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ABSTRACT

This is an investigation of the phonological units used by preschool children. Twenty-four English-speaking children aged 4:0 to 5:0 were given three experimental tasks which investigated their ability to segment initial consonant clusters into phoneme-length units: (1) in a segmentation task they gave the first sound of initial cluster words: (2) in a grouping task they made initial cluster words a separate category or a subset of a larger category of words beginning with the same sound: and (3) in a symbolization task they used colored blocks to represent the sounds in initial clusters. The children were aware that words are composed of smaller segments and treated the segments as discrete units before they could identify the number of segments in a word. Data support the hypothesis that children treat clusters as units before they segment clusters into component singletons. The ability to treat the cluster as composed of two parts and to relate these parts to singleton sounds correlated with the children's prereading knowledge. (Author)

DO CHILDREN TREAT CLUSTERS AS ONE UNIT OR TWO?[1]

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ABSTRACT. This is an investigation of the phonological units used by pre-school children. Twenty-four English-speaking children aged 4;0 to 5;0 were given three experimental tasks which investigated their ability to segment initial consonant clusters into phoneme-length units: in a segmentation task they gave the first sound of initial cluster words; in a grouping task they made initial cluster words a separate category or a subset of a larger category of words beginning with the same sound; and in a symbolization task they used colored blocks to represent the sounds in initial clusters. The children were aware that words are composed of smaller segments and treated the segments as discrete units before they could identify the number of segments in a word. Our data support the hypothesis that children treat clusters as units before they segment clusters into component singletons. The ability to treat the cluster as composed of two parts and to relate these parts to singleton sounds correlated with the children's pre-reading knowledge.

1.0 Introduction

Segmentation is one of the fundamental issues in phonological analysis. How does one decide which stretches of sound constitute single phonemes or sequences of phonemes in a particular language and in general? Typically the identification of appropriate phoneme-length segments is clear for most of the phonological system of a language. However, segmentation problems do arise at some point in the system and one problem is that of deciding whether certain stretches of sound constitute one phoneme or two (e.g. with consonant clusters or diphthongs). In the structuralist period almost every major phonological theorist struggled with this problem in general terms (e.g. Trubetskoy 1969; Martinet 1939). Although generative phonology has not dealt with the question of segmentation to any great extent, taking for granted earlier solutions, segmentation has recently re-emerged as a problem in the

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description of adult language (St. Clair 1973; Bell & Hooper 1978).

In spite of the phonological theorist's general interest in the status of consonant clusters as single units or sequences of smaller units, most studies of children have not focussed on this issue. That is the purpose of this study. Developmental descriptions of children's phonology have used the units derived from descriptions of the adult system; thus, traditional units such as phonemes have been presumed to be the underlying structural components of the child's system also. Since, in traditional phonological grammars, clusters are treated as sequences of phonemes, most child phonology studies have likewise treated clusters as made up of two segments.

Nevertheless, the question of the appropriate units for describing children's phonology has been raised when the child data do not fit easily into a segmental descriptive framework. This has been especially true with data from children around two years of age (Moskowitz 1973; Macken 1979) and can be interpreted as part of a general view that children begin with grosser units and gradually break them down into finer units (see, for example, Menyuk 1974).

Children's spontaneous speech production has been the main source of evidence for their phonological segmentations. Studies have described the major stages and processes which affect cluster acquisition (Smith 1973; Greenlee 1974; Vihman in press). In terms of productive control of the sound system, clusters are typically mastered later than most singleton segments, usually considerably after the component segments appear in isolation (e.g. Templin 1957; Hawkins 1973).

There are two common processes by which clusters are simplified prior to their mastery. One process deletes one consonant in a two consonant cluster, e.g. sweet is pronounced as [wit]. The other commom process is substitution; either one of the two consonants is replaced by a different segment, e.g. truck is produced a [tlʌk], or both consonants are replaced by a different segment, e.g. sweet is pronounced as [fit]. The substitution process includes the special case of conflation where features from each of the components of a cluster are combined into a single segment, e.g. /sw/ is produced as /f/. Two other processes are used only rarely: epenthesis, e.g. truck is produced as [tərʌk]; and metathesis, e.g. snow is produced as [nos].

Both the deletion and the substitution of one of the segments of a cluster are usually taken as evidence that the child has analyzed the cluster as two sequential separable phonemes. However, the deletion process does not give conclusive evidence for this analysis. Young children typically fail to produce all the features of many adult phonemes, phonemes which are nevertheless uniformly treated as single units by phonologists. For example, recent work (Macken and Barton 1980) has shown that at one stage in which English-speaking children produce both voiced and voiceless stop phonemes as voiceless and unaspirated, the children are in fact maintaining the phonological contrast. They do this not by means of aspiration as an adult would do, but rather by producing the voiceless stop phoneme with a slightly longer voice onset time than that used for the voiced stop. We can view the aspiration as being a component of the segment which is deleted. Similarly, the deletion of one member of a consonant cluster could simply be evidence for a phonologically unitary cluster being analyzed phonetically into components.

There have been experimental studies using acoustic analysis which supports the argument that clusters may be regarded as units with complex feature specifications(e.g. onset + particular release features) only some of which the child may recognize or be able to produce (Menyuk and Klatt 1968; Kornfield 1971; Menyuk 1971). Spectrographic techniques were used in these studies to investigate cluster production in children aged 1;6 to 2;6. The analyses of the spectrograms revealed temporal and spectral differences between stop phones produced for initial clusters and the same stops produced as the initial sound of a non-cluster word. Menyuk has used this evidence to support the position that at first clusters are lexically represented as units.

The conflation process also suggests that the elements of the cluster are being treated as one unit. When children produce a conflated segment for a cluster, this segment differs from the phones produced by the child for either of the component consonants in isolation. However, the conflation process has also been described within a system which treats clusters as two separable phonemes (Smith 1973).

The processes of epenthesis and metathesis provide the strongest evidence that clusters are not treated as single units, but these processes are used infrequently by children. If the difficulty that children have with clusters is only articulatory, then metathesis and epenthesis (which serve to break up the cluster) should be more common. If, on the other hand, the problem at least partially stems from the unitary property of the cluster, the rarity of metathesis is a function of the non-separability of the cluster into components.

In contrast to children, adults frequently metathesize individual consonants in clusters (Fromkin 1971) and epenthesis is frequently used to break up clusters in foreign words when they are borrowed into languages which prohibit initial clusters (Greenlee 1975). Although Fromkin's data show that adults produce slips-of-the-tongue in which features (as opposed to segments) are changed or transposed, her data show no cases in which adults conflate features from contiguous consonants. Thus, the data from adults demonstrate that clusters are organizes as sequences of phoneme-length segments. The processes by which adults simplify clusters differ in both number and kind from those used by children.

The hypothesis that children organize clusters as single units is supported to some extent by the data from children's productions. However, since that evidence is inconclusive the question of how children segment clusters, as one unit or as two separable units, can only be studied in a context where children are required to show that they have made one of the alternative analyses. If there is a developmental change from one analysis to another, we assume that treating clusters as separable units is the more mature analysis.

In the experimental tasks to be described we investigated the phonological organization of two initial clusters of English, /sw/ and /tr/, in children aged 4;0 to 5;0. /sw/ is one of the class of /s/ plus consonant initial clusters. It is typically one of the later clusters to be mastered by children, at around four to five years, and it is sometimes preceded by a conflation stage where it is realized as /f/. /tr/ is a member of the other class of initial clusters in English, stop plus liquid clusters. This cluster is typically one of the earlier clusters to be mastered, at around three to four years, and mastery is also sometimes preceded by a conflation stage. The adult /t/ in /tr/ clusters differs from initial singleton /t/ in its fricative off-glide, being phonetically between /t/ and /tʃ/. Phonetically /tr/ could be regarded as an affricate, at least in some dialects of English (Jones 1964, p 165), but phonological studies normally treat it as a cluster (see survey by Abel 1962). The early conflation strategies used by some children suggest that these two clusters have an acoustically-motivated susceptibility to categorization as phonemic single units.

If the experiments show that children aged 4;0 to 5;0 phonemicize these clusters as units, they will do so after having mastered the sequence of articulatory components; thus, the case for clusters-as-units would be fairly compelling. Since /tr/ is expected to have been articulatorily mastered long before /sw/, it could be that only the latter cluster would be treated as a unit by the child--a finding which would suggest that the categorization of clusters as units is either a temporary stage in development or a phonemenon associated with particular clusters and not with others. The evidence for the alternative hypothesis--that clusters are sequences of phonemes--is based mainly on the high frequency of the deletion process; weak support comes from the cases of metathesis and epenthesis.

