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# Auditory and Motor Aspects of Language Development in Males and Females

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The pattern of sex differences in reading ability which has emerged in large parametric studies in the U.S.A., Canada, England, Scandinavia, Germany, and elsewhere raises two fundamental issues. The first is that the sex differences must be taken seriously as an indication of *biological* differences in the neural organization of the brain. The sex ratios are too consistent to be the result of some spurious cultural accident.

The second issue is that rather than ignore the puzzle that what is "normal" for females is not "normal" for males, one can utilize this information to provide clues concerning which particular perceptual, motor and cognitive aptitudes combine to produce a fluent reader. Sex differences research seen in this regard becomes a *tool* to unraveling the mysteries of cognitive processing and not an end in itself.

This article focuses, therefore, on what aspects of reading difficulties are sex specific. This approach ignores all other possible causes of dyslexia such as brain damage, soft neurological signs, or deficiencies in sensory processing. It asks the question: Given perfectly normal brains, what factors could be involved when girls show little evidence of problems in learning to read whereas boys are often in difficulty?

To begin, I want to address and dispel three myths that have retarded our progress in understanding not only the sex differences but the reading process itself. The first myth is that sex differences arise because of sex-role stereotyping exclusively. If we could simply rearrange our sterotypes, the problem would disappear. As noted above, cross-cultural data make this extreme position untenable, but so, too, do other facts. It has been alleged, for example, that language skills are encouraged and fostered in females, but discouraged or neglected in males. This is an unwarranted position, because the preponderance of boys in remedial programs does not attest to behaviors that "discourage" or "neglect" male deficits. In fact, it is quite the opposite.

A cultural explanation, however, cannot be disposed of entirely because of certain cross-cultural data. There were few sex differences found in reading in an Israeli Kibbutz (Gross 1977) where reading is highly stereotyped as male; and in some British schools, boys outshine girls (Neville 1975; Johnson 1973–74). Verbal ability is highly emphasized and valued by the British middle and upper classes. Children in China also show few sex differences, which may be due to the pictorial nature of the written text, or to genuine social differences (Chang and Kuo 1973).

The important finding in the cross-cultural evidence is that by and large stereotyping reading as appropriate for one sex or the other has little effect on the performance of females, but a positive stereotype does have an effect on the performance of males.

The second myth is that males are developmentally retarded in physical, neurological, and psychological development with respect to females. Part of the evidence used to support this view is that the sex differences in reading are maximal in the first two grades of school, but diminish or disappear at later grades (Thompson 1975). In fact, though sex differences may disappear (Prange 1974), they are generally consistently found in all except high SES groups at the end of elementary school (Warren and Luria 1972; Forslund and Hull 1974; Jantz 1974; Wozencroft 1967; Clark 1967). Even if the differences are muted in the middle school years, they reemerge noticeably in adults (see Maccoby and Jacklin 1974) and are striking in elderly populations (McCoy 1978; Cohen and Wilkie 1979).

Furthermore, if a developmental lag theory is to be adopted, then it has to be modified considerably to account for the *earlier* onset of certain aptitudes in males. Thus, the most telling evidence against a global lag theory is the consistent finding in many cross-cultural studies of a male superiority in 3-D visuo-spatial problem solving. Pre-school boys were found to be accelerated in their ability to construct three-dimensional replicas of a model by age three, and the sex effect was highly significant at ages four and five, as shown in Table I (McGuinness, unpublished data). These sex differences are specific to 3-D tasks and are not found in 2-D tasks.

Similar sophistication in 3-D tasks in young males has been found in Scotland and Ghana by Jahoda (1979) and in the Pakeha of New Zealand (Brooks 1976). Piagetian conservation tasks, especially those involving quantity and area are solved at a *higher* developmental age by U.S. white boys (Lancaster, personal communication) and by boys in grades 3-6 in Papua, New Guinea (Shea and Yerua 1980). In the conservation tasks, although Papua boys were considerably retarded in terms of U.S. and European norms, they were two years ahead of the girls. One must ask: What then is "lagging?"

Table I.
Meantime and Error Scores in 2-D and 3-D Problem Solving in Pre-school Children.

JIGSAW—2D
Mean Time to Completion

| | Age 3 | Age 4 | Age 5 |
|---|---|---|---|
| Males | 127.0 | 89.0 | 78.7 |
| N | 19 | 22 | 14 |
| Females | 122.9 | 105.9 | 103.3 |
| N | 22 | 35 | 7 |
| Z | 0.14 | 1.29 | 0.15 |
| P | N.S. | p<.10 | N.S. |

LEGO BLOCKS—3D

| | Age 3 | Age 4 | Age 5 |
|---|---|---|---|
| Males | | | |
| Mean time | 47 | 36.7 | 20.25 |
| Errors | 1.95 | .66 | 1.08 |
| N | 20 | 24 | 12 |
| Females | | | |
| Mean time | 53.7 | 45.0 | 36.16 |
| Errors | 2.17 | 1.23 | 1.20 |
| N | 23 | 43 | 7 |
| Z | .90 | 1.84 | .169 |
| P | N.S. | p<.03 | p<.05 |

All errors N.A.

The third myth regards the nature of the perceptual skills involved in reading that still tends to persist. This is the view that reading has something to do with *vision*. Theories have been developed and tested that visual search, visual memory or visual-auditory pattern integration are involved in reading. Little support for these theories has been provided, at least for normal brains.

Visual confusion as represented by letter reversal problems was long thought to predict subsequent reading problems. However, no correlation between letter confusion in 5-6 year olds and later reading skills has been found (Calfee et al. 1975). Mason (1975) showed that good and poor readers were identical in visual search for letter targets when they were embedded in a nonsense string. When the stimuli were *words*, a difference emerged. Massaro and Taylor (1979) found that in both college and elementary school groups, target search accuracy was greater with regular or predictable orthographic structure than with words in which the frequencies or probabilities of letter *positions* were appropriate for English. In other words, the maximally useful code was a *phonemic* representation and not a visual one.

