Physical Maturation as a Mediator of Sex Differences In Sound Mimicry and Reading

by
Mark Speed

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Abstract

Despite being well documented, the fact that girls mature more rapidly than boys is seldom considered in studies of cognitive and behavioral sex differences. It is becoming increasingly evident, however, that variation in the rate of physical maturation is related to the development of sex differences in a number of areas. The purpose of this study was to test the hypothesis that the development of a specific group of language abilities, is related to physical maturity, and that physical maturity mediates sex differences in such abilities. Relative stature (percentage of estimated adult height attained) was used as an index for physical maturity of 91 public school children (kindergarten to grade 5). The maturity measure was then used to predict the children's scores on the Goldman-Fristoe-Woodcock Sound Mimicry and Reading of Symbols tests. Results for the Sound Mimicry test indicate that performance is related to maturational status, and that observed sex differences on this test are a product of differences in maturational rate. By linking an index of physical maturation, relative stature, to a component of language acquisition, sound mimicry, this research argues for the explicit consideration of physical maturation influences on the emergence of sex differences in cognitive development.

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Mark Speed

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Introduction

One of the most reliable sex-related differences is physical maturation. On average, girls reach 50% of their adult height at an earlier age than boys, enter puberty earlier, and cease earlier to grow (Tanner, 1978), but despite being well documented, the fact that girls mature more rapidly than boys is seldom considered in studies of cognitive and behavioral sex differences. It is becoming increasingly evident, however, that this should not be the case. Several studies over the past decade have found links between physical maturation and sex differences in temperament (Eaton and Yu, 1989), cognitive abilities (Waber, Mann, Merola & Moylan, 1985) and even hemispheric lateralization (Waber, 1977; Newcombe, Dubas & Baenninger, 1989). It is the purpose of this study to determine if there is a relationship between physical maturation and the development of two language skills, namely, the ability to mimic novel phoneme combinations and to read novel grapheme combinations.

Sex, Maturity and Language

How is physical maturation related to language acquisition? At first glance it might seem unlikely that the rate at which boys and girls grow is related to the rate at which they acquire language skills. It has been demonstrated, however, that sex hormones can induce differential rates of growth of neural tissue and can produce qualitative differences in the synaptic organization of the brain (Reinis & Goldman, 1980; Toran-Allerand, 1976). These hormones may cause the left cerebral hemisphere to mature more rapidly than the right hemisphere, and in doing so, influence patterns of cerebral lateralization (Levy & Levy, 1978) and the development of perceptual and cognitive skills that are directly related to language abilities (Smith, 1981; Bakker & Moerland, 1981).

If language acquisition is related to physical maturation, one would expect to observe certain phenomena over the course of development. For example, sex differences in maturational rate should be accompanied by sex differences in the rate of language acquisition. Also, irrespective of their relative rates of acquisition, children should tend to acquire basic language skills in a similar order, reflecting cortical maturation in a manner analogous to the cephalocaudal development of motor control in infants. It also seems likely that the acquisition of specific language skills would be related to other developmental milestones.

All of the above phenomena have, in fact, been reported in the literature. First, numerous studies have found that girls surpass boys in the development of language skills: Girls acquire phonemes ahead of boys, they talk earlier, articulate more clearly, acquire vocabulary faster, and lead in the development of "mature speech constructions" (Gullahorn, 1979). Girls also tend to be better readers than boys throughout the elementary school years (Fuchs, 1980).

Second, there is support for the notion that children differ in rates of language acquisition but not in the patterns of acquisition. For example, although there is considerable variation in the onset of each stage, children proceed from babbling, to single word utterances, to multiple word utterances (as in telegraphic speech) and finally to complete sentences, in that order. Similar findings have been reported for the development of phonological, morphological, and syntactic skills (Donahue, 1986; Menyuk, 1977).

Finally, studies have demonstrated a link between stages of language development and other developmental milestones. Ramsay (1980, 1984), for example, found a relationship between handedness and the appearance of pre-linguistic and linguistic utterances. More specifically, he found that the onset of unimanual handedness coincided with the appearance of duplicated syllable babbling (e.g., baba), while the onset of bimanual manipulation later in the first year coincided with the appearance of dissimilar syllables in speech (e.g., doggie). This finding is especially significant in light of evidence that the development of handedness is an indicator of neurological maturation (Coren, Searleman & Porac, 1986; Hicks & Kinsborne, 1976), and that the areas in the cerebral cortex relating to manual and vocal motor control appear to overlap (Dawson, Warrenberg & Fuller, 1985).

As the preceding discussion indicates, the language development literature provides indirect support for the hypothesis that physical maturation and language development are linked. There have been very few studies however, that directly examine the relationship between maturity and language, and amongst these there are conflicting findings.

The most often cited study of maturity and language was conducted by Waber (1977). Using secondary sexual characteristics to assess level of maturity (Tanner, 1962), this study compared groups of early maturing and late maturing adolescents on a dichotic listening task and a number of verbal tasks. The data were then analyzed for older and younger adolescents separately. The results from the dichotic listening task indicated that amongst older adolescents, late maturers of both sexes were more lateralized for phonemic processing than were their early maturing age-mates. Interestingly, there were no maturity-related effects for the verbal tests.

Waber's (1977) findings have proven difficult to replicate. Neither Rovet (1983) nor Waber et al. (1985) were able to detect maturity-related differences in lateralization for phonic processing. Waber et al. (1985) did, however, find that early maturers reported phonemic stimuli more accurately than did their later maturing age-mates.

Two questions are immediately raised by the Waber (Waber, 1977; Waber et al. 1985) and Rovet (1983) studies. Why are the dichotic listening results inconsistent? And why were lateralization differences not accompanied by performance differences on the verbal tests?

The most obvious explanation for the inconsistent dichotic listening results is related to differences in the composition of the adolescent groups. In the Waber studies (Waber, 1977; Waber et al. 1985), the group demonstrating the lateralization difference comprised older participants (grade 8 girls and grade 10 boys) than the groups for which no lateralization difference was found (grade 5 girls, grade 7 and 8 boys). Given the fact that spatial lateralization differences can be temporarily masked during the pubertal growth spurt (Waber, 1977), it is possible that verbal lateralization differences were masked in the younger groups. The older group, on the other hand, may have already passed through the critical phase in which masking occurs.

The fact that spatial processes can be temporarily disrupted during adolescence raises a general issue, namely that maturation effects during adolescence may not be the same as those in early or later periods. This observation may be directly related to Waber et al.'s (1985) failure to find lateralization differences for their pre-pubescent group. It is possible that the lateralization differences observed in the adolescent group (Waber, 1977) are peculiar to a period in early adolescence, and do not exist at any other time.