It is important to investigate the phonological organization of clusters by children before they have had any formal reading instruction. English orthography presents the reader with an analysis of clusters as two separable phonemes each of which is identical to a singleton segment. The hypothesis that children analyze clusters as one unit thus must be restricted to pre-literate children.

We investigate these hypotheses by giving children three segmentation tasks in which the cluster could be treated as a unit or as separable phonemes. These are wide disparities in the level of children's segmentation abilities reported in different experimental studies. These studies have been reviewed and discussed elsewhere (e.g. Clark 1978; Read 1978; Ehri 1979) and much of the variation can be explained in terms of the specific tasks which the children had to perform. However, very few studies have shown that four year olds can segment sounds in words. Thus, we based the design of two of our tasks on methods which have proved successful in eliciting children's segmentation skills (Zhurova 1964; Read 1975). Our third task required that the children use skills similar to those used in spelling.

All of the tasks required that the children be able to segment initial singleton consonants from words. Provided that we can assess this ability we can then investigate whether the children treat an initial cluster word as a word beginning with a singleton sound or as a word beginning with a cluster unit.

The tasks were given to the children in a fixed order so that in the second and third tasks the children would build upon the cumulative experience. The first task was a segmentation task based on Zhurova (1964). She found that Russian-speaking children aged four to five years could usually say the initial segment of a word in isolation after some training. The second task was a grouping task based on Read (1975). He found that children aged four to five years could group together words beginning with the same sound and he investigated whether children classified /tr/-initial words with /t/-initial words with /tʃ/-initial words or whether they formed a separate category. In the third task, a symbolization task, the children used colored blocks to represent the first sound(s) in words. This task required that the children ble to isolate the first segment of words (as in the segmentation task) also to match similar sounds (as in the grouping task). We assumed that task would be a difficult one for our subjects so it was important that e given prior experience with segmenting sounds and grouping sounds.

There was a theoretical as well as a methodological reason for including different but related experiments within this study. Children's analysis usters may well be influenced by the specific demands of the various s. We investigated this possibility by comparing the children's treatment lusters within and across all the tasks. We also assessed the children's ductions of the initial clusters and their general development and reading ills.

2.0 Subjects

The subjects were 24 children (13 boys and 11 girls) aged 4;0 to 5;0, with a mean age of 4;6.24. They were all monolingual, normally developing children who had had no formal instruction in reading. All the children were attending a nursery school which primarily serves the families of university faculty, staff and students.

In order to be able to compare performance on singletons and clusters within a task and also to compare across tasks, we established the following criterion for accepting children as subjects: we only accepted children who could carry out the segmentation task and the grouping task with singleton consonants, or who could be taught to carry out these tasks within the session. As a result of this limitation four potential subjects within the age range who either could not do the segmentation task or could not do the grouping task were dropped from the study. One further child who would not return to the second experimental session was also dropped.

3.0 Sessions

The children were tested individually in an experimental room at the nursery school. They sat beside an experimenter at a small table to carry out the tasks. An observer took notes and operated the recording equipment. All sessions were tape-recorded and the symbolization sessions were also video-taped.

The testing normally consisted of a series of seven fifteen-minute sessions, which were completed within four weeks. The first session was used to familiarize the children with the materials and to collect speech production data. The segmentation task was carried out during the second session and the grouping task during the third session. The remaining four sessions were devoted to the symbolization task which was carried out with four different sets of words. Data on reading knowledge and development were collected during the sessions.

For the sake of clarity in this paper, the rationale, procedures and results for each of the three tasks will be presented separately. The introductory session will be described first. Then the three experimental tasks will be described in the order in which they were given. Next the developmental measures will be described and finally the results across all the tasks will be discussed.

4.0 Production

The aims of this initial session were, first, to familiarize the child both with the experimental situation and with the test words to be used in the symbolization task and, second, to collect production data in order to be able to evaluate the effect of production deviations on performance. Given the vagaries of using real English words, we were forced to include in the word-sets for the symbolization task some words which would not be known previously by the children (cf. Barton 1978). Introducing these words and allowing the children to practice them in the first session helped ensure that all the words would be known before the children were required to use them in the experimental sessions.

The experimenter told the child simple stories involving all the words to be used in the symbolization task (see Table 1). Each word was illustrated on a card which the experimenter asked the child to name at the appropriate point in the story. The cards were laid out in front of the child and at the end of each story recall of all words was tested. The children's recall of words and details of any production deviation were also recorded on the other sessions.

array word	feet wheat seat tweet	feed weed seed freed	chick Rick tick prick	chip rip tip flip
target word	swede	sweet	trick	trip

Table 1. The words introduced in the first session and used in the symbolization task.

Analysis of the children's production data showed that all except two children had components of both segments on all the clusters studied. The exceptions were two children who pronounced /sw/ as [f] or [fw]. The other relevant production deviation was that three children regularly pronounced /tr/ as [tʃr]. Some of the effects of these two production deviations are mentioned in the discussion of results of the experimental tasks; however, a complete analysis of these effects will not be undertaken in this paper.

5.0 The Segmentation Experiment

5.1 Purpose

The primary goal of the segmentation experiment was to analyze the children's segmentations of the first sound in a word beginning with a cluster. The question to be answered was: do the children give the first singleton sound of a cluster when asked for the first sound in a cluster word or do they instead give the entire cluster as the first sound?

To this end the children were taught when necessary, to give the first singleton sound of a cluster when asked for the first sound of words beginning with singleton sounds and then they were tested on words beginning with clusters. The data on singleton sounds serve to replicate Zhurova's (1964) results.

5.2 Method

The children were presented with illustrations of words one at a time. Some of these were words which had been introduced in the story while others were words which were very likely to be known (e.g. mouse, bear, swing, train). The children were first asked to name the word and then to give the first sound in the word. There were 3 sets of words: the first set presented had continuants as first sounds, the second set had singleton stops as the first sounds. The third set consisted of words beginning with /tʃ/, /tr/ and /sw/. Within each set, words were presented in a random order.

If a child could not spontaneously give the first sound of a word beginning with a singleton consonant he or she was taught to do so during the presentation of the first two sets of words. Teaching procedures similar to those described in Zhurova (1964) were used in the order in which they are presented below. The word mouse is used as an example.

1) The experimenter lengthened the first sound when pronouncing the word, e.g. [m:aus], and again asked the child to segment the first sound, or the experimenter asked the child to repeat the word with the lengthened first sound, e.g. [m:aus] and again asked the child to segment the first sound.
2) The experimenter said the first sound of the word in isolation twice and then said the word, e.g. [m̩ m̩ maus] and then asked the child to repeat just the first sound.
3) The experimenter told the child what the first sound of the word was e.g. [m̩] and asked the child to repeat the sound.

Teaching or correcting was only done when necessary and only during the presentation of the first two sets of words. During the presentation of the third set of words, those beginning with /tʃ/, /tr/ and /sw/, no teaching was done and no examples of segmentations of the clusters or the affricate were provided by the experimenter.

5.3

The instruction given during the first two sets of words beginning with singleton consonants was successful. In fact, five children needed no examples or correction at all. Four children spontaneously gave the first letter of the word instead of the first sound but when they were again asked for the first sound rather than the letter name they could give the sound. Eight children needed only one example from the experimenter and could segment all the subsequent words correctly. Seven children needed more than one example: four needed two examples, one needed three, one needed four, and one needed two examples on the segmentation of continuants and three more examples on the segmentation of stops.

Because most of the children needed so little instruction on segmenting initial continuants and stops there were enough spontaneous responses to analyze. /tʃ/ was segmented as a unit and thus will be analyzed along with the other singleton consonants. These results will be presented next and the results of the children's segmentations of the first sound in the /tr/ and /sw/ cluster words will be presented separately.

In general, the children's segmentation of the continuants, the stops and the affricate /tʃ/ were phonetically accurate or reflected the same deviations as were exhibited in their pronunciations. The data presented in Table 2 consist only of the children's spontaneous segmentations of the singleton consonants; imitations of a model provided by the experimenter are excluded. If the children gave more than one segmentation of a word, the last segmentation was chosen as their response. We have presented the results for the singleton consonants at this level of detail in order to document the phonetic forms of the children's spontaneous segmentations.

	syllabic consonant	consonant + schwa	consonant + following vowel	consonant + other verb
words with initial continuants	55.8%	40.0%	4.2%	0
words with initial stops	-	82.7%	15.0%	2.3%
words with initial affricates	24.2%	50.5%	20.0%	5.3%

Table 2. Segmentation experiment: the segmentation of initial singleton consonants broken down by phonetic form.

The vowels were realized as voiced or voiceless. The two voiced stops were more often followed by a voiced vowel (84.1%) than were the four voiceless stops (28.1%). The use of a voiced or voiceless vowel in the segmentation of a continuant or the affricate /tʃ/ appeared to be unsystematic. For example, several children used both voiced and voiceless vowels and if they gave more than one segmentation of the first sound in a word they would alternate between the two.

