iy
ɪ - uw
ə - ay
ɪ - æ
a - ə
uw - o
iy - ey
ɛ - uw
ə - ey
iy - ay
ɪ - ə
o - a
uw - ay
o - ə
ɛ - ey
a - æ
ey - o
ə - ɛ
a - ɪ
ay - ɛ
æ - ə

Series 2

ɛ - ay
ə - ɛ
a - æ
ə - o
a - o
ay - iy
uw - ɛ
o - uw
ɪ - æ
ɪ - ey
ɛ - æ
iy - uw
a - iy
o - æ
ey - ay
a - ɛ
ɛ - iy
uw - æ
æ - iy
uw - ə
æ - ey
uw - ɪ
ay - ə
iy - o
ɛ - ɪ
o - ɛ
ə - æ
a - ɪ
o - ey
ay - uw
ɪ - ə
ə - a
ey - ɛ
iy - ɪ
ey - ə
a - ey
ay - a
uw - ey
ɪ - o
æ - a
o - ay
uw - a
ə - iy
ay - ɪ
ey - iy

Series 3

æ - ɪ
iy - ey
ə - ɪ
uw - ay
ə - o
o - ey
a - uw
ay - ɪ
æ - ə
ɪ - a
ɪ - uw
o - iy
uw - ey
a - iy
a - æ
ɛ - ay
ɛ - ə

---

[1]X item in A-B- X paradigm.

æ - a

a - ə

ɪ - iy

o - ay

æ - o

ε - ey

o - a

ə - ey

æ - uw

ey - a

iy - ə

ε - æ

o - uw

ey - ɪ

ay - ə

æ - ey

ɪ - ε

ay - ey

uw - iy

ε - uw

ɪ - o

ε - a

ə - ay

æ - iy

ε - o

ə - uw

ε - iy

Series 4

ey - ɪ

o - ɪ

æ - a

iy - a

ə - iy

iy - ε

ə - uw

ə - a

ay - uw

ɪ - iy

ay - ey

ey - uw

ɪ - ay

uw - æ

ɪ - ε

ey - iy

o - ə

æ - ε

ε - a

ey - æ

iy - o

ə - ay

uw - o

iy - ay

ey - ε

ɪ - a

iy - uw

a - ay

uw - ɪ

æ - a

ey - o

ay - ε

ay - o

a - ey

æ - ɪ

a - uw

æ - o

iy - æ

o - ε

ə - æ

ə - ɪ

ey - ə

uw - ε

a - o

ε - ə

Test Series for Consonant Discrimination Task

Pre-Test

p - ǰ
m - f
b - z
š - w
v - y

Series 1

p - b
s - z
t - k
n - m
f - h
v - θ
r - w
l - y
θ - t
t - d
k - p
m - ŋ
s - f
k - g
š - s
d - ð
w - l
f - v
θ - s
g - b
č - ǰ
n - ŋ
r - y
ð - θ
b - d
f - θ
p - t
r - l
č - š
g - d
v - ð
š - θ
w - y
t - č
h - θ

Series 2

f - s
k - g
z - s
d - t
b - g
θ - s
m - n
b - p
t - p
s - š
y - w
l - r
k - t
ŋ - m
θ - h
v - ð
č - t
θ - t
l - w
ǰ - č
h - f
v - θ
š - č
d - g
w - r
y - l
p - k
ð - d
v - f
n - ŋ
θ - ð
y - r
θ - š
d - b
f - θ

Series 3

θ - h
y - w
ð - v
š - č
t - p
b - d
y - r
ǰ - č
s - θ
l - w
s - š
s - f
p - k
t - θ
w - r
h - f
k - t
b - p
θ - f
ŋ - n
b - g
f - v
ð - d
g - k
m - ŋ
t - d
t - č
š - θ
d - g
r - l
s - z
n - m
θ - r
y - l
θ - ð