Though auditory-visual integration scores correlate with memory and vocabulary scores for 6-7 year old boys (not girls) (Jorgensen and Hyde 1974), this correlation shrinks dramatically when IQ is partialled out (Rae 1977), and accounts for only 9 percent of the variance in boys' reading achievement scores and none in the girls. A 15-week training program for 96 first graders on the Winterhaven perceptual battery revealed *no effect* whatsoever on subsequent reading scores over an age and I.Q. matched control population. Meanwhile, girls once again came out significantly ahead on the reading achievement battery (Seaton 1973).

Finally, one doesn't need to *see* to show symptoms of dyslexia. One of my students, Phyllis Lindamood, has just found that the same deficits in auditory sequencing ability on the Lindamood battery (Lindamood and Lindamood 1971), shown in normal children to correlate highly with reading disabilities (Calfee et al. 1973), also predicted performance on the Braille version of the WRAT in a population of 30 blind adults. Figure 1 illustrates the WRAT score range for subjects split above and below 90 percent accuracy on the Lindamood test.

## Environmental Factors in Reading Difficulties

The data reviewed by Finucci and Childs (see pp. 1–9) illustrate an interesting effect. In school populations, the sex ratio for dyslexia is found to range between 2.5-3.0:1.0. However, in clinical or remedial settings the ratio is as high as 5 or 6:1. These figures strongly suggest, as Finucci and Childs have noted, that there are two factors at work. One, I believe, is a biological factor—of whatever variety—which is outside culture; the other is *environmental* and shows that males are at risk to environmental factors which predispose against the acquisition of fluent reading skills.

It was noted above that in societies where reading is highly stereotyped as male or highly valued among males, sex differences either disappear or may tip the other way. Other data suggest that almost any aspect of environmental manipulation affects male scores. When the reading material is equated for interest of individuals, boys do as well as girls on reading tests, but when low interest material is involved, they do remarkably worse (Asher and Markell 1974). Testing procedures are important. Rowell (1976) tested 240 third-fifth graders on oral and silent reading comprehension. Girls did equally well on both tests, but boys were superior in oral reading compared to silent. When emphasis is on vocabulary, rather than fluency and comprehension, males are often found to be superior (Brimer 1969 [England]; Alexander et al. 1968 [United States]; Gies et al. 1973 [United States]). Training methods make a

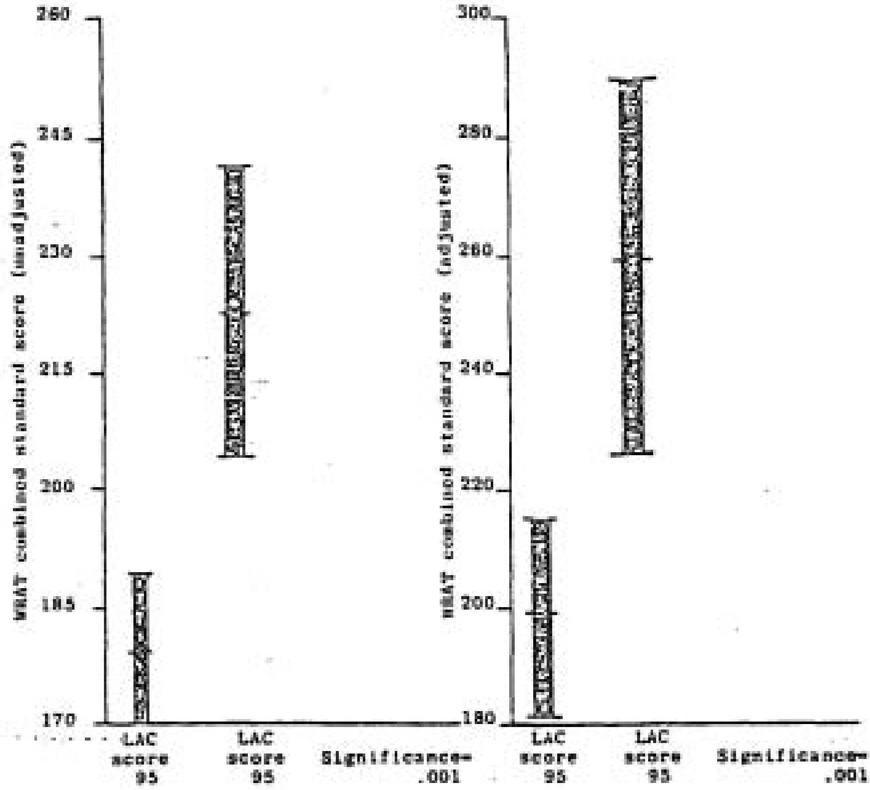


FIGURE 1. Range of scores of 30 blind young adults on the WRAT for those below and those above 90 percent accuracy on the Lindamood Auditory Comprehension Test.

difference. In phonics oriented classrooms, where sound blending is encouraged, females improve significantly over males (Farmer et al. 1976 [English sample]). Gies et al. (1973) found that vocabulary scores were significantly higher in boys in closed classroom environments compared to open class environments. Girls scored higher than males on other language abilities regardless of classroom.

Racial differences are also noticeable in U.S. samples with black males superior to black females (Asbury 1973) and to white males (Henderson et al. 1971). Low SES and minor birth complications also play a role in diminishing male reading ability in Denmark (Hesselholdt and Aggerholm-Madsen 1974) and the U.S.A. (Gies et al. 1973) as well as emotional maladjustment (Lanthier and Deiker 1974). Yule and Rutter (1968) found in a British sample that boys were referred for therapy because of antisocial tendencies and these correlated highly with reading deficits. Girls were referred more often because of neurotic symptoms which did not correlate with reading ability. Manipulating anxiety and reinforcement contingencies strongly affect male but not female reading scores in 9–11 year olds (Cotler and Palmer 1971).