Similarly, the choice of using a syllabic consonant or a consonant plus a vowel in the segmentation of the continuants and the affricate /tʃ/ appeared to be unsystematic. In parallel with the voicing of the vowel described above, if the children gave more than one segmentation of the first sound in a word often they would alternate between different forms, sometimes giving a syllabic consonant and at other times a consonant plus a vowel.

These results show that all of the children could satisfactorily segment initial singleton consonants from the words presented to them. There were only a few segmentations of initial singleton consonants that were not phonetically accurate. These exceptions occured on some segmentations of the initial voiced stop /b/ and on some segmentations of the affricate /tʃ/. Two of the children each once gave an aspirated stop [pʰə] instead of [bə] as the first sound of a word with an initial voiced stop. Two children each once gave the first sound of a word beginning with /tʃ/ as [tʰə]; one child twice gave the voiced segment [dʒ] as the first sound of a word beginning with /tʃ/.

The results of the cluster segmentations show that there are two alternative response types. The children either segmented the first singleton sound of the word, e.g. [sə] for swing, or they gave the whole cluster, e.g. [swə] for swing. Within the results for the /tr/ cluster there is somewhat more complexity. The first singleton sound of the word was realized as [tʃə] equally as often as it was realized as [tʰə] and the cluster sound of the word was realized both as [tʃɽ̩] and as [tɽ̩].

As in their segmentations of singleton consonants the children's segmentations of the first sound in cluster words occured in the form of syllabic consonants, e.g. [s̩], or in the form of a consonant or cluster plus a vowel, e.g. [sə] or [swə]. This variation in phonetic form appeared to be unsystematic.

The children's use of a singleton or a cluster segmentation was not random. Rather, the children tended to consistently respond with one or the other type of segmentation. The number of children who gave singleton segmentations or cluster segmentations for the two clusters is shown in Table 3.

	/sw/	/tr/
consistent singleton	8	9
mainly singleton (3 words out of 4)	5	1
equal singleton and cluster	4	3
mainly cluster (3 words out of 4)	0	1
consistent clusters	5	10
·er responses ·=[f] for /sw/)	2	—

Table 3. Segmentation task: the number of children giving singleton responses and cluster responses when segmentating word-initial /sw/ and /tr/ clusters.

We also found some consistency in the treatment of /sw/ and /tr/ clusters: 6 of the 8 children who gave consistent singleton responses for /sw/ also did so for /tr/. Similarly, four of the five children who gave consistent cluster responses for /sw/ also did so for /tr/. The question of consistency will be pursued further, when we compare the results of all the tasks, since only four instances of segmentations of each cluster were collected here and additional segmentations were collected in the symbolization task.

6.0 The Grouping Experiment

6.1 Purpose

In the main part of this experiment, the children were asked to group together words beginning with the same sound as a target cluster word. Our goal was to discover how children categorize initial clusters. Within the constraints of the task there are two main ways to categorize the clusters: the child could treat all words beginning with clusters of a given type as constituting a single category, or the child could treat these words as a subset of a larger category. We examined the membership of the categories which the children formed in order to infer the organizing principles they used.

The set of words to be matched to an initial /sw/ cluster word consisted of words beginning with /sw/, with /s/ and with /f/. If a child grouped /sw/ initial words alone or with /f/ initial words, a presumed conflation of the /sw/ unit, then we assumed that the child's categorizations were based on the analysis of /sw/ as a unit. If a child grouped /sw/ initial words with /s/ initial words, we assumed that the child's categorizations were based on an analysis of the /sw/ cluster into singleton sounds.

The set of words to be matched to an initial /tr/ cluster word consisted of words beginning with /tr/, with /tʃ/ and with /t/. In constructing these categorizations children who analyze the /tr/ cluster as a unit were presumed to group the /tr/-initial words alone. Grouping of /tr/-initial words with /tʃ/-initial or /t/-initial words was assumed to be based on an analysis of the /tr/ cluster as singleton sounds. We assumed that the groupings of /tr/ with /t/ rather than with /tʃ/ would be made by those children with more experience with English orthography (cf. Read 1975).

6.2 Method

In the grouping tasks the child named each card in an array of 12 cards and was then asked to pick out all of the pictured words beginning with the same sound as a newly introduced target word. Those words that the child judged to begin with the same sound as the target word were made into one stack of cards, while those that were no so judged were made into another stack of cards. After the child's spontaneous groupings were made the experimenter pointed to any word in the array that had not been classified and asked the child whether it began with the same sound as the target word. If the child's choices reflected inconsistent groupings (e.g. if a child grouped 4 /sw/ words with two /f/ words), the experimenter would recheck the groupings to determine whether or not the child would narrow his or her classification to, e.g., the /sw/ words alone.

In order to introduce the children to the problem of categorizing words on the basis of initial sounds we first asked the child to play the game with a set of words that all began with singleton sounds: the target word began with the singleton stop /k/, and the child had to pick out the four words beginning with /k/ from the array. If a child could not carry out the task with this /k/-initial set then he or she was dropped from the study. The set of words beginning with singletons was followed by the two experimental sets: in one the target word began with /sw/ and in the other the target word began with /tr/. The order of the two experimental tasks was randomized and so was the order in which the cards were presented.

6.3 Results

In our procedure we accepted both the children's spontaneous choices and their choices made when the experimenter rechecked the groupings, but we rejected any choices where there was any indication of experimenter influence in the child's choice. The results of the three grouping tasks will be presented first, then the results of the grouping of the /tr/ clusters will be compared with that of the /sw/ cluster.

	number of /k/-initial words chosen		
	4/k/	3/k/	2/k/
only /k/-initial words chosen	11	6	2
other singleton words added to classification	1	2	2

Table 4. Grouping experiment: grouping of singleton sounds; number of children in each category.

The results for /k/ are given in Table 4. Seventeen of the twenty-four children had relatively little difficulty grouping together those words beginning with /k/. These are the children who classified all, or all but one, of the /k/-initial words together and did not include any words beginning with other consonants in their grouping. The other seven children showed degrees of difficulty grouping singleton sounds but this difficulty was judged (as a result of responses to follow-up questions) to be not so extreme as to necessitate the exclusion of these children from the study.

The classifications of the children's responses in the two experimental tasks was complicated by the fact that some children were more inconsistent than others in their treatment of the clusters. For example, in the grouping task inconsistency is shown by the failure to treat all four /tr/ words or all four /tʃ/ or all four /t/ words in the same way. In classifying the responses we decided that if the child grouped a majority of one set of words in a consistent way, then the majority grouping was sufficient to establish the child's response-type. That is, if a child grouped three /tr/ words and one /tʃ/ word he or she was classified as a subject who grouped together only the words beginning with a /tr/ cluster.

In the following tables of results the cells contain the number of subjects who represent each response-type, taking account of the number of inconsistencies in the groupings they constructed. Returning to the example cited above, if a child grouped three /tr/ words with one /tʃ/ word he or she would be included in the response-type (columns) "/tr/alone" and would have a "-2" consistency rating (rows). [Note that this presentation of the results is modeled after Read (1975) to allow for an easy comparison of the data. The consistency rating of "-2" is computed according to the number of exceptions to a consistent "/tr/alone" grouping, i.e. 3/tr/ words instead of 4/tr/ words = -1; similarly the inclusion of one /tʃ/ word = -1.]

consistency	/tr/+/tʃ/	/tr/alone	/tr/+/t/	/tr/+/tʃ/+/t/
-0	3		2	4
-1	2	2		2
total	5	2	2	6
-2	1	2		2
$-\geq 3$	2			2
total	8	4	2	10

Table 5. Grouping experiment: /tr/ grouping results; number of children in each category.