Series 4

s - ś
d - ð
f - s
w - l
ŋ - m
v - f
d - t
g - k
ŋ - n
h - θ
p - b
m - n
p - t
r - y
č - t
z - s
l - y
f - h
w - y
l - r
θ - f
g - b
t - k
d - b
θ - š
θ - v
g - d
ð - v
r - w
t - θ
č - ǰ
s - θ
k - p
ð - θ

Test Series for Vowel Word Discrimination Task

Pre-Test

beet - bat
bot - bite
bit - bet
bait - boat
boot - but

Series 1

beet - bit
pull - pool
bite - bit
bet - bait
bait - boat
bet - but
bite - bat
boat - boot
but - bite
beet - bot
bot - but
boot - bit
boot - bet
bot - boat
bat - boot
boat - but
bet - bite
bait - bat
but - bit
bit - bait
cot - caught
beet - boat
bait - beet
bat - bit
boot - bait
bot - bat
bet - beet
boat - bit
bat - but
bait - bite
bet - bat
beet - bait
bet - bit
beet - boot
boat - bite
but - boot
bot - bit
boat - bet
bite - bot
beet - but
boot - bite
bait - bot
boot - bot
beet - bat
bait - but
bot - bet
boat - bat

Series 2

bat - bot
bit - bat
boat - beet
bait - bit
bet - bite
boot - bat
bet - boot
bit - boot
bot - beet
boot - boat
but - bet
bait - bet
pool - pull
bit - boat
bite - bait
beet - bait
bait - boot
boot - but
bet - boat
but - beet
bot - bait
bat - beet
bet - bot
bat - boat
bit - beet
bit - bite
bat - bite
but - bot
bot - boat
boat - but
bat - bait
bit - but
caught - cot
boat - bait
bite - but
beet - bait
bait - boot
beet - bet
but - bait
bot - boot
bite - boot

bot - bite
bit - bot
bite - boat
bit - bet
bat - bet
but - bat

Series 3

boat - bit
bat - but
bat - bet
boot - beet
boat - bet
boot - bot
bot - bat
but - bit
bit - boot
bait - bet
bit - bet
bat - beet
bait - but
boat - bat
bite - bit
bat - bite
bet - boot
bait - bit

beet - bet
bait - bite
bait - beet
boat - bite
boot - but
bit - bot
bite - bot
but - beet
bait - bot
bite - boot
bet - bot
boot - bait
beet - bit
bat - bit
pull - pool
boat - bait
bait - beet
bet - but
boat - boot
beet - bot
boat - bot
but - boat
bait - bat
cot - caught
boat - beet

bite - bet
bat - boot
but - bot
bite - but

Series 4

bot - beet
bot - but
boot - bet
but - boat
bit - bait
bait - boot
bat - bot
bet - beet
but - bat
bait - beet
but - boot
beet - but
but - bait
bot - bet
bat - boat
bit - bat
beet - bait
caught - cot
bat - bait
boot - bat

but - bite
bet - bait
bit - bite
pool - pull
bit - beet
beet - bat
bot - boot
boot - bite
bet - boat
bot - bit
beet - boot
bet - bit
bit - boat
bait - boat
but - bet
bite - bat
boot - bit
boat - bot
bite - bet
bit - but
bet - bat
bite - boat
bot - bite
bot - bait
boot - boat
bite - bait
beet - boat

Test Series for Consonant Word Discrimination Task

Pre-Test

pit - led
sin - that
red - hat
vat - bit
done - gap

Series 1

pit - bit
fat - vat
jest - chest
tin - pin
gun - bun
vat - that
thick - vic
thin - sin
rim - ring
wed - led
yet - let
shin - chin
tin - thin
rung - young
red - led
sin - sing
nap - map
tin - sin
thigh - high
fin - thin
tin - kin
gun - done
thy - thigh
dip - tip
sip - zip
tin - pin
bun - done
fat - hat
shin - sin
thin - shin
wed - red
yet - wet
chin - tin
die - thy
cap - gap