In Lanthier and Deiker's (1974) study of 117 adolescent inpatients, it was found that male, but not female, reading and math achievement scores were significantly correlated to parent scores, especially those of the *mother*. The effect of the sex constitution of families turns out to be an extremely important variable in male reading achievement. Cicirelli (1967) studied 600 middle class white families. In the population as a whole females were superior on the verbal elaboration sub-test of the Minnesota Creative Thinking battery and on the California Language Achievement test. When Cicirelli looked at the sex of siblings in two-, three-, and four-child families, the general finding was that boys' performance on language tests increased noticeably (as did IQ scores) if they had at least one female sibling in families with more than two children. Male-only siblings in three and four child families showed a mean reduction in IQ of seven points and one standard deviation lower on reading scores.

An obvious conclusion from these data is that females are more *spontaneously* gifted in language and reading skills (at least in non-black populations) and that these abilities are not diminished by low SES, emotional troubles, size, or sex-constitution of the family, whereas male reading ability is affected by all these factors.

These data bring us to the crux of the nature-nurture issue. In a constant environment sex differences are found to emerge—a biological program. In extreme environments the performance of males, not females, swings dramatically. Males are at *risk* to many environmental situations. One might ask: Is the *predisposition* to risk also biological? The interactive process of biology and environment is thrown into high relief, and to say merely that nature and nurture interact gets us nowhere. In a remarkable paper on the genetic and developmental basis for cognitive functioning, Scarr (in press) proposes that we can escape from a nature-nurture bind by rephrasing the question. She asks instead: what is *easy* or *difficult* to learn? What is easy is least upset by environmental factors and most biologically programmed. What is difficult is least biologically programmed and most influenced by the environment. Walking and talking are universally human. Reading is not. It is a cultural invention. Nevertheless, females find it *easy* to learn to read; males find it *difficult*. The question is why?

If stereotyping, developmental lag and visual perceptual skills are ruled out as major contributing variables, what then is involved? The remainder of this article explores the evidence for sex differences in auditory and motor skills and the correlates of language function and reading achievement. A theory, is proposed (more fully elaborated in a paper by McGuinness and Pribram, 1978) that motor functions develop differently in boys and girls and that it is in sensory-motor integration that the sex differences become most pronounced. This view is similar to the hypothesis put forward by Waber (1979) in which she emphasized that it may be in cross-modal integration where sex effects are maximal. The theory here is more specific: that in girls auditory-fine motor systems are integrated to produce greater linguistic ability: a *communicative* mode of information acquisition; whereas in males visuo-gross-motor systems conjoin to produce greater aptitude in sport and in visuo-spatial problem solving: an *action* mode of information acquisition.

## Neurophysiological Correlates of Language

Two lines of research converge on the notion that speech and language skills depend upon maturity of auditory pathways and fine-motor systems and that these are coordinated in the left hemisphere of the brain initially, though in females may be represented more bilaterally (McGlone 1980).

The first body of evidence is reviewed by Netsell (in press). During the acquisition of speech (3-12 months) several neural systems begin to myelinate simultaneously. These are the fine-motor systems involving the extrapyramidal tract, middle cerebellar peduncle and corpus striatum, and the post thalamic auditory relays. (Visual relays are completely myelinated at birth and consolidated at 3-4 months.) These maturational landmarks accompany a dramatic shift from primitive respirational and nasal noises to the production of a range of vowels, diphthongs and consonants. The auditory pathways continue to myelinate until the fourth-fifth year, though words appear as most of the sensory-motor pathways are completely hard-wired between 12–24 months. It is interesting that at this age talking and walking rarely occur simultaneously, which suggests that they may be initially competing for the same neural substrate, *or* that one type of neural organization inhibits the other. This may have profound implications for speech development in males who are notoriously more mobile than females, especially with respect to whole-body movement (see McGuinness and Pribram 1978).

The spatial-temporal coordination of fine-motor mid-line systems (vocal tract, velopharynx, tongue, lips) mature at about 3-4 years and first involve micro-timing or coordination of these systems and secondarily phase interactions involving the duration of activity in these systems (Gilbert and Purves 1977). Netsell (in press) establishes a developmental chart for these speech progressions, but this has yet to be tested systematically.

The second piece of evidence on neural organization is the finding by Kimura (1977) that transitional fluency of motor behavior (that aspect of fine-motor timing that is most precise) correlates with the severity of aphasia in left-hemisphere damaged patients. Highly aphasic subjects who were required to carry out a sequence of manual operations were most retarded in efficiency (*not* sequencing ability) and produced significantly more hesitations and perseverations.

### Sex Differences in Auditory and Fine-Motor Skills

Though the evidence reviewed below is sparse, it does support the contention that females show greater aptitude in speech development, auditory integration and fine-motor control. Sensitivity to loudness is significantly greater in females, in children (Elliott 1971) and young adults (McGuinness 1972). Threshold shift—an effect which shows auditory sensitivity to noise by increasing inhibition—is greater in females over ages 4–11 years (Siegenthaler and Barr 1967). In the over 50s, males were found to have significantly more hearing loss and poor speech discrimination scores in 60 subjects with no known hearing deficit (McCoy 1978). These findings confirm those in the survey carried out by Corso (1959) in which females were found to have superior hearing to much later ages. These data suggest a greater sensitization to auditory signals in females.

However, the auditory system is not a unitary system exhibiting equal facility in all domains. In the McGuinness (1972) study, males and females were found to be similar in performance on the threshold task up to approximately 4,000 Hz and identical on a difficult pitch discrimination task when years of musical training were taken into account. Furthermore, the scores on the various auditory tests were uncorrelated. The overwhelming sex difference occurred in sensitivity to loudness (Figure 2). Should this sex effect be maintained in loudness discrimination, as would be predicted from studies investigating the slope of the loudness function, this would indicate that females would have a considerable advantage in processing information concerning the *dynamics* of speech which conveys emotional quality. This would result in females extracting information about the emotional aspects of speech before semantic processing had begun. Support for this view comes from studies by Shuter (1968) showing female musicians to have greater awareness of musical dynamics than males and in investigations of mother-infant interactions showing that females are more consoled by their mother's speech, and that speech increases their babbling rate to the mother (Lewis 1972). Lewis describes this as proximal and distal stimulation—the latter comforts females but not males. This interaction is of primary interest because it has not been found that mothers speak differently to sons or daughters (Phillips 1973; Fraser and Roberts 1975).