The results for /tr/ are given in Table 5. What are the non-dominant response-types within each category? Of the four children who grouped /tr/ words with other /tr/ words all four included one affricate in their grouping. That is, none of our subjects were pure examples of this response-type. The ten children who grouped all the sets of words together generally chose all the /tr/ words and an approximately equal number of /tʃ/ words and /t/ words (e.g. three /tʃ/ and two /t/ words). Thus only four children classify /tr/ clusters predominately with other /tr/ clusters. Eight children judge /tr/ clusters to be similar to the affricate /tʃ/ and two judge them to be similar to the stop /t/. Almost half, that is, ten, of the children judge the /tr/ clusters to be similar to both the affricate and the stop. The results are similar to Read (1975) although they reflect a less mature population of subjects for two reasons: 1) our subjects constructed a higher percentage of inconsistent groupings in that they failed to treat all words beginning with the same sound as similar (e.g. failed to include all the /tr/ words in the /tr/ groupings) and 2) a higher percentage of our subjects chose members of both the /tʃ/ and /t/ initial words as having the same initial sound as /tr/ resulting in an undifferentiated response-type.

consistency	/sw/+/f/	/sw/alone	/sw/+/s/	/sw/+/f/+/s/
-0		1	11	
-1		1		2
total		2	11	2
-2		4		1
-≥3			2	2
total	0	6	13	5

Table 6. Grouping experiment: /sw/ grouping results; number of children in each category

The results for /sw/ are given in Table 6. What are the non-dominant response-types within each category? Of the six children who grouped /sw/ words with other /sw/ words three included one /s/-initial word in their grouping, and two included one or two /f/-initial words. The five children who grouped both /s/ words and /f/ words with /sw/ chose an approximately equal number of /s/ words and /f/ words in their grouping (e.g. 3/sw/+4/s/+3/f/ or 3/sw/+2/s/+1/f/). Thus we find that seven children out of the twenty-four do sometimes show that they judge /sw/ clusters to be similar to singleton /f/ but this is not a dominant response-type.

/sw/ Grouping Response Type	/tr/with/tʃ/	/tr/alone	/tr/with/t/	/tr/with/tʃ/&/t/
/sw/with/f/	0	0	0	0
/sw/alone	1	3	0	2
/sw/with/s/	7	1	2	2
/sw/with/f/&/s/	0	0	0	5

Table 7. Grouping experiment: comparison of /tr/ results and /sw/ results; number of children in each category.

We will now compare the children's grouping of /sw/ with their grouping of /tr/, as in Table 7. There are no significant differences between the children's treatment of the /sw/ and /tr/ clusters if we accept the hypothesis that grouping /sw/ clusters with /f/ indicates an analysis of the cluster as a unit.

If we compare the children's response-type across the two grouping tasks we find that three children only classified cluster words with other cluster words: this is the narrowest type of categorization. The construction of this type of category is presumed to be based on the analysis of the cluster unit as a single initial sound.

Nine children always grouped the clusters with a singleton set: seven grouped /s/-initial words with /sw/ words and /tʃ/-initial words with /tr/ words and two grouped /s/-initial words with /sw/ words and /t/ words with /tr/ words. Three other children grouped /sw/ with /s/ but grouped /tr/ clusters with both /tʃ/ and /t/. The construction of this type of category is presumed to be based on the analysis of the first sound of the cluster as a singleton.

Four children differed in the type of classification they constructed in the two tasks. Three categorized /sw/ uniquely but grouped /tr/ clusters with /tʃ/ or with both /tʃ/ and /t/. One child categorized /tr/ clusters uniquely but grouped /sw/ clusters with /s/. These results as well as the results of the segmentation experiment indicate that some children of this age do not maintain a stable analysis of the first sound in an initial cluster word. They may at one time treat the cluster as a unit and at another time they may segment it. The five children who grouped the /sw/ cluster with both /f/ and /s/ and the /tr/ cluster with both /tʃ/ and /t/ may also be described as children who fail to maintain a stable representation of the first sound in a cluster word. For the most part these five children are able to accept any relationship based on acoustic-articulatory similarity of the clusters to the singleton sounds.

7.0 The Symbolization Experiment

7.1 Purpose

In the symbolization task the children were shown how to use symbols to represent the first sounds of words beginning with singleton consonants. At the same time they were shown that these symbols could be combined to represent initial cluster sounds. After this introduction the children were asked to use symbols to represent the cluster in words beginning with initial /sw/ clusters and initial /tr/ clusters. The purpose of this experiment was to discover whether the children would use the symbols which represented the component singleton sounds of the cluster to represent the cluster or whether they would choose novel symbols to represent the cluster.

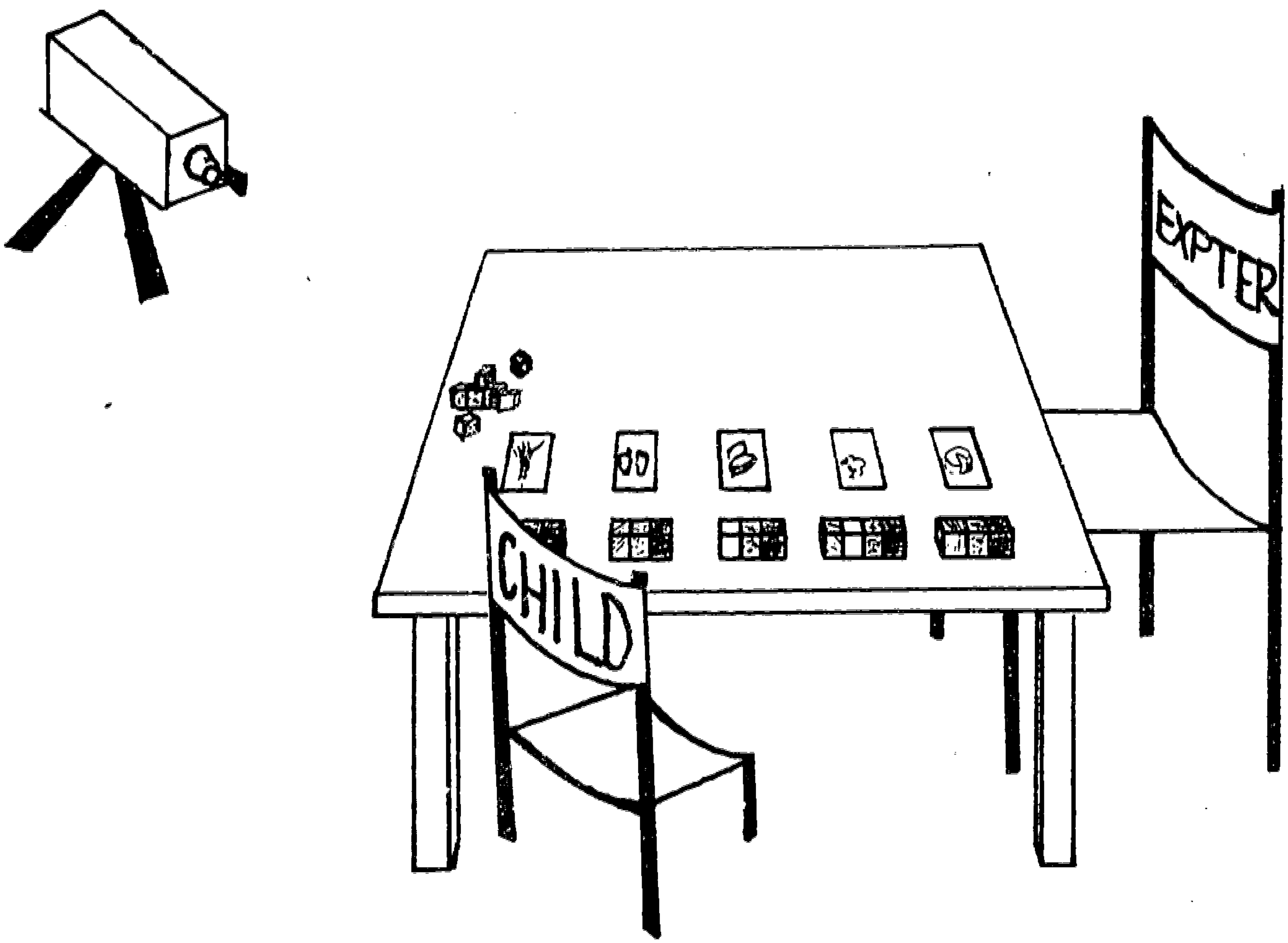
7.2 Method

The children were tested in four separate experimental sessions. In each we examined a different set of words. The words used in each session are listed in Table 1. Note the structure of the list of "array" words that precede each of the "target cluster" words. The sets of words were structured so that some of the first sounds in the array words could be used to form the target cluster. Furthermore, in every set of words except in the <u>trip</u> set one sound occurs both as a singleton and as a component of the cluster. In the <u>sweet</u> set, the first sound of <u>wheat</u>

was treated as being the same as the secoung sound of tweet. The experimenters pronounced wheat as [wit] in the sessions and none of the children spontaneously used [hw] in /w/-initial words. (Further, in the /tr/ sets, as in the rest of this study, /tʃ/ was treated as a singleton.) The order of presentation of the sets of words was randomized and so was the order of presentation of the words preceding the /sw/ or /tr/ cluster word.

In all the sessions the children used painted blocks as symbols to represent sounds in words. Each different sound was to be represented by a different color of block and each sound that was the same was to be represented by the same color of block. To demonstrate the method we will outline the procedure using as an example the set of words associated with the spelling of sweet. The experimental setting is illustrated in Figure 1.