An alternate explanation for the inconsistent lateralization findings is related to the fact that the children in the Waber et al. (1985) study were grouped retrospectively, based on maturity measures made during adolescence. Since growth tends to be variable throughout childhood (Tanner, 1978), the rank ordering of the children (in terms of maturity) may have changed over the two-year interval between the first administration of the dichotic listening task, and the maturity assessment. Thus, the children in Waber et al.'s (1985) early and late maturing groups may not have differed significantly in their average level of physical maturity.

The fact that lateralization differences were not accompanied by performance differences on the verbal tests, may also be related to the selection of the tests. Over the past two decades it has become increasing obvious that language is not strictly a left hemisphere function. Both hemispheres participate in linguistic processing, although they may perform different functions (Segalowitz, 1983; Bradshaw & Nettledon, 1981). Thus, if physical maturation is directly related to a maturation of the left hemisphere, the most heavily influenced verbal tasks will likely be the ones that are most dependent on left hemisphere processes. It is possible that the tasks employed by Waber (1977) do not meet this criterion.

To briefly reiterate, research findings are equivocal concerning the hypothesized relationship between maturity and language. On one hand, studies indirectly addressing the hypothesis are generally supportive: it has been established that there are links between sex, physical maturation, neurological maturation, and language development. On the other hand, direct examination of the maturity-language relationship has produced inconsistent findings, possibly stemming from the limitations of the maturity and language measures employed. The maturity measure appears to be a particularly weak point because the ones used to date can only discriminate between maturity levels during adolescence, which is a particularly difficult developmental period during in which to study the relationship between maturity and language. The development of many language skills has been completed by this time, and the measurement of other skills may be disrupted during the adolescent growth spurt.

The purpose of the present study was to re-examine the maturity-language relationship, using new maturity and language measures. These measures have characteristics that minimize many of the methodological problems discussed. It is to these new measures that the discussion now turns.

Maturity Measure

In place of secondary sexual characteristics, we used relative stature as our index of physical maturity. Relative stature is defined as the ratio of present height to predicted age 18 height. Thus, two children of the same age and stature can have different relative statures if one is closer than the other to his or her estimated adult height. Predicted age 18 height can be derived from a formula, developed by

Roche, Wainer and Thissen (1975), which utilizes information on the parent's statures and on the child's sex, age, weight, and present stature. For the ages of interest to the present study (5 to 11 years), the correlation between predicted and actual adult stature ranges from .71 to .77 for boys and from .56 to .69 for girls (Roche et al., 1975).

There are several advantages to using relative stature as an estimate of physical maturity. Relative stature is less expensive and less invasive than traditional methods of estimating physical maturity. It also correlates well with other accepted measures such as peak height velocity, skeletal age of the left hand-wrist, and skeletal age of the left knee (Roche, Tyleshevski, & Rogers, 1983). Furthermore, when it is based on relative stature, physical maturity can be calculated over a much wider age range than when it is based on secondary sexual characteristics. Using the R-W-T method (Roche, Wainer, and Thissen, 1975), relative stature can be calculated for girls ranging from 3 to 13 years in age, and for boys ranging from 5 to 15 years.

Auditory Perception Tests

The hypothesis that physical maturity is related to sex differences in language development dictated that the language tests selected for this study should have two basic characteristics. First, because girls tend to mature more quickly than boys, they should tend to have higher scores on the chosen tests. Second, since physical maturity and chronological age (CA) are correlated, the language test scores should also be correlated with CA. A moderate correlation between test scores and age is more desirable than a high correlation, however. A high correlation would be more compatible with a situation in which language skills are learned from common experiences, such as formal schooling. A moderate correlation, in contrast, would leave a substantial amount of the variation in language development to be accounted for by non-shared influences. These influences may include aspects of the home environment, like parental modeling, and physiological differences, like maturational rate.

Thus, our first two guidelines for test selection stemmed directly from our hypothesis that language development was related to physical maturity. A third guideline was related to the hypothesis that physical maturity is related to the development of left hemisphere language functions. If this hypothesis is correct, then the type of test most likely to demonstrate a maturity-language development relationship, would be one that depends heavily on left-hemisphere modes of processing.

Two tests from the Goldman-Fristoe-Woodcock (G-F-W) Auditory Skills Test Battery appear to meet the guidelines set out above. They are the Sound Mimicry test and the Reading of Symbols test. The tests are designed to assess abilities which, according to the authors, lie between basic auditory abilities such as sensation and acuity, and more complex ones such as comprehension (Woodcock, 1976).

Sound Mimicry

The Sound Mimicry test assesses the ability to imitate an auditory stimulus. In this case, the participant is asked to repeat nonsense words such as "*shif,*" "*uft,*" and "*bafmotbem.*" Nonsense words are used to simulate the experience of hearing a real word for the first time. Such a task assesses phonic skills as well as auditory and echoic memory. A relatively low level of cognitive processing is involved in translating from the aural to the oral modality (Woodcock, 1976).

The Sound Mimicry test appeared to meet the three test selection requirements. First, it seemed likely that there would be sex differences in performance on this task, given that girls acquire phonemic discrimination and production abilities faster than boys (Gullahorn, 1979). Second, the test manual (Woodcock, 1976) lists a moderate correlation between test scores and CA. Between the ages of 3 and 8 this correlation was approximately .34. Third, the literature suggests that the left hemisphere was dominant for both articulation (Molfese, Molfese & Parsons, 1983) and phonemic processing (Bradshaw & Nettledon, 1981).

Reading of Symbols

The Reading of Symbols test is a test of word attack skills. Like the Sound Mimicry test, the Reading of Symbols test employs nonsense words. In this case however, the words are presented on cards, and the participants are asked to read them aloud. Such a task assesses the ability of the child to perform grapheme-to-phoneme translations and to apply phonic and structural analysis skills in order to pronounce unfamiliar words.

Like the Sound Mimicry test, the Reading of Symbols test appeared to meet our criteria for test selection. Again, sex differences in test performance seemed likely. Girls generally score higher than boys on reading tests, particularly those, like the Reading of Symbols test, that require grapheme-to-phoneme translations (Gullahorn, 1979; Segalowitz, 1983; Whyte & Harland, 1984). Test scores also appeared to have a moderate correlation with CA. A plot of the average Reading of Symbols score versus age (included in the G-F-W manual) closely resembled that for Sound Mimicry. And finally, the literature suggested that grapheme-to-phoneme translations are processed primarily by the left hemisphere (Segalowitz, 1983).