Auditory sensitivity is also accompanied by a more precocious speech development in girls. Moore (1967) found in an English sample that scores on the Griffiths Speech Quotient were higher in girls at age 6 months, and that by 18

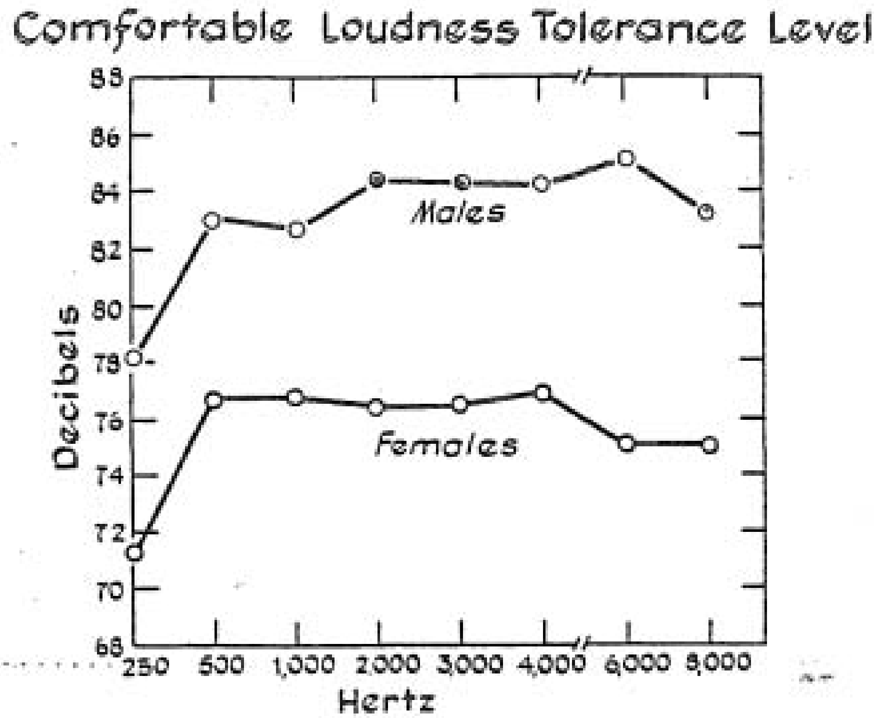


FIGURE 2. Comfortable loudness levels for 25 male and 25 female college students.

months this difference was significant ($p=.01$). The mean score for girls at 6 months was 104, for boys at 18 months, 101! Speech quotient scores were not found to correlate with vocalization, as has been found by Smith and Connolly (1972) when they contrasted vocal output per se with *talking* in pre-schoolers. Furthermore, the speech quotient scores at both 6 and 18 months were highly correlated with subsequent language development in girls tested at 3, 5 and 8 years, but not in boys. Only tests given at 3 years were found to correlate with subsequent ability in boys, and the best predictor was a performance scale (Griffiths S.Q.).

By age 2 to 2½ years children are completing their repertoire of consonants. In 90 children Paynter and Petty (1974) found that there was no significant difference between boys and girls at age 2, but by age 2½ many more girls had added the final most complex sounds: s, l, st, r to their repertoire. When sounds were scored as occurring in 90 percent of all cases, boys had 5 consonants, girls, 7. SES was not a factor. By 4–5 years males are found to produce more dysfluencies (hesitations, revisions) than girls, though this only occurred in a middle class population (Brownnell 1973). Similarly, boys have considerably more trouble singing in tune (Bentley 1968; Roberts 1972) and are subject to speech disorders more often than girls (Hull et al. 1971; Ingram 1975). Verbal fluency remains higher in girls at 6 years (Spring 1975), from 6–13 years (Gaddes and Crockett 1975), and in cross-cultural studies of Czechoslovakian children (Potasova 1975), and Nepalese adults (Thomas et al. 1978), while being resistant to interference from conflicting cues, as in the Stroop Test (Golden 1974).

In auditory discrimination tests perception of cv syllables or words, it has been found that when the lag time is increased between presentation to right or left ears, females are superior at all ages tested, 7–15 years (Mirabile 1978), and in visual presentation of words, increasing interstimulus delays between words retards learning in college males, but not in females (King 1975). The conclusion of these authors is that females need fewer available cues to maintain verbal information and are superior temporal processors, benefitting maximally in the Mirabile study by asynchronies in onset time.

The issue of timing is an important one because it may tell us something about the relationship between reception and production—in that it is possible that they both engage similar motor programs—and that it is the *capacity* to generate such temporal programs that may be a critical distinction between the sexes. Evidence supporting a *general* motor capacity underlying language comes from a study of 5–7 year old deaf children by Gaffney (1977) where he investigated receptive language in response to signing. Girls were significantly better overall in complex linguistic aspects of syntax, word order, inflection and interrogation. This superiority was independent of I.Q., hearing impairment, and months of schooling.

A greater female aptitude in fine-motor sequencing ability has been found by Annett (1970) and by Denckla (1973, 1974) in two studies of children who were asked to produce a series of movements between thumb and fingers as rapidly as possible. Girls' superiority over boys actually increased from ages 5 to 10. Boys did not improve after 8 years. Repetitive tapping showed no effect of sex. Heel-toe sequences were also performed faster by females ages 8–10 (the only ages tested). In an unpublished study we found that teaching a simple 16-bar dance sequence to 8 novice females was accomplished in one or two trials. By contrast several males of the 8 tested were unable to make transitions between movements although they understood the patterns and the sequence perfectly well.

Hand posture has been found to differentiate good and poor readers, and in a sample of 167 children aged 6–10 years, females had significantly more normal hand postures than males (Allen and Wellman 1974). The trend to normal posture increased with age. A high degree of motor lateralization does not appear to be involved in the hand posture result, as findings by Kershner (1978) show the opposite, that highly lateralized 9 and 11 year old males (hand, eye, foot and ear concordance of either side) are more often the poorest readers. Lateral concordance was never so pronounced in females and was unrelated to reading ability.