Figure 1.
The Experimental Setting for the Symbolization Task



The experimenter had a pile of blocks to represent the common last part of all the words: /it/. /it/ was represented by two differently colored blocks that were glued together. The experimenter manipulated a puppet which, supposedly, could spell only the last parts of words. The child also had a puppet and was asked to help the experimenter's puppet to spell the first parts of words.

In each session the experimenter presented four words one at a time. These words formed the "array" and are referred to as the "array words." For each word the child was asked to name the card, e.g. wheat. The puppet then provided the blocks to represent the last part of the word /it/. The child was asked to say the first part of wheat, to say whether the first part was one or two sounds, and to choose a block or blocks to represent the first part. The child chose blocks from a pile of different colored blocks and in this case should have chosen one block to represent one sound /w/. The blocks chosen by the children to represent the first part of the array words will be referred to as the "array blocks."

After each of the second, third and fourth array words was presented the procedure included an additional question. The children were also asked to say if they could use any "old" blocks to make the first sound or if they needed "new" blocks. "Old" blocks were colors that had been chosen to represent the first part of the array words and these blocks had been given a fixed singleton sound to represent. "New" blocks were those which could represent sounds that had not occurred before in the array words. The children's choices of blocks were corrected for each word so that in the end the array consisted of e.g. wheat, seat and feet, each having one block to represent the first part and tweet having two. The second block of tweet would be the same color as the first block of wheat.

When the array words were completed the sounds for the array blocks were reviewed and the children were asked which word had two sounds in the first part and which words had the same sound in them (represented by the same color of block). These answers were the last to be corrected. During the rest of the session the children were free to construct the target cluster as they wished.

After the review of the array blocks, the "target" cluster word was presented to the children, in this example sweet. The experimenter-puppet spelled the last part and the children were asked to name the card, to say the first part of the word, to say whether the first part was one or two sounds and to represent the first part using old (array singleton) or new blocks. The children then chose either one or two, new or old, blocks depending on whether they had said that the first part was one or two sounds and whether they had said that the sound had occured before in the array sounds.

After the children had made a choice of blocks the experimenter asked what sounds the chosen blocks represented. There was then a set of questions to investigate the child's choice. The specific questions which were asked depended on whether the child had chosen old (array singleton) blocks or new blocks. If new blocks had been chosen the child was asked if any of them had the same sound as any of the array blocks. If yes, he or she was asked to "fix it." If old (array singleton) blocks had been chosen the experimenter compared the target word and the array word and asked the child if the repeated block represented the same sound in the target word as in the array word. If no, he or she was asked to "fix it." The children were not given any specific instructions on how to fix the blocks in the target word. These questions were intended to function as a reminder to the child that the same color block should represent the same sound and that different color blocks should represent different sounds.

Sometimes the children's representations of the target word caused it to be represented identically to an array word. For example, if the children chose the same color block to represent the first sound of sweet as for seat, then both sweet and seat would be represented as /s/ + /it/. In this situation the experimenter would ask if the repeated block represented the same sound in the target word as in the array word. If the children said, "yes," then they were asked if sweet and seat were the same word. The children usually agreed that they were not the same word. Then they were asked if they wanted to spell different words in the same way. These questions were asked to see if the child could spontaneously recognize that the first part of the target word had two sounds instead of one, and to see if the child could recognize the second component of the cluster. The session ended when the child was satisfied with the choice of blocks or could find no way to improve on it.

In the fourth and last symbolization session, where there was no chance of the experimenter influencing the child's spontaneous choices on later sessions, there were further instructions to the children: after the child had made a choice of blocks for the target word, the experimenter told the child that the first part of the target word consisted of two sounds and that both of these sounds had been used before and were in the array. The rationale underlying these further instructions was to discover if the children could relate the cluster to its singleton components when they were explicitly told to, even if they had not spontaneously done so.

7.3 Results

The children had become very familiar with the experimental setting by the time they reached the symbolization sessions and they regarded the task of teaching a puppet to spell with colored blocks as a plausible activity.

The first thing that the children were required to do was to represent the first sound(s) in the array words. The children's choices of blocks were guided by their answers to questions by the experimenter. The children's responses to each question will be discussed one by one.

7.3.1 Array segmentation results - responses to "What is the first part of the word?"

The children segmented the first part of the words beginning with singleton consonants correctly. The segmentation results which are of interest are those for the array cluster words.

When asked for the "first part" of the cluster words in the array the children gave 43.5% (40/92) singleton segmentations and 56.5% (52/92) cluster segmentations. There were no differences among the clusters as to the percentage of times the children segmented them as entire units or gave the first singleton sound. Furthermore, the children did not treat the question "What is the first part of the word?" as being different from the question "What is the first sound of the word?". There were no children who gave cluster segmentations when asked for the "first part" of the cluster words and gave singleton segmentations when asked for the "first sound" of the cluster words in the segmentation task .

The children were allowed to construct their representations of the array clusters before they were corrected. Not one of the children spontaneously constructed a representation which mapped both of the singleton components of the cluster. They represented the first part of the array cluster word as they had segmented it, i.e. they represented the first singleton sound alone or the entire cluster as a unit.

When the children were told that the "first part was two sounds" nine of the children who had given the first singleton segment in the cluster also added the second (16 out of 36 cases). One other child always gave the vowel in the cluster word. None of these children gave the second singleton in the /tw/ cluster.

Six children who segmented the entire cluster as a unit attempted to segment the cluster after they were told that the "first part was two sounds." Each did this just one time. Three of them gave the first singleton sound correctly, then gave the entire cluster as the second sound; e.g. [f], [frə]. The other three gave the entire cluster as the first sound and the second segment or the cluster as the second sound, e.g. [flə], [lɪ] for flip. The remaining children could not re-analyze their first segmentations. These children usually gave the entire cluster for both the first and second sounds, e.g. [flɪ], [flɪ] for flip.

After the construction of the array was complete the children were asked to recall all of the singleton sounds in the first part of the array words. Fifteen of the children learned to give both singleton sounds of at least one array cluster (43 out of 60 cases). However, five children never learned to give a component singleton sound for any of the cluster sounds and four children only learned one of the singleton sounds of the cluster and never both segments. If the children learned only one of the component singleton sounds of the clusters (24 cases) they were twice as likely to learn the first singleton sound as the second one (16 cases vs 8 cases).

7.3.2 Responses to "Is the first part one or two sounds?"

None of the children could systematically say whether the first part of the words consisted of one or two sounds. We compared the number of times that singletons and clusters were called one sound or two sounds and there were no differences between them. Even dividing the singleton sounds into stops, continuants and affricates and the cluster group into the specific clusters, there were still no differences; that is the children were equally likely to say that any of them were one sound as two sounds. These results hold irrespective of the way that the children segmented the first part of the cluster word, i.e. whether they treated it as one unit or as two units.

These results highlight the difficulty children have in quantifying linguistic units. We have found that the children in our study can segment units from the first position in words before they can count the number of phonemic-length sounds they have pronounced. That is, they are aware that words are composed of smaller segments and treat the segments as discrete units before they can identify how many segments are in a word.

7.3.3 Array repeated sound results - responses to the question "Do you need an 'old' (array) block or a 'new' block? Have we had that sound before?"

In three of the symbolization sets there was a repeated sound, a sound which appeared in the array words both as an initial singleton and as a component of the cluster. We were interested in whether the children could relate the singleton components of clusters to the same singletons in other environments, and, after the relationship had been pointed out to them, whether they could later identify which two words contained the same sound.

Overall the children correctly chose the previously used block for the repeated sound 35% of the time (25 out of 72 cases). If they did not choose the old block for the repeated sound, their choice was corrected. They were shown where the sound had occurred before in another word and were shown how to use the same color block to represent the same sound. When the array was complete they were asked which two words contained the same sound, the children were correct 65% of the time (41 out of 63 cases - there was judged to be experimenter influence in the remaining 9 cases).

There were two variables in this experimental situation which could affect their ability to relate the two identical sounds. The first variable was that the repeated sound could appear in the cluster as the first sound or as the second sound. In the set of words that included feed and freed the repeated sound /f/ was the first sound of the cluster. In the other two sets of words, those including wheat and tweet and Rick and prick, the repeated sounds /w/ and /r/ were the second sounds of the clusters. The second variable was that the array words were presented in random order and thus sometimes the children had to locate the repeated sound in a previously presented cluster and at other times they had to locate it in a previously presented singleton word.

We analyzed the data in terms of whether the repeated sound was the first or the second sound of the cluster and whether the singleton word or the cluster word was presented first.

Table 8 shows the numbers of times the children encountered the repeated sound as a singleton or as a component of a cluster and whether or not they recognized it as having occurred before.