Reliability and Validity of the G-F-W Tests

Woodcock (1976) examined the content validity for the G-F-W battery and reported three major findings. First, intercorrelations among the tests, with age effects removed, are sufficiently low to allow the inference that the tests measure different abilities. Second, consistent with the notion that auditory skills are developmental in nature, correlations between age and test scores tend to be high and positive for ages 3 to 8, lower and positive for ages 9-18, and high and negative for ages 19-80. Third, the data suggests that the battery effectively discriminates between persons with dysfunctional abilities and those who are normal. Based on the reliability and validity data in the manual, Loser (1979) has suggested that the battery is useful in evaluating various auditory perception skills of normal children between the ages of 3 and 12 years. With an age range of approximately 5-11 years, our sample fell safely within this group.

Potential Confounds

At this point, mention should be made of a number of other variables that may have a bearing on this study. It is clear that many factors, unrelated to physical development, contribute to the development of language skills. For example, children who speak a second language at home may perform differently than unilingual children on either of the G-F-W tests. Other important factors might be the educational background of the parents and the child's amount of exposure to reading, both in the home and at school. With respect to reading, differences in teaching methods may also influence performance on "word attack" type reading tasks. For example, children taught to read according to the phonic approach are encouraged to "sound-out" new words, or to treat them as the sum of phonic segments. In contrast, children taught according to the whole-word approach are encouraged to recognize words as units (Lapp & Flood, 1986). As a result of this, children with phonics training tend to find the word attack tests (like the Reading of Symbols test) to be easier than do children trained in the whole word approach.

While the above factors affect boys and girls equally, other non-biological factors may contribute to sex differences in the development of language abilities. Our culture, for instance, likely encourages greater development of verbal competence in girls. Evidence suggests that from the time their offspring are infants, mothers tend to speak differently to daughters than to sons. Similarly, teachers tend to expect their female students to be more competent verbally than boys, and may in fact encourage more verbal responses from girls (Harris, 1977).

Cultural influences do not appear to completely explain sex differences in language skills however. Rather, it seems more likely that small differences in language skills (and probably spatial skills) exist from infancy, and that these differences influence cultural expectations, which in turn enhance these sex differences (Gullahorn, 1979). For example, the reason that mothers speak differently to their infant daughters may be related to the fact that infant girls are more responsive to phonemic variations than are infant boys (McGuinnes, 1979). Thus, there could be an interaction between the infant and the environment: the infant girl's innate verbal abilities encourage more verbal responses from the mother, which in turn enhance development of verbal skills in the infant.

In order to address some of the issues presented in this section, we incorporated several additional measures into the study. These included child bilingualism, parent education, the length of time that the child has been in school, and the type of instruction used by the teachers. These supplementary measures notwithstanding, the relationship between cultural biases, physical maturity and sex differences in language development was largely beyond the scope of this study. However, in recognition of the interactive nature of language development, we did not expect that physical maturity would completely mediate sex differences in performance on the G-F-W tests.

Summary

In summary, the purpose of this study was to test the hypothesis that the development of the ability to mimic novel phoneme combinations and to read novel grapheme combinations is related to physical maturation. Thus, we predicted that more mature children would tend to score higher on the Sound Mimicry and the Reading of Symbols tests than their less mature age-mates. Furthermore, sex differences in the test scores would be mediated by differences in maturational status. Given the environmental influences discussed above, we expected that physical maturity would only partially mediate sex differences in test performance. More specifically, we predicted that sex differences on the G-F-W tests would be significantly reduced, but not eliminated, after the maturity variable was taken into consideration.

Method

Subject Recruitment

Permission to conduct the study was obtained from the Department of Psychology Human Ethical Review Committee and the superintendent of the Winnipeg School Division Number 1. Several schools were then approached, and two agreed to participate. The first school, Earl Grey P.S., is located in a suburban residential area of Winnipeg while the second, River Elm P.S., is located in an urban, semi-industrial area of the city. Most of the students attending these schools come from middle-class and lower middle-class families.

The investigators met with the respective principals, discussed the study in detail, and distributed the letters and consent forms that were to be sent home to the parents. The letters explained the purpose of the study and requested parental consent (see Appendices A and B). All students in classes from kindergarten to grade five were eligible to participate, and a total of 127 students did so. Thirty-one percent (n = 49) of the eligible Earl Grey students participated, as did thirty-three percent (n = 72) of the River Elm students. Participants were those children who returned signed parent permission forms to the school. How many permission forms actually reached the parents is not known.

Exclusion Criteria

Before analyzing the data, it was decided that six members of the total group would be excluded. One participant was excluded because missing data made it impossible to calculate relative maturity. The remaining five participants were excluded because, in the opinion of the interviewer, a valid assessment of mimicry or reading was not obtained; three of these participants had speech impairments that made them difficult to understand, and two participants demonstrated poor attention. Thus, a total of 121 participants remained. One of these participants was excluded from the Reading analysis because of poor attention on this test. He was included in the Mimicry analysis however.

The girls in the sample had a mean chronological age (CA) of 8.4 years with a standard deviation of 1.8 years. The mean CA of the boys was only 7.9 years, with a standard deviation of 1.7 years. Because the girls were, on average, six months older than the boys and because CA is related to both maturity and to G-F-W test scores, it was decided that the male and female groups should be matched more closely on the basis of CA. The matching process was performed in two steps. First, males and females were matched in terms of CA within each year-group. Second, subjects were dropped in order to match the sexes in terms of the proportion of subjects within each year-group.

Table 1

Frequencies of Male and Female Participants by Age (matched sample).

Age	Gender	
	Male (n=45)	Female (n=49)
5	4	5
6	6	7
7	12	12
8	6	5
9	9	10
10	6	7
11	2	3

Note: N=94.

As an example, consider the initial group of 6-year-olds. This group was composed of 14 boys and 9 girls. The mean age of the boys was 6 years and 6.8 months, while the mean age of the girls was 6 years and 4.6 months. In order to bring the mean ages closer together, the three oldest boys and the two youngest girls were dropped from the sample. Then the proportion of boys and girls in each group was adjusted by removing five boys from across the 6-year-old age range. This resulted in a group of 6 boys and 7 girls, with mean ages of 6 years, 5.8 months and 6 years, 5.9 months respectively.

After repeating the above procedure for each age-group, the final sample of subjects consisted of 94 children (45 boys and 49 girls). The boys had a mean age of 8.3 years with a standard deviation of 1.7 years whereas the girls had a mean age of 8.3 years and a standard deviation of 1.8 years. Table 1 lists the number of males and females by age in this matched sample.