In cross-modal research the few studies investigating sex differences show that effects are most pronounced when information has to be transformed and *not* in recognition tasks. Auditory-visual integration studies sometimes show sex differences (Reilly 1971) and sometimes not (Jorgenson and Hyde 1974; Rae 1977; Ward 1977). In a study measuring speed of tapping from a stimulus item to a target in a display of response cards, college females were found to be superior in tasks of color:color, color:name, shape:name. No sex differences were found in shape:shape conditions. When the response card matrix was scrambled on every trial as a control for memory, females improved noticeably to males by an average of 5–7 seconds in most conditions

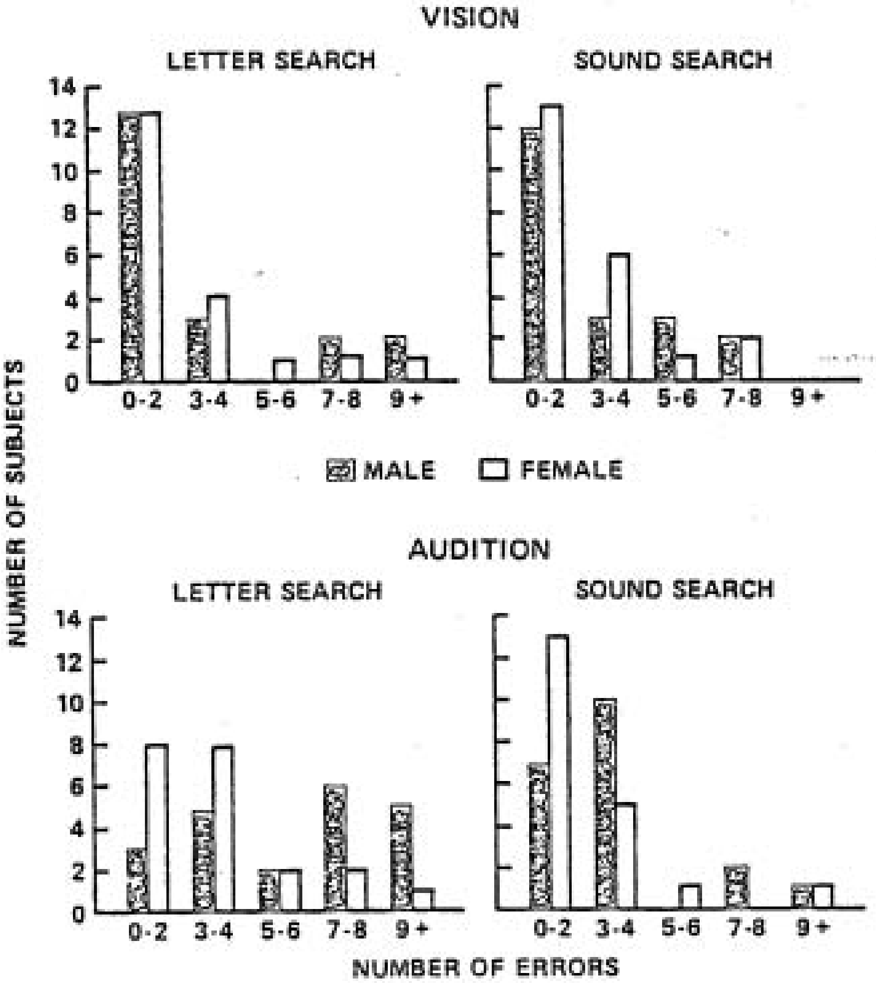


FIGURE 3. A histogram of the error scores for 50 college males and females in searching for a target letter or a target sound in words presented visually or auditorially.

(Majeres 1977). The author concludes that it is the translation to a *verbal* code that produces the efficient response in females. Similar results in a decoding task were found by Decker and DeFries (1980).

Evidence to support Majeres' conclusions comes from a study in our laboratory (McGuinness and Courtney, in preparation) in which college males and females were asked to search for target letters (A or I) or target sounds (eh or ae) in words presented visually or auditorily. In the visual condition when searching for letters or for sounds, the sexes did not differ noticeably in reaction time or error scores. However, when asked to identify, a sound in a spoken word, males made significantly more errors than females, and performed *at chance levels* when asked to determine whether a target *letter* was present in a spoken word. The error data for all conditions are illustrated in Figure 3. These are surprising results for a highly verbal university population in Great Britain; and suggest males have great difficulty translating an auditory phonemic code into its visual counterpart.

Haptic cross-model tasks involving transition to all possible modes showed no sex effects in 99 6-year-olds (Gurucharri 1974). In this study and one involving haptic training (Tyler 1978), haptic discrimination was found to correlate with reading performance, but no control for IQ was attempted, which as Rae (1977) showed for auditory-visual cross-modal processing, accounted for nearly all the variance in the reading relationship. In a better controlled study Hurley (1968) found that performance on tasks involving visual-tactile-kinesthetic integration was unrelated to reading ability.

### From Perception to Production to Reading

The evidence is overwhelming that females are *fluent* processors not only of speech and motion, but also in certain auditory discrimination tasks. Does this fluency have anything to do with reading? The data, on this issue, point to a *consistent* relationship between receptive language systems and reading attainment.

In a study of 48 children Lexier (1979) tested auditory discrimination of discrete phonemes, auditory blending, and phoneme segmentation. Blending scores correlated to reading ability $r=.52$, segmenting at $r=.44$. Simple discrimination was not related. Sex differences were not reported. Sex differences were found, however, in a similar battery of auditory tasks, which also included letter memory, and digit span (Jarvis 1974). Females (age 7) were superior across the three schools tested. The strongest relationship to reading was auditory comprehension. This finding has been confirmed by Jackson and McClelland (1979) who found that listening comprehensions showed the highest relationship to reading ability, along with speed of letter naming.