Repeated sound was the first sound in the cluster	Did the children recognize the repeated sound situation?	
order of freed & feed:	YES	NO
singleton word before cluster word	4	28
cluster word before singleton word	9	7
Repeated sound was the second sound in the cluster	**Did the children recognize the repeated sound situation?**	
order of prick & Rick, tweet & wheat:	YES	NO
singleton word before cluster word	4	28
cluster word before singleton word	9	7

Table 8. Children's identification of the repeated sound in the array.

The children were more likley to choose the same sound for the repeated block when it was the first sound of the cluster as in freed than when it was the second sound, as in tweet and prick: with freed they chose the same sound 50% of the time (12 out of 24 cases) and with tweet and prick they chose it 27% of the time (13 out of 48 cases). The most diffucult situation for the children was when the singleton word came before the cluster word and the repeated sound was the second segment of the cluster. In this situation the children were successful only 4 out of 32 times. This difficulty is probably related to the fact that none of the children spontaneously gave the second segment of the cluster when they were asked for the first part of the word. There were no learning effects due to the order or presentation of the sets of words: that is, there were no differences between the children's ability to recognize or learn which were the repeated sounds from one session to another.

7.4 Symbolization of the /sw/ & /tr/ clusters

The children's construction of the array prepared them for their treatment of the target clusters, beginning with /sw/ and /tr/. Each of the issues discussed in the presentation of the array cluster related to a specific part of the symbolization of the target cluster: i.e. the segmentation of the first part of the cluster word; the judgement of whether the first part consisted of one or two sounds; and the judgement of whether any of the sounds in the first part had occurred before in another word, indicated by the choice of old blocks. In this section we will only deal with the overall results of the children's symbolizations of the /sw/ and /tr/ clusters. The results from individual children will be discussed in section 9.2.

When asked for the first part of swede and sweet the children gave 39% singleton [s] segmentations, 55% cluster [sw] segmentations and 6% [f] segmentations. The [f] segmentations are from two children, one of whom gave [f] for the first part of both swede and sweet.

When asked for the first part of trick and trip the children gave 43% singleton segmentations, [t] or [tʃ] and 57% cluster segmentations [tr] or [tʃr]. There are no significant differences between the type of segmentation given for the /sw/ and /tr/ words.

None of the children correctly judged the number of sounds in the first part of the cluster words. These results are identical to the results presented for the array words.

The children were able to relate the first sounds in the cluster words to the singleton sounds in the array. Many times, however, they chose new blocks to represent the first part of the cluster words. As described in the procedure section, the children chose old or new blocks and then were asked to say what sounds the blocks represented in the cluster word. The experimenter would then question the children further about their choices of symbols. As a result of the contradictions pointed out by these questions, the children sometimes changed their choices of blocks. At the end of the fourth symbolization session the children were told that the cluster word had two sounds in the first part and that these sounds could be found in the array. Many of the children were able to act on this information and changed their choice of blocks. The children's initial choice of blocks is compared with their "best" choice, i.e. the choice that the children were satisfied with after questioning, in Table 9.

	S	W	S+W	F	only new	other
1st	13	6	3	3	20	3
best	16	5	6	3	18	0

	T	CH	R	T+R	CH+R	only new	other
1st	8	11	5	0	0	23	1
best	3	16	4	5	3	16	1

Table 9. Children's choices of blocks.

In Table 9 we have not analyzed the left-to-right order in which the symbols were placed, since this was often influenced by the experimenter; thus we have counted R+T as the same as T+R. Where the children chose both an old symbol and a new symbol we have counted only the old symbol since in this analysis we are primarily concerned with indicating to which singleton sounds the children related the cluster sound.

There were a total of 56 changes made by the children. In Table 10 these are described as changes made in response to specific questions. Twenty-six of these changes occured on the fourth symbolization as the result of extra information offered to the children; fifteen changes consisted of adding an array block or replacing a new block with an array block and eleven consisted of adding a second block.

Source of change	Number of changes	Example
comparison with array	16	F replaced by new block
can any array blocks be chosen?	24	new block replaced by S
can two blocks be chosen?	13	R block added to CH
self-correction	3	new block replaced by T
Total number of changes	56	

Table 10. Changes in the children's choices of blocks analyzed in terms of the questions which elicited the changes.

8.0 Developmental measures

8.1 Purpose

A test of reading knowledge and a developmental measure were also administered during the sessions. These measures had two functions: they were used to give us some basis for comparing these children with other populations and they were used within the study to compare the children in terms of development. Since we hypothesized that knowledge of orthography might affect children's categorizations, it was important to know what the children's reading skills were. Although none of the children had had formal instruction in reading, we thought it likely that as middle-class children in a literate culture they would have some pre-reading skills.

8.2 Method

The children were questioned to determine the extent of their knowledge of letters and words. The abilities tested were those which show developmental changes in studies of comparable four-year-old children (Mason 1980). As her samples of children learned to identify and print letters they began to read by recognizing signs (such as traffic signs) and labels (such as on a milk carton). During their fourth year the children seemed to independently work out letter and sound relationships and they progressed to reading highly familiar nouns and pronouns, a few verbs and adjectives and simple three-letter words. Several four-year-olds in the sample who were learning to read at such a rapid rate that their parents could not estimate their reading vocabulary were also able to read unfamiliar multisyllabic words and words with abstract meanings.

Thus, in order to assess different levels of reading ability within our sample we asked the children to 1) identify upper-case letters; 2) identify lower case letters; 3) give the first letters of spoken words; 4) write their names; 5) write five letters; 6) read five contextually bound words; 7) read fifteen non-contextually bound words. The contextually bound words were pictured in photographs of common road-signs (such as stop sign) or commercial signs. The context independent words were printed on cards in lower case letters; the list contained familiar words which varied in length and reading difficulty but were all within the most common two hundred words in early reading materials (Dolch 1951).

The developmental measure used was the Goodenough-Harris Draw-a-person test. This test was chosen as an easily administered test that is not based directly on language skills. The test consists of asking the child to draw a person, and it is scored by rating attributes of the child's drawing. The procedure used was that given by Harris (1963) (except that we collected only one complete drawing from each child). It is not a test which can be used to measure development independently of other tests, but it is to be interpreted in conjunction with other measures.

8.3 Results

The children's ages, Draw-a-person scores and reading knowledge scores are given in Table 11. The children varied a great deal in their knowledge of letters and words. Nevertheless, our measure proved to be appropriate to their abilities in that all of the children could answer some parts of the test while none of them could complete it all. The child exhibiting the least knowledge named some upper-case letters and a few lower-case letters, did not write any letters, recognized one word in a sign but did not read any words presented out of context. The child exhibiting the most knowledge named all the upper and lower case letters, wrote the letters, recognized all the words which were presented in a pictured context and read 9 out of the 15 words which were presented in isolation.

CHILD NUMBER	AGE	DRAW-A-PERSON	READING KNOWLEDGE
1	4;8.23	4	10
2	5;0.0	12	25
3	4;11.25	18	35
4	4;11.0	18	37
5	4;11.4	25	61
6	4;10.11	21	42
7	4;9.13	16	24
8	4;4.14	14	41
9	4;10.9	22	48
10	4;9.28	13	47
11	4;9.20	15	40
12	4;2.18	17	47
13	4;1.27	14	18
14	4;5.26	18	31
15	4;7.18	15	64
16	4;5.28	18	30
17	4;2.16	11	34
18	4;0.10	0	21
19	4;8.9	9	58
20	4;4.21	13	32
21	4;0.22	17	37
22	4;0.17	9	24
23	4;3.6	12	39
24	4;11.6	12	46

Table 11. Children's ages, draw-a-person scores and reading knowledge scores.

The other children's abilities ranged between these two extremes. Sixteen of the twenty-four children did not read any of the words which were presented in isolation. They varied in their abilities to identify and print upper-case letters and had difficulty in identifying lower-case letters and the words pictured in common signs. The eight children with the highest scores could recognize most of the words in signs and could read some of the words presented in isolation. Five of these children read, at most, four of the fifteen isolated words, one child read six of them and two children read nine words. Thus, overall, the children in the study were at the beginning stages of learning to read. In these abilities our sample of four-year-olds is comparable to other samples from the same background (Mason 1980).

We scored each of the questions and added them to give each child an overall score of reading knowledge. We have used this score to investigate the relationship of reading knowledge and segmentation abilities in section 9.3.

The drawings from the Draw-a-person test were scored by an experienced practitioner. The raw scores had a mean of 14.2 and a standard deviation of 5.4. The raw scores were converted to standard scores using the figures given by Harris (1963). The mean standard score for our sample was 100.3. Thus, these scores fall very close to the standard scores when compared with Harris's data. (However, Harris notes that, unlike the higher ages, his figures for children under five years are not to be taken as representative but are likely to be higher than the norm.) The relationship of the Draw-a-person scores to the children's segmentation abilities is discussed in section 9.3.