Data Collection

A brief questionnaire was attached to the parental consent form. It included items regarding the biological parents' heights, level of education, and their child's gender and date of birth (see Appendix B). The answers to these questions, in conjunction with other information, enabled the calculation of relative stature values.

Participating children were seen at the schools individually, in testing rooms that were relatively free from distractions. During this single session, both physical and G-F-W measures were obtained. The average length of each session was approximately 25 minutes. The Earl Grey students were seen in May and June of 1989, while the River Elm students were seen in November and December of that same year.

Physical Measurements

Maturity was estimated using the method developed by Roche, Wainer, and Thissen (1975). This method requires child age, sex, weight and stature, as well as mean parent stature in order to predict the child's adult stature. Child weight and stature measures were obtained at the beginning of each testing session. Participants were weighed on a digital scale (General Electric model DS400, or Thinner model 105). Stature was measured using a GPM anthropometer which had been attached to the wall. In order to ensure accuracy, subjects were positioned with their backs toward the anthropometer and with one heel on each side of it. They were instructed to keep their hands at their sides, to look straight ahead, and to take a deep breath before being measured.

Both the weight and the stature measurements were made twice in order to estimate their reliability. The Pearson correlation (*r*) between the two weight measurements was .99, as was the correlation between the two stature measurements. Parent stature and child birthdate were obtained from the parent questionnaire. Himes and Roche (1982) have found that self report estimates of parent stature tend to slightly overestimate actual stature, but the resulting increase in the child's predicted adult stature is very small (e.g., on the order of 2 millimeters when predicting the adult stature of a 10-year-old girl).

Maturity Measure

Relative stature was used as an index of physical maturity. As described earlier, this measure is a ratio of the child's current stature to his/her predicted adult stature. The R-W-T formula (Roche, Wainer and Thissen, 1975) for predicting adult stature is as follows:

$$PS = \beta_0 + \beta_{RL}(RL) + \beta_W(W) + \beta_{MPS}(MPS) + \beta_{SA}(SA),$$

where PS = predicted adult stature (in centimeters), RL = recumbent length, W = child weight (in kilograms), MPS = mid-parent stature (in centimeters), and SA = skeletal age (expressed as a decimal). If recumbent length is not available, it can be estimated by adding 1.25 cm to stature (Roche et al., 1975). Chronological age is substituted for skeletal age when irradiation (to determine skeletal age) can not be justified (Roche et al., 1983). Tables XXVII and XXVIII in Roche et al. (1975) provide beta coefficients (β_0, β_{RL}, β_W, β_{MPS} and β_{SA}) for each month of age. Separate coefficients are given for boys and girls.

As an example, for a girl aged 10 years and 0 months, the beta coefficients would be $\beta_0 = 50.53$, $\beta_{RL} = .803$, $\beta_W = -.250$, $\beta_{MPS} = .216$ and $\beta_{SA} = -2.581$. If the girl's height was 144 centimeters, her weight was 32 kilograms, and her father's and mother's heights were 177 and 157 cm respectively, then the girls's predicted adult height would be 169.43 cm, as calculated in Table 2. Relative stature would then be calculated using the following formula:

relative stature = 100 x (current stature / predicted stature).

Table 2

Sample Calculation for Predicted Adult Stature of a 10-year-old Girl.

Constant		=	+50.53
Recumbent Length (cm)	(0.803)(144 + 1.25)	=	+116.64
Weight (kg)	(-0.250)(32)	=	- 8.00
Mid-Parent Stature (cm)	(0.216)[(177 + 157)/2]	=	+ 36.07
Skeletal age[a]	(-2.581)(10)	=	- 25.81
Predicted Stature (cm)			+169.43

[a]Using CA as an estimate of SA.

Thus, the relative stature score for the girl in the above example is 144/169.43 = .85 . In other words, the girl has reached 85% of her predicted adult stature. Summary statistics for both the physical measures and the G-F-W measures are presented in Table 3.

G-F-W Tests

After the maturity measures were obtained, the G-F-W Sound Mimicry test was presented. Then, participants enrolled in grades 1 to 5 were administered the Reading of Symbols Test. Kindergartners were not given this test, as very few had received any instruction in reading. For both Mimicry and Reading tests, the investigator and participant sat facing each other at a table. A testing easel was placed on the table so that the participant could not see the scoring sheet. Participants were periodically encouraged, and told that they were doing well, but information regarding the number of correct or incorrect responses was not given.

Sound Mimicry. For this test, participants are asked to listen to, and then repeat, a series of nonsense words (see Appendix C for instructions and Appendix D for a list of the words). The words are of one to three syllables in length, and the syllables represent a wide variety of consonant-vowel combinations. The 55 words in the test are arranged in order of increasing difficulty. Each word is presented twice before the participant is required to respond. Approximately three seconds is allowed for each response. Testing begins with the first word and continues until six consecutive errors are recorded. In order to standardize administration, the nonsense words are presented on an audio tape (provided in the G-F-W kit). The participant used headphones to reduce outside distractions, and the investigator used one headphone to monitor the tape, while listening to, and scoring the participant's responses.

Reading of Symbols. This test requires participants to pronounce nonsense words which are presented on cards. The 70 items of the Reading of Symbols test are composed of one to three syllables and contain all the major spellings of the English phonemes. As in the Sound Mimicry test, items are presented in order of increasing difficulty. During the test, participants are encouraged to respond to each item within approximately 5 seconds, although extra time is permitted for individual items if requested by the participant. Beginning with the first word, the participant continues until he/she fails all six items on a given card. A pronunciation guide is provided to ensure accurate scoring.

Scoring and Inter-Rater Reliability. Scores for each of the G-F-W tests were equal to the number of correct responses. Analyses were based on these raw scores, and not on derived (e.g., norm-referenced) scores. Inter-rater reliability was established by tape-recording the tests, and re-scoring 10 of the recordings (selected at random) from each school. The Pearson correlation (*r*) between raters was .84 for Mimicry and .99 for Reading. Cohen's kappa statistic (κ) was used to assess beyond chance agreement of the two raters' scores for this subgroup of twenty participants. The formula for kappa is:

$$\kappa = \frac{\Sigma P_{ii} - \Sigma P_{i\cdot} P_{\cdot i}}{1 - \Sigma P_{i\cdot} P_{\cdot i}};$$

where ΣP_{ii} is the observed proportion of agreement, and $\Sigma P_{i\cdot} P_{\cdot i}$ is the "chance" proportion of agreement. For the Sound Mimicry test κ = 0.68. For the Reading of Symbols test κ = 0.84. In other words, rater concordance accounted for 68% and 84% of the beyond-chance agreement for the two tests respectively, a good level of agreement using a stringent criterion.