In a large normative study, 660 children aged 5–11 years were tested on complex auditory discrimination task (the Lindamood LAC test) involving assigning phonemes to colored blocks (Lindamood and Lindamood 1971; Calfee et al. 1973). If the match is to 2 or 3 isolated phonemes, the test does not do particularly well in discriminating good from poor readers. If, however, the listener is asked to *operate* on the information, performing various transformations, such as "if that is 'aps' show me: 'asp.' " Poor readers of *all* ages have considerable difficulty. This deficit in dealing with phonological recoding is also documented in a series of studies (Mason 1978) in which good and poor readers were similar in time to read familiar high-frequency words (lexical access) but poor readers became severely retarded when trying to name non-words. Considerable evidence has been amassed to support these findings in Liberman's laboratory (see pp. 151–167). These data suggest that what may be required in reading is a transformation from the visual information to phonological and/or *motor* programs—that subserve listening to speech or generating it, or both. It is also possible that information from speech signals is stored in the auditory system as phase relationships in dendrite networks, so that imitation of speech and the subsequent generation of language operate on similar programs, in an input-output relationship. If this were not at least partially true, then we could not explain the uncanny ability to imitate. Another possibility is that these programs are stored independently but regulated by a third superordinate system which correlates the two. It seems clear from a wide range of data that naming (semantics, the lexicon, etc.) and syntax (the *rules* of generating linguistic strings) are independent systems from those which receive speech information and generate fluent utterances. This may explain why sex differences are rarely found on tests of vocabulary.

Although females are somewhat more advanced in learning letter names (Iverson et al. 1970), the problem in learning to read is not one of *remembering* which sounds are attached to which letters. The problem is rather being able to make the letter-sound transform at *sufficient speed* to be able to generate a word. The sex effect appears to be determined in large part by the speed at which these transform operations occur. It is of course not surprising that if one is efficient (faster and less effort) in a perceptual-motor skill that underpins a cognitive process, then that cognitive process will be favored over others. This of course leads to an explanation of why females persist in adopting verbal strategies when these are inappropriate to the task, such as in spatial reasoning, and secondly provides a hypothesis about why they do poorly in algebra and especially poorly in geometry and trigonometry. Mathematics, a language describing objects in space, is more related to syntax than to phonics. It is impossible to "talk mathematics" or communicate it verbally; hence the reason mathematicians inevitably retreat to blackboards or table napkins when asked what they are "talking about."

This has been an attempt to distill out of a maze of tangled threads what might underlie sex effects in reading disability. So far many of the studies on auditory processing deficits in poor readers do not report sex effects except in spelling scores. Mason (1975) doesn't report on the sex of her subjects. Often where sex is reported, subjects are selected because they are "poor readers" or "good readers." For example, the Calfee et al. (1973) study reports no sex differences, but one child of each sex was selected both from above and below the class median—thus biasing the sample to an excess of poor females and good males. Furthermore, motor sequential fluency has never been tested in conjunction with reading in normals, though the simple Denckla paradigm is an admirable starting place.

All one can conclude so far is that the strongest predictor of reading ability is phonological encoding and a general "language" facility. Females appear adept in both.

### A Sociobiological Speculation

The last puzzle is of course, *why* this should be the case. Why questions, in terms of evolution, are perhaps silly questions, but tempting to answer. The linguistic facility in females has a decided selective advantage in care-taking and in the emergence of *sharing*, thought by many anthropologists and primatologists to be a key factor in the evolution of human social systems. Sharing involves not only the distribution of food, but also of work: organizing working parties, baby sitting arrangements, or *any* division of labor (a hallmark of human groups). These activities profit immeasurably from linguistic competence. Several authors have made convincing cases for the important role of female-specific skills in human evolution (Lancaster 1978; McGuinness 1979; Fisher 1979).

Further, mothers are *teachers*. Bruner (1978) has documented the exquisite sensitivity of linguistic "tuning" in mother-infant interactions—the mother pressing ever more precision on her offspring's utterances as well as developing the pragmatic aspects of speech. Fathers do not appear to share this intimate tuning sensitivity to their offspring's level of production and competence (McGaughlin personal communication), at least until woodwork and football are involved in the interaction.

In humans the division of labor gave rise to sex-specific activities: gathering, hunting small game, and cooking to females, and hunting large game to males. It has been suggested that extensive sharing initially began between females and infants and progressed to females and adult kin, females and juvenile *sons* (who are usually driven out) and finally females and mates. The human social system probably became established when males bought into a female kinship group.

It is also quite possible that males were important as scouts and defenders—their primary role in all non-human primates, ultimately developing skill in aimed throwing and in chasing and capturing large game. Kinesthetic whole body motion becomes integrated with vision in 3-dimensions.

This gives males an advantage in the world of large animals, large objects (shelters) and objects in motion.

It must be noted, despite the persistence of Darwinian views that language developed through "hunting," that the essence of the hunt is *silence* and that the typical vocalizations of all non-human primate males' signal: "Get out of here!" (Mitchell, 1979), scarcely an inducement to communicative rapport.

## References


Alexander, T., Stoyle, J., and Kirk, C. 1968. The language of children in the "inner city." *Journal of Psychology* 68:215–221.

Allen, M., and Wellman, M.M. 1974. Hand position during writing; Cerebral laterality and reading: Age and sex differences. *Dissertation Abstracts International* 38A, 2011.

Annett, M. 1970. The growth of manual preference and speech. *British Journal of Psychology* 61:545–558.

Asbury, C.A. 1973. Cognitive correlates of discrepant achievement in reading. *Journal of Negro Education* 42:123–133.

Asher, S.R., and Markell, R.A. 1974. Sex differences in comprehension of high and low interest reading material. *Journal of Educational Psychology* 66:680–687.

Bentley, A. 1968. *Monotones.* London: Novello & Co.

Brimer, M.A. 1969. Sex differences in listening comprehension. *Journal of Research and Development in Education* 3:72–79.

Brooks, I.R. 1976. Cognitive ability assessment with two New Zealand ethnic groups. *Journal of Cross Cultural Psychology* 7:347–356.

Brownnell, W.W. 1973. The relationship of sex, social class and verbal planning to the disfluencies produced by nonstuttering children. *Dissertation Abstracts International* 34A:888.