9.0 Comparison of the three tasks

Having analyzed the individual tasks, we now turn to investigating whether the children act consistently across the tasks: were they acting from a consistent representation or were the specific demands of each task more important in affecting the treatment of clusters? From this synchronic study we are also interested in the possibility of hypothesizing developmental changes in the treatment of clusters. The most plausible hypothesis, one which emerges from the studies of the phonologies of younger children discussed earlier, is that of a developmental change towards progressively finer units. Here, the hypothesis is that children first treat clusters as indivisible units and them later learn to break them down into separate segments which they relate to singleton segments. To investigate this, we correlate their abilities on these tasks with age, development and knowledge of reading. In any developmental change we would also want to know if different clusters are treated differently, that is whether certain clusters are broken down before others.

9.1 The segmentation continuum

There were three situations in which the children gave segmentations of the words beginning with clusters: in the segmentation task they gave the first sounds of the four /sw/ words and the four /tr/ words; in the symbolization task they gave the first sounds of two /sw/ words, two /tr/ words and four other cluster words; then after they had chosen the blocks for the target clusters in the symbolization tasks, they gave the sounds of the blocks representing the cluster. Twenty-one of the children acted consistently in each of these situations: either they gave the first singleton sound of the cluster, or they gave the entire cluster, or they gave mixed singleton and cluster segmentations.

There were only three children who gave a different type of segmentation in different tasks. In all three cases the distinction was that the clusters in the segmentation task were treated differently than the clusters in the symbolization task. Two children gave mainly singleton segmentations in the segmentation task but all cluster segmentations throughout the symbolization task. One child gave all cluster segmentations in the segmentation task but all singleton segmentations in the symbolization task.

If we look at the children's treatment of the different clusters there were no children who gave consistenly more singleton segmentations for /sw/ or for /tr/ across the three situations. In this respect, /sw/, /tr/ and the other clusters were not treated differently: there was no significant difference in the overall number of correct singleton responses in these three groups (/sw/ 46.6%, /tr/ 42.7%, other clusters 43.8%).

We added the number of times the children gave the first sound of a cluster as a 'correct' singleton (i.e. [s] for /sw/ clusters, [t] or [tʃ] for /tr/ clusters, etc.) across the three situations. The total is the segmentation score for each child. The segmentation scores vary from 100% for those children who always gave a singleton segmentation of the clusters down to 0% for those children who always gave a cluster segmentation. The children can be ordered according to this segmentation score to form a continuum; the distribution of their scores along this continuum is shown in Figure 2. At each end of the continuum there is a small group of children who are consistent and stable in the type of segmentation they gave. There are five children at the extreme singleton end of this continuum who always gave singleton segmentations of the clusters (with one exception by one child) and there are four children at the cluster end who consistently gave cluster segmentations (with one exception by one child). The remaining children are spread between these extremes.

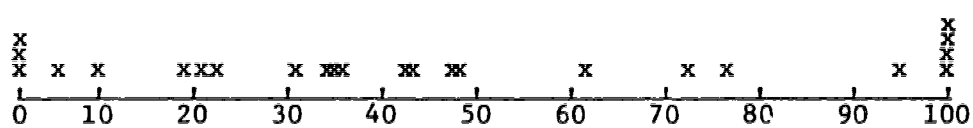


Figure 2. Distribution of the children's segmentation scores. (percentage of correct singleton responses given for clusters)

In Table 12 the children are ranked according to their segmentation scores and these scores are given, along with the individual results of the grouping task and the symbolization task. We have used this segmentation score ranking as the means to compare the children's performance across the different tasks. By doing this, we found that the children have consistent ways of treating clusters which hold up across the tasks and which relate to development. The remainder of this paper will be devoted to analysis of the results within this framework. This analysis, particularly the interpretation of the symbolization task, yields the major findings of this study.

RANKING	CHILD NUMBER	% SINGLETON SEGMENTATIONS	GROUPING						SYMBOLIZATION CHOICES			
			sw	s	f	tr	t	ch	swede	sweet	trick	trip
1	5	100	4	4		3		4	S+n	S	T+R	CH+n
2	10	100	3	3		4		4	S	S+W	CH	CH
3	15	100	4	4		4	4		S+n	S	T+n	T+R
4	19	100	3	4		4	4		S	n	n	T+R
5	9	94.4	4	4		4		4	S	S	CH+R	CH
6	14	77.5	3	4		2		3	S+W	S+W	n	n
7	8	73.	4	4		4		1	n+W	S+n	CH	CH
8	11	61.1	4	4		4		4	S	S+W	CH	CH
9	24	47.4	4	4		4	4	4	S	S	R	T+CH
10	23	47.	4			4		3	n	n	n	CH+n
11	6	43.1	4	4		4	4	4	S	S+W	n+R	n
12	16	42.1	3		1	4	2	4	n	n	R	n
13	7	36.	2	2		4	4	3	S	n	T	CH
14	22	35.	3	2	1	2	3	3	S	W	n+n	CH+n
15	3	34.3	4	4		3		3	n	n	CH	CH
16	12	31.6	3	4	3	4	3	4	F	S+n	CH	n
17	1	22.1	4	3	4	3	4	3	S+W	F+F	CH+R	T
18	13	21.	4	4	3	4	4	3	n	n+W	T+R	n
19	17	19.	3	1		4	4	4	n	n	n	n+n
20	20	10.	0	4		1		2	n+W	F+F	T+R	n+n
21	4	5.	3	1		3		1	n+n	n+n	n+n	n
22	2	0	4		2	4		1	n	n+n	CH	n
23	21	0	3	2	1	4	4	4	n+W	n	n	n
24	18	0	3	1		3		1	n+n	n+n	n+n	n

Table 12. Children ranked by their singleton score.
(in symbolization, n = new block chosen)

9.2 Sound-symbol relationships formed by the children

We begin our discussion by analyzing the children's choices of blocks in the symbolization task in relation to the sounds the blocks represented. The symbolization task builds upon the segmentation nd grouping tasks in two important ways: again the children are asked to segment initial singleton and cluster words; again they are asked to establish relationships between classes of sounds. What is unique to this task is the use of symbols to form relationships of similarity and dissimilarity between sounds.

A different symbol (new color of block) was to be chosen to represent each new phoneme, and identical symbols (old color of block) were to represent the same phoneme (if it had occurred before). In the formation of the array this rule ultimately determined the assignment of old or new blocks. However, during the representation of the target cluster the decision as to the novelty of the sound-symbol relationship was determined solely by the child, i.e. the child decided which blocks were to be used and what sound they were to represent. There were four different possible sound-symbol relationships which could be created when representing the target cluster. The expected relationships were those described above: 1) old block represents old (singleton) sound from array and 2) new block represents new (cluster) sound not in array. The other possible relationships were also created by the children: 3) old block (singleton in array) represents new (cluster) sound; and 4) new block represents old (singleton) sound in array.

First we compare the sound-symbol relationships created by the children with their ranking on the continuum of segmentation scores. Overall there are clear differences in terms of which blocks they chose and what sound they gave them. These results are summarized in Table 13.

	children ranked by segmentation score			
	1-5	6-12	13-20	21-24
% old singleton blocks	90	68	65	12
% singleton sounds given for old block	100	94	10	0
% new blocks	10	32	35	88
% cluster sounds given for new blocks	0	86	82	104

Table 13. Children's choice of blocks and names for blocks, broken down by ranking on segmentation score.

Looking first at one of the two extremes, at the 'cluster' end of the segmentation scale, there are four children, subjects ranked 21st through 24th. We see that these children who virtually never segment the cluster into smaller units represent the cluster with old singleton blocks only 12% of the time, 2 out of 16 cases. In these two cases the children said that the singleton symbols represented the entire cluster sound when the experimenter asked what sound the block made. For example, one child (ranked 22nd) chose the CH symbol to represent the first part of trick. When the experimenter asked what sound the CH symbol made in trick, the child said [t^hrə]. These children seldom form any relationship between the cluster sounds and the singleton sounds they are composed of. The greatest part of the time they represent the cluster with a new block, and they say that the block represents the cluster sound.

At the other extreme, at the singleton end of the segmentation scale, we have five children, subjects ranked 1st through 5th. These children who always segment the cluster into smaller units represent the singleton sounds that make up the cluster with old blocks 90% of the time (18 out of 20 cases). In their representations of the clusters they maintain the correspondence between sound and symbol that was formed in the representations of the array words. Specifically, they show by their use of the symbols that the cluster is made up of singleton sounds, and they recognize these singleton sounds in other contexts, i.e., in the array words.