Table 3

Summary Statistics for Maturity and G-F-W Measures

	Male		Female	
	Mean	SD	Mean	SD
Maturity Measures				
Child Height (cm)	127.3	9.6	129.3	12.5
Child Weight (kg)	28.5	7.7	29.0	8.5
Mid-Parent Stature (cm)	168.7	6.1	169.8	5.6
CA (years)	8.3	1.7	8.3	1.8
Predicted Stature (cm)	176.2	6.2	165.2	4.1
Relative Maturity x 100	72.3	5.6	78.2	6.8
G-F-W Measures				
Sound Mimicry[a]	39.5	6.9	42.6	5.9
Reading[b]	26.6	21.0	26.3	18.4

[a]Kindergarten to grade 5. [b]Grades 1 to 5 only (n=84).

Results

Before addressing our hypothesis, a number of potentially confounding variables were considered. First, we compared the two schools that participated in the study. No differences were detected for either the Sound Mimicry (t_{92} = .90, p > .36) or for the Reading of Symbols (t_{82} = .64, p > .52) scores[1], and we therefore pooled the data from the two schools. Subjects were then compared on the basis of spoken language. Unilingual English-speaking subjects were compared to subjects who spoke English plus a second language (Bilingual) and to subjects for whom English *was* a second language (E.S.L.). T-tests did not reveal differences between the English-only group and the Bilingual group on either the Mimicry (t_{85} = .43, p > .66) or Reading (t_{75} = -.52, p > .60) tests. Neither was there a difference between the English-only group and the E.S.L. group for Mimicry (t_{83} = -1.38, p > .17) or Reading (t_{73} = 1.31, p > .19). Since no language group differences were detected, child language was not considered in the

[1]Kindergartners did not take the Reading of Symbols test. Hence, the sample size is smaller and there are fewer degrees of freedom for Reading of Symbols than for Sound Mimicry.

remaining analyses. Means and standard deviations for the G-F-W scores are reported by school and by language group in Table 4.

Parents were asked to indicate the number of years of education that they had completed, including high school, college, university, and other institutions (see Appendix B). A variable was constructed by summing the number of years of eduction for both parents, and dividing by 2, to yield an average number of years of education. Scores on the two G-F-W tests were then regressed on this parent education variable. The results failed to reach significance for either Mimicry ($F_{1,88} = 1.20$, $p > .27$) or Reading ($F_{1,78} = .23$, $p > .63$) and parent education was not considered in the remaining analyses.

We had hoped to compare subjects on the basis of the type of reading instruction received in the classroom. To this end, we prepared a questionnaire (Appendix G) that asked teachers whether they taught speech-sound discrimination or letter-sound relationships. Unfortunately, we received only 6 completed questionnaires. We therefore had insufficient information upon which to base an analysis of teaching techniques. While it is possible that there are grade-related differences

Table 4

Summary Statistics for G-F-W Tests by School and by Child's Language.

	Sound Mimicry			Reading of Symbols		
	n	*M*	*SD*	*n*	*M*	*SD*
School						
Earl Grey	38	41.9	6.8	34	28.1	19.5
River Elm	56	40.6	6.4	50	25.3	19.7
Child's Language[a]						
English	80	41.2	6.2	70	25.9	19.1
Bilingual	7	42.3	6.1	7	21.9	21.8
E.S.L.[b]	5	37.0	12.1	5	37.6	23.3

[a]Two parents declined to complete questionnaire, thus N=92 for Mimicry and N=82 for Reading. [b]E.S.L. = English is second language.

instructional techniques, it seems unlikely that teacher use of a particular instruction technique is maturity-related or sex-related. Thus, the most probable result of differing instructional techniques is an increased error variance in the predication of Reading scores. This, in turn, would make it more difficult to demonstrate a relationship between Reading and any other variable like physical maturity.

The Mediational Model

Our basic hypothesis was that the development of auditory perception abilities is related to physical maturation. An important implication of this hypothesis was that sex differences in development would be partially mediated by differences in physical maturity. In other words, one reason that auditory perception development tends to be more rapid in girls than in boys is that girls tend to mature more rapidly than boys. To test our hypothesis, we followed a procedure for mediational analysis set out by Baron and Kenny (1986).

According to Baron and Kenny's (1986) model, relative stature would qualify as a mediator of sex differences in G-F-W performance if three conditions could be met. First, sex must account for a significant proportion of the variance in both G-F-W test scores and relative stature scores. Second, relative stature must account for a significant proportion of the variation in G-F-W test scores. Third, the sex differences in G-F-W performance should be significantly diminished when sex differences in relative stature are taken into account. The proposed relationships between sex, relative stature and auditory perception abilities are depicted graphically in Figure 1.

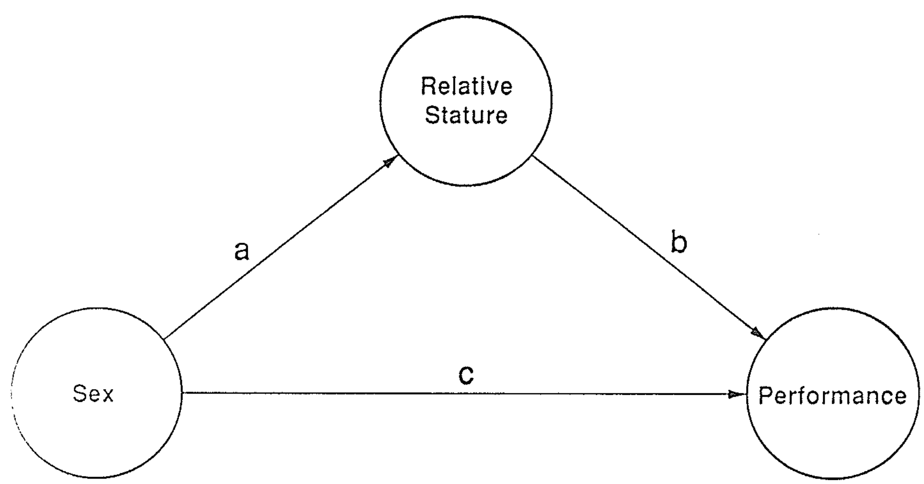

Figure 1. - *Hypothesized model with relative stature as a mediator of the relation between sex and test performance.*

Four regression equations are needed to test our mediational hypothesis: Relative stature should be regressed on sex (Figure 1, path a), then G-F-W scores should be regressed on relative stature (path b) and sex (path c) individually, and finally, G-F-W scores should be regressed on relative stature and sex together. For relative stature to qualify as a mediator, all three simple regression models should be statistically significant. If relative stature completely mediates the sex effect, then the regression coefficient for sex should not differ significantly from zero in the full model, which includes both sex and relative stature as predictors of performance.