Bruner, J.S. 1978. Learning the mother tongue. *Human Nature* 1:42–49.

Calfee, R.C., Fisk, L.W., and Piontkowski, D. 1975. "On-Off" tests of cognitive skill in reading acquisition. *In* M.P. Douglas (ed.), *Claremont Reading Conference 39th Yearbook.* Claremont, California; Claremont Graduate School.

Calfee, R.C., Lindamood, P., and Lindamood, C. 1973. Acoustic-phonetic skills and reading. Kindergarten through twelfth grade. *Journal of Educational Psychology* 64:293–298.

Chang, C., and Kuo, S. 1973. The relationship between verbal complexity and paired-associate learning and retention in elementary school children. *Bulletin of Educational Psychology* 6:1–13.

Cicirelli, V.G. 1967. Sibling constellation, creativity, I.Q. and academic achievement. *Child Development* 38:481–490.

Clark, E.T. 1967. Sex differences in the perception of academic achievement among elementary school children. *Journal of Psychology* 67:249–256.

Cohen, D., and Wilkie, F. 1979. Sex-related differences in cognition among the elderly. *In* M.A. Wittig and A.C. Petersen (eds.), *Sex-Related Differences in Cognitive Functioning.* New York: Academic Press.

Corso, J.F. 1959. Age and sex differences in thresholds. *Journal of the Acoustic Society of America* 31:498–507.

Cotler, S., and Palmer, R.J. 1971. Social reinforcement, individual difference factors, and the reading performance of elementary school children. *Journal of Personality and Social Psychology* 18:97–104.

Decker, S.N., and DeFries, J.C. 1980. Cognitive abilities in families with reading disabled children. *Journal of Learning Disabilities* 13:517–522.

Denckla, M.B. 1973. Development of speech in repetitive and successive finger-movement in normal children. *Developmental Medical Child Neurology* 15:635–645.

Denckla, M.B. 1974. Development of motor co-ordination in normal children. *Developmental Medical Child Neurology* 16:729–741.

Elliott, C.C. 1971. Noise tolerance and extraversion in children. *British Journal of Psychology* 62:375–380.

Farmer, A.R., Nixon, M., and White, R.T. 1976. Sound blending and learning to read: An experimental investigaton. *British Journal of Educational Psychology* 46:155–163.

Fisher, E. 1979. *Woman's Creation*. N.Y.: Anchor Press/Doubleday.

Forslund, M.A., and Hull, R.E. 1974. Teacher, sex and achievement among elementary school pupils. *Education* 95:87–89.

Fraser, C., and Roberts, N. 1975. Mother's speech to children of four different ages. *Journal of Psychological Research* 4:9–16.

Gaddes, W.H., Crockett, D.J. 1975. The Spreen-Benton Aphoria Tests, normative data as a measure of normal language development. *Brain and Language* 2:257–280.

Gaffney, D.W. 1977. Assessing receptive language skills of five to seven year old deaf children. *Dissertation Abstracts International* 38:1665–1666.

Gies, F.J., Leonard, B.C., Madden, J.B., and Jon, J. 1973. Effects of organizational climate and sex on the language arts achievement of disadvantaged sixth graders. *Journal of Educational Research* 67:177–181.

Gilbert, J., and Purves, B. 1977. Temporal constraints and consonant clusters in child production. *Journal of Child Language* 4:417–432.

Golden, C.J. 1974. Sex differences in performance on the Stroop color and word test. *Perceptual and Motor Skills* 39:1067–1070.

Gross, A.D. 1977. Sex differences in an Israeli kibbutz system: Reading disabilities, maturation and sex-role standards. *Dissertation Abstracts International* 38A:1998.

Gurucharri, K.A. 1974. Haptic performance and first-grade reading achievement. *Dissertation Abstracts International* 38A:1998.

Henderson, N.B., Gotteney, B., Butler, B.V., and Clarkson, Q.D. 1971. Differential rates of school promotion from the first grade for white and Negro, male and female 7-year olds. *Psychology in the Schools* 8:101–109.

Hesselholdt, S., and Aggerholm-Madsen, G. 1974. Process and product in the marble-board test. The biosocial interaction and reading ability. *Skolepsykologi* 11:277-303.

Hull, F.M., Mielke, P.W., Timmons, R.J., and Willeford, J.A. 1971. The national speech and hearing survey: Preliminary results. *ASHA* 3:501–509.

Hurley, O.L. 1968. Perceptual integration and reading problems. *Exceptional Children* 35:207-215.

Ingram, T.T.S. 1975. Speech disorders in childhood. *In* E. H. and E. Lenneberg (eds.). *Foundation of Language Development*. N.Y.: Academic Press.

Iversen, I.A., Silberberg, N.E., and Silberberg, M.C. 1970. Sex differences in knowledge of letter and number names in kindergarten. *Perceptual and Motor Skills* 3:79-85.

Jackson, M.D., and McClelland, J.L. 1979. Processing determinants of reading speed. *Journal of Experimental Psychology (General)* 108:151–181.

Jahoda, G. 1979. On the nature of difficulties in spatial-perceptual tasks: Ethnic and sex differences. *British Journal of Psychology* 70:351–363.

Jantz, R.K. 1974. The effects of sex, race, I.Q. and SES on reading scores of sixth graders for both levels and gains in performance. *Psychology in the Schools* 11:90–94.

Jarvis, E.O. 1974. Auditory abilities of primary school children. *Dissertation Abstracts International* 35A:890–891.

Johnson, D.D. 1973–4. Sex differences in reading across cultures. *Reading Research Quarterly* 9:67–86.

Jorgenson, G.W., and Hyde, E.M. 1974. Auditory-visual integration and reading performance in lower social-class children. *Journal of Educational Psychology* 66:718–725.

Kershner, J.R. 1978. Lateralization in normal 6-year olds as related to later reading disability. *Developmental Psychobiology* 11:309–319.

Kimura, D. 1977. Acquisition of a motor skill after left-hemisphere brain damage. *Brain* 100:527–542.