Series 2

vat - fat
pin - tin
that - vat
sin - thin
let - yet
young - rung
sing - sin
sin - fin
kin - tin
thigh - thy
zip - sip
pin - tin
gap - cap
tin - chin
red - wed
sin - shin
done - bun
tip - dip
thy - die
hat - fat
bit - pit
chest - jest
bun - gun
wet - yet
shin - thin
done - gun
thin - fin
vic - thick
ring - rim
high - thigh
nap - map
led - red
thin - tin
led - wed
chin - shin

Series 3

thy - die
yet - wet
thin - shin
fat - hat
done - bun
sip - zip
thy - thigh
tin - kin
high - thigh
bit - pit
tin - pin
wed - led
gap - cap
map - nap
rung - young
yet - let
thick - vic

gun - bun
fat - vat
jest - chest
tin - chin
red - wed
shin - sin
that - vat
thin - sin
tin - pin
dip - tip
fin - sin
ring - rim
shin - chin
led - red
done - gun
thin - fin
sin - sing
tin - thin

Series 4

bun - done
pin - tin
tip - dip
kin - tin
map - nap
chin - shin

vat - that
die - thy
vat - fat
let - yet
gun - done
thigh - thy
zip - sip
cap - gap
wed - red
chest - jest
rim - ring
thin - tin
fin - thin
hat - fat
thigh - high
sin - thin
red - led
vic - thick
pin - tin
led - wed
young - rung
sing - sin
sin - fin
chin - tin
pit - bit

sin - shin
wet - yet
shin - thin
bun - gun

Test Series for Vowel Production Task

Pre-Test	*Series 1*	*Series 2*	*Series 3*	*Series 4*
ɪ	o	ɪ	ay	æ
æ	ay	æ	ɔ	o
ay	uw	u	ɪ	iy
ɛ	ɔ	ɔ	iy	uw
o	æ	o	u	a
	ɪ	ə	ə	ay
	ɛ	ay	a	ɔ
	iy	iy	ɛ	ɪ
	a	a	ey	u
	u	ey	æ	ə
	ey	uw	uw	ey
	ə	ɛ	o	ɛ

Test Series for Consonant Production Task

Pre-Test	*Series 1*	*Series 2*	*Series 3*	*Series 4*
p	p	ð	θ	ǰ
f	k	č	y	y
m	ð	h	p	θ
y	č	b	g	b
š	w	z	ð	h
	h	ǰ	m	ð
	ŋ	f	ŋ	p
	s	l	b	č
	b	š	ǰ	w
	t	p	l	s
	v	w	n	z
	θ	ŋ	k	f
	z	t	s	l
	r	s	w	g
	y	v	d	v
	m	r	h	t
	d	m	z	ŋ
	ǰ	g	f	k
	f	k	š	š
	n	θ	t	p
	l	y	č	n
	š	d	v	r
	g	n	r	m

Test Series for Vowel Word Production Task

Pre-Test	*Series 1*	*Series 2*	*Series 3*	*Series 4*
bat	bit	boot	beet	bought
bite	bite	put	bet	put
bit	boot	but	but	boot
boat	beet	bit	bot	bat
but	put	bot	bit	but
	bet	bought	bat	beet
	but	bait	boat	bite
	bat	bite	boot	bet
	bot	bet	bait	bot
	boat	beet	put	bit
	bought	bat	bite	boat
	bait	boot	bought	bait

Test Series for Consonant Word Production Task

Pre-Test	*Series 1*	*Series 2*	*Series 3*	*Series 4*
bit	bit	thin	cap	jest
sin	cap	Vic	jest	tin
led	thy	jest	wed	shin
vat	jest	chin	map	pin
gun	hat	done	gap	gun
	wed	tin	vat	young
	shin	high	thigh	sin
	map	let	yet	nap
	pit	shin	fin	wet
	gap	bun	tip	sing
	chest	fat	red	zip
	vat	pin	led	fat
	dip	that	dip	let
	thigh	zip	chest	done
	sip	gun	pit	Vic
	led	rim	shin	thin
	yet	sing	hat	chin
	ring	young	thy	high
	zip	kin	bit	bun
	fin	wet	sin	that
	red	sin	zip	rim
	tip	rung	ring	kin
	sin	nap	sip	rung

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