Sound Mimicry

Our findings for the Sound Mimicry test confirmed the existence of all three paths depicted in Figure 1. Sex was found to significantly predict both relative stature and Mimicry scores, accounting for over 18% of the relative stature variance ($F_{1,92} = 20.67$, $p < .0001$) and for nearly 6% of the Mimicry variance ($F_{1,92} = 5.66$, $p < .05$). Girls had higher relative stature scores than boys and outperformed boys on the Sound Mimicry test. Relative stature was also found to significantly predict Mimicry scores, accounting for 17% of the Mimicry variance ($F_{1,92} = 18.88$, $p < .0001$), with higher relative statures associated with better performance.

In order to ensure that the maturity effect operated *within* each sex, we calculated the correlations between relative stature and Mimicry scores for boys and girls separately. The correlations were statistically significant for both boys (r = .40, p < .01) and girls (r = .33, p < .05). We then compared the magnitude of these correlations using the following formulas, as suggested by Appelbaum and McCall (1983):

$$W = \sum_{i=1}^{k} (n_i - 3)(z_i - \bar{z})^2$$

where

$$\bar{z} = \sum_{i=1}^{k} (n_i - 3)z_i / \Sigma (n_i - 3)$$

and

$$z_i = \log_e(1 + r_{xy}) / 2(1 - r_{xy}).$$

W is distributed asymptotically as a chi square with k - 1 degrees of freedom. Large values of W suggest rejection of the null hypothesis of homogeneity of the k independent correlations. For Mimicry, k = 2 (boys and girls), and W = .08 (p >.75). Thus, there was no significant sex difference in the strength of the relationship between relative stature and Mimicry in our sample.

To this point all findings are consistent with the notion that sex differences in mimicry are mediated by maturational differences. We then examined whether this mediation is partial or complete by regressing Mimicry on both relative stature and sex. We found that the sex difference was no longer significant ($F_{1,91} = .55$, $p > .45$). Adding relative stature to the prediction model dropped the proportion of Mimicry variance explained by sex from nearly 6% to approximately 0.5%. The following formula was used to test the significance of the reduction in the variance accounted for sex:

$$F_{1,k} = \frac{(r^2_{y1} - r^2_{y1.2}) / 1}{(1 - R^2_{y.12}) / k};$$

where k is the degrees of freedom of the two predictor model (with both sex and relative stature as predictors); the r^2 values are the partial correlations between the Mimicry and sex for the one predictor (r^2_{y1}) model and the two predictor ($r^2_{y1.2}$) model; $R^2_{y.12}$ is the square of the multiple correlation coefficient for the two predictor model. The reduction in the size of r^2 was found to be statistically significant

($F_{1,91} = 5.84$, $p < .025$). Thus, when relative stature was added to the model, the proportion of Mimicry variance accounted for by sex was significantly reduced, and no longer differed significantly from zero. This mediational analysis indicates that sex differences in Mimicry are completely mediated by processes associated with relative stature.

Reading of Symbols

For the Reading of Symbols Test we found a rather different pattern of results. In this smaller sample (grades 1 to 5 only, $n = 84$), sex accounted for nearly 25% of the relative stature variance, but virtually none of the Reading variance. As in the larger sample, the mean relative stature was greater for girls than boys ($F_{1,83} = 27.16$, $p < .0001$). However, girls and boys were nearly identical in terms of Reading ($F_{1,83} = .01$, $p > .9$). Relative stature was, as assumed, predictive of Reading scores, explaining over 20% of the variance, with greater relative stature associated with higher test scores ($F_{1,83} = 20.92$, $p < .0001$). The Pearson correlation between relative stature and Reading was .58 for boys ($p < .0001$) and .48 for girls ($p < .001$). These correlations were not significantly different ($W = .36$, $p > .5$), indicating that the relationship between relative stature and Reading was the same for both sexes.

The preceding evidence suggests the existence of a link between maturation and reading, but this link does not appear to lead to sex-related differences in reading. Thus, one of the assumptions of our mediational model was not met, and the technique for mediational analysis, as suggested by Baron and Kenny (1986), does not strictly apply. Nonetheless, it is interesting to note that when reading is regressed on both relative stature and sex, the sex difference *becomes* significant ($F_{1,81} = 15.37$, $p < .0001$). When maturity-adjusted performance is considered, boys actually do much better on average than do girls ($M = 32.7$ vs. $M = 20.7$)[2].

CA and Maturity

CA and maturity are conceptually and practically related; CA is, in fact, one of the four variables used to calculate relative stature. As pointed out earlier, G-F-W scores are also related to CA. Therefore, it

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[2]Least squares means.

is important from both a practical and theoretical standpoint to determine if the observed correlations between relative stature and G-F-W scores are true ones, or are simply a consequence of the fact that all of the variables are related to CA. We examined this possibility by regressing Mimicry and Reading on CA alone, and on CA along with relative stature. The results indicated that CA predicted nearly 12% of the variance in Mimicry ($F_{1,92}$ = 12.14, $p < .001$) and close to 30% of the variance in Reading ($F_{1,82}$ = 34.75, $p < .0001$). When the Mimicry scores were regressed on both CA and relative stature, the Type III Sums of Squares (SS)[3] was significant for relative stature ($F_{1,91}$ = 6.07, $p < .05$), but not for CA ($F_{1,91}$ = .17. $p > .68$). In other words, the inclusion of relative stature improved the prediction of Mimicry scores after CA was considered but not vice versa. When Reading was regressed on both CA and relative stature, the opposite was found: the Type III SS was statistically significant for CA ($F_{1,81}$ = 10.90, $p < .005$) but not for relative stature ($F_{1,81}$ = .02, $p > .89$). CA improved the prediction of Reading scores after relative stature was

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[3]Type III SS is the sum of squares for a variable when it is the last variable entered into the model.

considered, but again, not vice versa. This finding provides, from another perspective, evidence that maturity processes are more closely linked to Mimicry than to Reading performance in this middle childhood sample.

Child Education

The results in the preceding section indicated that CA was particularly important for understanding performance on the Reading of Symbols test. But CA may be considered a proxy for some time-related processes such as learning. In light of this, one variable worth considering is the amount of time spent in school by the child. We constructed such a variable, one that reflected the child's number of full-time months in school[4]. In the K to 5 sample, this variable, School Exposure, was found to be highly correlated with both CA (r = .97, p < .0001) and with relative stature (r = .85, p < .0001). When the G-F-W scores were regressed on school exposure, school exposure explained 12% of the variance in Mimicry ($F_{1,92}$ = 12.68, p < .001) and a staggering 37% of the variance in Reading ($F_{1,82}$ = 47.34, p < .0001).