We turn now to the children between the two extremes. What are the sound-symbol relationships formed by the children who are not consistent in their segmentation of the clusters? If we divide these children into two groups, the following pattern emerges. As the children show that they are able to segment the clusters into smaller units a greater number of times, they also represent the clusters with blocks that have represented singleton sounds in the array. The large discrepancies in the proportions of singleton segmentations of the cluster (10-30%) and the proportion of singleton blocks chosen (65%) can be explained by the fact that the children in the lower half of the continuum "re-name" the singleton block they have chosen and say that it represents the sound of the entire cluster 90% of the time (18 out of 20 cases). Thus, the children ranked 13th to 20th fail to maintain the unique correspondence between sound and symbol that has been established in the array words, as do the two subjects ranked 22nd and 23rd. Because they do not maintain this correspondence, they do not explicitly show that they know the cluster is made up of singleton sounds. Rather when these children choose a symbol that corresponds to a singleton sound within the cluster, they show only an awareness of the similarity of the singleton sound to the cluster sound. The specific nature of the relationship between the singleton and the cluster has not been discovered.

That these children are representing a global relationship of similarity can be further shown by an analysis of these children's choice of specific blocks. These children are as likely to pick W or F to represent /sw/ as S. (Note: those children who pronounce /sw/ as [f] choose new blocks to symbolize the first sound in the /sw/ cluster.) S, W and F are all possible choices if a child is forming a broad relationship of similarity; whereas S or S+W is the only possible choice if the children have segmented the cluster into smaller units.

When do the sound-symbol relationships established in the array begin to have "conventional" meaning for these children? The children in the upper half of the continuum (ranked 6th to 12th) do approximate the children at the upper limit of the segmentation scale. If they choose a singleton block from the array to represent the cluster, then the singleton block retains its singleton sound in its new environment 94% of the time (18 out of 19 cases). Conversely, when they segment the cluster as an entire unit, they do not choose a singleton block to represent it. For example, one subject, ranked 11th, segmented the first part of the /tr/ cluster as [t^{h}ɹ̥]. She first chose the /t/ block from the array to represent the [t^{h}ɹ̥], then rejected it. She next chose the /r/ block to represent [t^{h}ɹ̥], then rejected it. She then chose a new block to represent the cluster.

The children in this group (ranked 6th to 12th) are extremely flexible in their segmentations of the cluster. That is, the percentage of the time they segment the first singleton sound from the cluster varies from 42% to 77.5%. In line with this, they only choose singleton blocks to represent the cluster 68% of the time. In the number of singleton blocks and new blocks chosen, they are equal to the children in the lower half of the continuum. The change we see between the two groups is that the notion of similarity between singleton sounds in singleton environments and in cluster environments can be made more explicit.

In summary, when the cluster is segmented as an entire unit, the cluster sound is not often related to any singleton sound within it. As the children begin to be able to segment the cluster into smaller units, they begin to be able to show that it is similar to the singleton sounds that compose it. When the children consistently segment the cluster into smaller units, they match the first singleton sound in the cluster to the same singleton sound in other environments.

9.3 Segmentation in relation to grouping

The results from the grouping task fit in with this pattern. Three out of the four children at the lowest end of the segmentation score continuum grouped both the /sw/ and the /tr/ clusters predominately with other words beginning with the same cluster. Again, they show that they rarely relate the cluster to its component singleton sounds.

The children at the uppermost end of the segmentation continuum group /sw/ cluster words with words beginning with /s/, and /tr/ cluster words with words beginning with either /t/ or /tʃ/. Furthermore, four of the five children chose the subsets of the groups in a specific order. So, for example, if a child was looking for the words that started with the same sound as <u>tree</u> and the first card he or she chose was <u>tip</u>, the child would find all the rest of the words beginning with /t/ before adding any of the words beginning with /tr/. This kind of performance clearly shows that these children relate the first singleton sound in a cluster to the same singleton sound in other contexts, and it suggests that they have a consistent singleton representation of the first sound in a cluster word.

The children who do not consistently segment the cluster into smaller units sometimes group the cluster words alone but most of the time they group the /sw/ cluster with both /s/ and /f/ and the /tr/ cluster with both /t/ and /tʃ/. These groupings do not indicate that the children have a consistent singleton representation of the first sound of the cluster and are matching words that begin with the same segment. Rather, the children seem to treat the cluster sound as a unit and to form relationships based on acoustic or articulatory similarity. As the children segment the cluster into singletons a large proportion of the time their groupings are exactly like those of the children who consistently segment the cluster, but they do not form their subgroups in the same ordered way.

9.4 Relationship to development

Up to this point we have assumed that the singleton segmentations of the cluster are more mature, and in discussing the segmentation continuum we have assumed that there is a development from treating the cluster as a unit to segmenting it into parts. The implicit origin of these assumptions has been that the singleton segmentation is more adult-like. What support for these assumptions are there in our measures of development? We can investigate this by looking at how the scores on the singleton continuum correlate with age, Draw-a-person scores and reading knowledge. The correlations are given in Table 14.

Correlations

	Age	Draw-a-person	Reading
Segmentation	.32	.37*	.72**
Age		.36*	.29
Draw-a-person			.50**

Partial Correlations

Segmentation	Draw-a-person.	Reading	.01
Segmentation	Reading.	Draw-a-person	.67**
Segmentation	Reading.	Draw-a-person Age	.66**

Table 14. Correlations between segmentation score, age, Draw-a-person and reading knowledge (*$p < .05$, **$p < .01$).

All of the correlations are in a positive direction. The singleton score correlates significantly with age and reading. There is also a positive correlation of singleton score and age, although it is not significant. To investigate these correlations further we looked at the partial correlations. If we take the first order partials, we see that the correlation of singleton score with Draw-a-person disappears when the effects of reading are accounted for and excluded. On the other hand, the correlation of singleton score with reading remains moderately high when the effects of both age and Draw-a-person are accounted for and excluded (the second order partial correlation).

Thus, of our measures, it is knowledge of reading which is most related to whether the children treat the cluster as one unit or two units. What is the meaning of this correlation? All of the children in the study could segment initial singleton consonants from words and could recognize some letters. What differentiates the children who could always segment the cluster into smaller units from the other children is the ability to read some isolated printed words. The correlations indicate a relationship but they do not tell us about the direction of causality, that is, whether some minimum reading ability facilitates the breaking down of clusters or whether the ability involved in breaking down clusters facilitates the early stages of reading. Other studies suggest there is no clear-cut answer and that, rather than a unidirectional effect, these variables interact (see discussion in Ehri 1979, Ehri and Wilce 1979).

One place in our data that we interpret as reflecting the specific influence of the orthography on the children's representations is the children's symbolization of the first part of /tr/ as /t/. The children at the singleton end of the segmentation continuum are acting from a consistent representation where they treat the clusters as being composed of two separable units, and they relate each of these units to a singleton segment. In the symbolization task the children can be viewed as treating the symbols as letters, and we suggest that they are working from an orthographic-like representation. However, for several of the children their representation is not identical to English orthography in that they relate the first sound of /tr/ to /tʃ/ rather than to /t/. As mentioned in the introduction there is a straightforward phonetic justification for this, but in relation to English orthography it is incorrect. The only children to consistently use /t/ throughout the tasks had high scores on reading knowledge and we suggest that it is through exposure to English orthography that they change and stabilize their representation.

Exposure to orthography is not the only possible explanation for this change. Throughout development, as children become more adult-like in their speech production, there is evidence that lexical representations also change; that they will restructure a representation which has been lexicalized incorrectly (cf. Smith 1973, Macken, to appear). The change in /tr/ could be an example of this. The reason we go beyond this explanation, which accounts for much of the acquisition of phonology, is the correlation we find between the change in /tr/ and knowledge of print.

Is the reanalysis of /tr/ a special case or is it part of an overall phonological reanalysis that knowledge of English orthography provides? One hypothesis would be that the children's ability to access different linguistic levels changes: that the children who treat the cluster as one unit are accessing a surface phonetic level and are making comparisons relying on articulatory and acoustic similarities, while the children who treat the clusters as two units are accessing a deeper phonological level consisting of sequential singleton segments. The assumptions underlying this hypothesis are that the children have already acquired a representation at the phonological level which is composed of segment-length units and as they develop they are able to access it more readily. This ability is probably facilitated by exposure to orthography and can be seen as part of an overall development in metalinguistic awareness. A traditional approach utilizing only segment-length units could propose this hypothesis to account for our data. To support it further one would need evidence from elsewhere that younger children with little exposure to orthography nevertheless analyze clusters into two units.

For most aspects of segmentation orthography may provide a confirmation of the child's analysis, but the evidence from our study suggests that for clusters it offers a specific analysis which the child may not have had earlier: the orthography demonstrates that clusters can be analyzed into parts and that these parts can be related to singleton sounds. We are therefore proposing that children first have a representation in which clusters are treated as a unit and that they change this as a result of encountering English orthography.

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