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[4]Kindergartners only attend school for half-days, and so were awarded .5 months for every month in which they attended class.

When Mimicry scores were regressed on both relative stature and school exposure, the Type III SS was significant for relative stature ($F_{1,91}$ = 5.39, $p < .05$) but not for school exposure ($F_{1,91} = 0.00$, $p > .97$). Once again, the opposite was true for Reading. When Reading was regressed on both school exposure and relative stature, the Type III SS was highly significant for school exposure ($F_{1,81} = 21.51$, $p < .0001$), but not for relative stature ($F_{1,81} = .57$, $p > .45$). This is consistent with the view that maturity is more important than school exposure for Mimicry, while school exposure is more important than maturity for Reading -- at least in the age range studied.

Discussion

Our primary hypothesis was that physical maturity (as indexed by relative stature) would be related to the development of abilities such as those assessed by the G-F-W tests. Based on previous research, we expected that girls would be more physically mature and would perform better than boys on the Sound Mimicry and Reading of Symbols tests. Our secondary hypotheses tied these phenomena together, by suggesting that sex differences in physical maturity would partially mediate sex differences in performance on the tests.

For the Sound Mimicry test, our hypotheses were confirmed. Physical maturity did indeed predict Mimicry performance. Furthermore, it does not appear that the relationship between maturity and Mimicry was a product of their common link with CA. Maturity was the *best single predictor* of Mimicry, better than CA, sex, or child education. In addition it was found that maturity was able to significantly improve the prediction of Mimicry when added to a regression model containing CA. Thus, it appears that maturity is making a significant contribution to the prediction of Mimicry scores and that this contribution is independent of the relationship between Mimicry and CA.

The data also shows that sex differences in physical maturity mediated the observed sex difference in Sound Mimicry performance. As expected, the girls in our sample had higher scores on the Sound Mimicry test and were more physically mature than the boys. When this difference in maturity was taken into account, the sex difference in

Mimicry performance was significantly reduced. Indeed, contrary to our predictions, physical maturity appears to have completely mediated the sex effect, reducing it to nearly zero.

For the Reading of Symbols test the results were not so clear-cut. As expected, maturity was a strong predictor of Reading performance, but was not nearly as strong a predictor as was CA. CA was, in turn, highly correlated with school exposure which was the best single predictor of Reading. Maturity did not significantly improve the prediction of Reading when it was added to a regression model containing CA. This latter finding may be attributable to factors such as the high correlation between physical maturity and CA, the relatively small sample size, and the huge proportion of the Reading variance already accounted for CA. All of these factors may have limited the statistical power to detect an independent maturity effect. Nevertheless, the present findings do not allow us to conclude that the observed relationship between physical maturity and Reading is independent of the relationship between CA (or school exposure) and Reading.

Our secondary hypothesis that maturity differences would mediate the sex effect in Reading scores was supported, although not quite in the way predicted. Rather than eliminating a sex difference in Reading, adding the maturity variable to the regression equation actually *created* quite a large sex difference. We found, in effect, that when boys are girls are matched on the basis of physical maturity, boys do much better on Reading of Symbols test.

Two factors make this finding difficult to interpret. First, because we did not find an initial sex difference in Reading, we are left in the position of explaining how a third variable mediates a null comparison. This issue is not addressed by the Baron and Kenny (1986) model, which assumes that initial group differences exist. However, the phenomenon we are reporting does not appear to be qualitatively different from that described by Baron and Kenny. In their model, apparent group differences are produced by a mediational process. In our study, actual group differences were masked by a "mediational" process. The difference in the two scenarios is in the initial status of the groups, and not in the process underlying the change in their relative status.

The second, and more important, caveat with respect to the Reading data is related to the intercorrelations between the predictor variables in this study. Because maturity, CA and school exposure are all highly correlated, our comparison may have had the undesirable side-effect of matching older, more educated boys to younger, less educated girls. This would be expected to have a large impact on group differences given that child education explains approximately 37% of the variance in Reading scores. We were unable to separate the maturity-sex relationship from the relationship between maturity, CA and child education. Only child education was statistically significant when all four variables were entered into the model. Once again, limited statistical power may be important here.

In summary, it appears that the development of the ability to mimic is at least partially dependent on physical maturation, and sex differences in Mimicry may be a result of sex differences in the rate of physical maturation. For Reading, the results also support a maturational link, but the difficulty in disentangling a number of time-dependent variables makes stronger conclusions unwarranted at this time. Clearly, given the relatively small size of physiologically-related sex effects (Waber, 1979) and the problems of multicollinearity, larger sample sizes are required to properly address these issues.

Based on the above, the findings of this study should be considered preliminary. There is solid evidence to suggest that processes related to physical maturation underlie performance on the Sound Mimicry test, and that sex differences in physical maturity may mediate sex differences in test performance. Similar relationships may exist for Reading of Symbols, although the findings are inconclusive. Further work is needed to isolate the effects of maturation, CA, and education, and to determine the generality of our findings. Not all measures of physical maturity are highly correlated, and alternate measures may produce different results. Likewise, there are many other language measures which may be of interest and which may show different patterns of results. Nevertheless, these preliminary results are encouraging and provocative.

Our findings have a number of practical and theoretical implications. In general, they would suggest that even in middle to late childhood, the rate of auditory perception development is associated with the rate of physical development, which is clearly not equivalent to chronological age. By extension, our findings may also lend support to the developmental delay theory of language learning disabilities (e.g. Bishop and Edmundson, 1987; Satz, Fletcher, Clark, and Moris, 1981). Rather than having deficits, some "learning disabled" children may simply represent the lower extreme of the maturational continuum. The fact that boys tend to mature more slowly than girls would account for the fact that there is currently a higher proportion of boys who are diagnosed to have learning disabilities. A maturation-language development link therefore has implications for both the assessment and treatment of learning disabled children. Finally, this research advances the sex difference discussion by drawing attention to the oft-ignored fact that there are marked sex differences in maturational rate. The linkage of an index of maturation, relative stature, to a component of language acquisition, sound mimicry, argues for the explicit consideration of physical maturation influences on the emergence -- and possible disappearance -- of sex differences in cognitive development.

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Appendix A: Letter to Parents

November, 1989

Dear Parents/Guardians:

My graduate student and I are conducting research on a possible relationship between a child's physical maturity and his or her language development. Your child's school has kindly agreed to cooperate, and I am writing to request your permission to allow your daughter or son to participate in this research in the near future.

If your child participates, we will spend approximately 20 minutes with him/her, making weight and height measurements, and administering one or two short language tasks. My own children have tried these tasks and found them to be quite intriguing and fun.

If you are willing to have your child participate, please complete the attached form and return it to the school as soon as possible. All obtained information will be used only for research purposes and will remain confidential.

By way of thanks for your participation, we will send you your child's current height and weight, and estimated age 18 height. If you have any questions, please call me or my student (Mark Speed) at 261-9075.

Yours truly,

Warren O. Eaton, PhD.
Professor

Appendix B: Parental Consent Form and Questionnaire

RIVER ELM SCHOOL

Please complete the following and return it to the school as soon as possible.

Child's name: ____
(first name) (surname)

Teacher: ____________________

______ **I do** consent to let my child participate in Dr. Eaton's study on maturity and language.

______ **I do not** consent to let my child participate in Dr. Eaton's study on maturity and language

Parent or guardian signature:________________________ Date:_____________

The following information is necessary for us to predict your child's adult height.

Child's birth date: _____/_____/_____
Day Month Year

Height of child's biological father: _____________

Height of child's biological mother: _____________

Parent Questionnaire (cont.)

The information below would be very helpful to us, but is not essential for your child's participation.

Is English your child's native language? ___ Yes ___ No

Does your child speak any other languages? ___ Yes ___ No

What is the highest grade or year (1 to 13) of secondary (high) or elementary school ever attended?

Mother ______ Father ______

How many years of education have been completed at university?

Mother ______ Father______

How many years of schooling have been completed at institutions other than those listed above. Include years of schooling at community colleges, institutes of technology, CEGEPs (general and professional), private trade schools or private business colleges, diploma schools of nursing, etc.

Mother______ Father______

Appendix C: Sound Mimicry Instructions

The administrator will read the following instructions:

You are going to hear some words that are not real words --they are nonsense words like "maf," "ost," and "plon." I want you to say the words back to me. For example, if I say "maf," you would say ...

The administrator will pause for the subject to respond. If necessary he/she will demonstrate the proper response, and then repeat the instructions with another example. Once the subject has understood the instructions, the administrator will say:

Now we are going to do some others, but this time you will hear the words through the earphones. Wait until the voice has said the word two times before you say the word to me.

Appendix D: Sound Mimicry Items

1. ab
2. dod
3. poe
4. ap
5. bab
6. nud
7. tash
8. nid
9. nen
10. wips
11. lev
12. quiles
13. kak
14. hets
15. shif
16. fooch
17. len
18. friz
19. fet
20. wips
21. und
22. rog
23. esh
24. gog
25. postjip
26. laift
27. gubbest
28. quo
29. ong
30. lift
31. quibbest
32. plen
33. yobe
34. wang
35. uft
36. imbaf
37. obquob
38. zeepstol
39. fubwit
40. jesh
41. maft
42. wifyep
43. abfim
44. eth
45. gacked
46. odlud
47. elbom
48. bofmib
49. ufwut
50. wubfambif
51. wotfob
52. ull
53. febmifsack
54. depnonlel
55. bafmotbem

Appendix E: Reading of Symbols Instructions

The administrator will start by reading the following:

I want you to pronounce some words that are not real words. I want you to tell me how they sound. (Point to "bab.") How does this word sound?

The administrator will pause for the subject to respond. If the subject responds incorrectly to "bab", the administrator will point to "bab" and say it clearly. He will then ask the subject to repeat the word. No other test words will be pronounced by the administrator. The administrator will then continue by reading the following:

Some of the other words may be too hard for you to say. Try each one anyway because I want to find out which parts of each word you can say. I will tell you each time when I want you to say the next word. Say each word slowly and clearly. How do these words sound? (If necessary, the administrator will point to each word.)

Reading Instructions (continued)

If the subject fails to respond to a word within a few seconds, he will be encouraged to respond. If the subject fails to respond, the administrator will record a score of zero for the word and continue by pointing to the next word. A subject may go back and change his pronunciation of a word.

Appendix F: Reading of Symbols Items

1. dee
2. ap
3. nay
4. bim
5. rayed
6. kack
7. riz
8. shum
9. cag
10. len
11. weet
12. hend
13. fing
14. neap
15. wuff
16. suss
17. fy
18. twib
19. yox
20. rhunk
21. floke
22. pell
23. plad
24. nile
25. whie
26. hets
27. fime
28. sirk
29. wosh
30. lundy
31. hode
32. cheb's
33. toaf
34. rembay
35. yev
36. ying
37. spoze
38. gocks
39. reth
40. baim
41. bligh
42. vitnap
43. quox
44. jaist
45. phet
46. troil
47. pipped
48. sloy
49. gouch
50. zurdn't
51. thootch
52. wralt
53. sploonch
54. wubfambif
55. sube
56. screve
57. squow
58. cigbet
59. knomps
60. wrey
61. pelnidlun
62. cedge
63. bafmotbem
64. juence
65. goos
66. vawge
67. pnir
68. scraumb
69. gnouthe
70. cyr

Appendix G: Teacher Questionniare

TEACHER: ____________________ **SCHOOL:** ______________

PART 1: SPEECH-SOUND DISCRIMINATION

Have you worked with speech-sound discrimination?

yes no

If no please go to part 2 of this form (over).

Are you presently using speech-sound discrimination?

yes no

If no Approximately how long ago did you stop emphasizing this skill?

(a) 1 year ago

(b) 2 years ago

(c) 3 years ago

(d) 4 or more years ago

If yes For approximately how many years have you emphasized this skill?

(a) 1 year

(b) 2 years

(c) 3 years

(d) 4 years or more

Have you worked with speech-sound discrimination

in isolation? Y N

within words? Y N

with nonsense sound clusters? Y N

Teacher Questionniare (continued)

PART 2: LETTER-SOUND RELATIONSHIPS

Have you taught letter-sound relationships?

yes no

If no, you may disregard the remainder of this page.

Are you presently teaching letter-sound relationships?

yes no

If no Approximately how long ago did you stop emphasizing this skill?

(a) 1 year ago

(b) 2 years ago

(c) 3 years ago

(d) 4 or more years ago

If yes For approximately how many years have you emphasized this skill?

(a) 1 year

(b) 2 years

(c) 3 years

(d) 4 years or more

Have you worked with letter-sound relationships

in isolation? Y N

within words? Y N

with nonsense sound clusters? Y N