King, D.J. 1975. Sex differences in learning connected discourse as a function of exposure and interitem interval. *Psychological Reports* 37:191–194.

Lancaster, J.B. 1978. Carrying and sharing in human evolution. *Human Nature* 1 (Feb.).

Lanthier, I.J., Deiker, T.E. 1974. Achievement scores of emotionally disturbed adolescents and parents educational level. *Child Study Journal* 4:163–168.

Lewis, M. 1972. State as an infant-environment interaction: An analysis of mother-infant interaction as a function of sex. *Merrill-Palmer Quarterly* 18:95–121.

Lexier, K.A. 1979. Auditory discriminability, blending and phoneme segmentation ability: Exploring basic skills in reading acquisition. *Dissertation Abstracts International* 2469A–2470A.

Lindamood, C.H., and Lindamood, P.C. 1971. *Lindamood Auditory Conceptualization Test.* Boston: Teaching Resources Corp.

Maccoby, E.E., and Jacklin, C.N. 1974. *The Psychology of Sex Differences.* Stanford, California: Stanford University Press.

Majeres, R.L. 1977. Sex differences in clerical speed. Perceptual encoding vs. verbal encoding. *Memory and Cognition* 5:468–476.

Mason, M. 1975. Reading ability and letter search time: Effects of orthographic structure defined by single letter positional frequency. *Journal of Experimental Psychology (General)* 104:146–166.

Mason, M. 1978. From print to sound in mature readers as a function of reader ability and two forms of orthographic regularity. *Memory and Cognition* 6:568–581.

Massaro, D.W., and Taylor, G.A. 1979. Reading ability and the utilization of orthographic structure in reading. Technical Rep. #515. Madison: Wisconsin Research and Development Center for Individualized Schooling.

McCoy, C. 1978. Experimental study of hearing in the aged as measured by pure tones, word discrimination and the SSW. *Dissertation Abstracts International* 38:4719.

McGlone, J. 1980. Sex differences in human brain assymetry: A critical survey. *The Behavioral and Brain Sciences* 3:215–264.

McGuinness, D. 1972. Hearing: Individual differences in perceiving. *Perception* 1:465–473.

McGuinness, D. 1979. Was Darwin conscious of his mother. *In The Re-evaluation of Existing Values and the Search for Absolute Values.* New York: International Cultural Foundation.

McGuinness, D., and Courtney, A. In preparation. Sex differences in visual and phonetic search.

McGuinness, D., and Pribram, K.H. 1978. The origins of sensory bias in the development of gender differences in perception and cognition. *In* M. Bortner (ed.). *Cognitive Growth and Development: Essays in Memory of Herbert G. Birch.* New York: Brunner/Mazel.

Mirabile, P.J., Porter, R.J., Hughes, L.F., and Berlin, C. T. 1978. Dichotic lag effect in children 7–15. *Developmental Psychology* 14:277-285.

Mitchell, G. 1979. *Behavioral Sex Differences in Non-human Primates.* New York: Van Nostrand Reinhold.

Moore, T. 1967. Language and intelligence: A longitudinal study of the first 8 years. *Human Development* 10:88–106.

Netsell, R. In press. The acquisition of speech motor control: A perspective with directions for research. *In* R. Stark (ed.). *Language Behavior and Early Childhood.* Amsterdam: Elsevier.

Neville, M. 1975. Effectiveness of rate of aural message on reading and listening. *Education Research* 18:37–43.

Paynter, E.T., and Petty, N.A. 1974. Articulatory sound: Acquisition of two-year-old children. *Perceptual and Motor Skills* 39:1079–1085.

Phillips, J.R. 1973. Syntax and vocabulary of mother's speech to young children. Age and sex comparisons. *Child Development* 44:182–185.

Potasova, M. 1975. Speech development in collectively reared preschool children. *Psychologia a Patopsychologia Dietata* 10:43–60.

Prange, J.L. 1974. An investigation of the relationships obtaining between Cloze test measures of reading, performance and measures of critical reading, general reading, intelligence and sex. *Dissertation Abstracts International* 34A:6459.

Rae, G. 1977. Auditory-visual integration, sex, and reading ability. *Perceptual and Motor Skills* 45:826.

Reilly, D.H. 1971. Auditory-visual integration, sex and reading achievement. *Journal of Educational Psychology* 62:482–486.

Roberts, E. 1972. Poor pitch singing. Unpublished Ph.D. thesis. University of Liverpool.

Rowell, E.H. 1976. Do elementary students read better orally or silently? *Reading Teacher* 29:367–370.

Seaton, H.W. 1973. The effects of visual perception training on first grade reading achievement. *Dissertation Abstracts International* 34A:1155.

Scarr, S. In Press. Comments on psychology, genetics and social policy from an anti-reductionist. Paper presented at the Conference: *Psychology and Society: Psychology Second Century, Enduring Issues*, Houston. To be published: Holt, Rinehart & Winston.

Shea, J.D.C., and Yerua, G. 1980. Conservation in community school children in Papua New Guinea. *International Journal of Psychology* 15:11-25.

Shuter, R. 1968. *The Psychology of Music.* London: Methuen.

Siegenthaler, B.M., and Barr, C.A. 1967. Auditory figure-background perception in normal children. *Child Development* 38:1163-1167.

Smith, P.K., and Connolly, K. 1972. Patterns of play and social interaction in preschool children. *In* N. Blurton-Jones (ed.). *Ethological Studies of Child Behavior.* Cambridge: Cambridge University Press.

Spring, C. 1975. Naming speed as a correlate of reading ability and sex. *Perceptual and Motor Skills* 4:134.

Thomas, L.L., Curtis, A.T., and Bolton, R. 1978. Sex differences in elicited color lexicon size. *Perceptual and Motor Skills* 47:77–78.

Thompson, B.G. 1975. Sex differences in reading attainment. *Education Research* 18:16–23.

Tyler, E.J. 1978. Interaction effects of readiness level and type of form discrimination emphasis on training and transfer in young children. *Dissertation Abstracts International* 39A:790–791.

Waber, D.P. 1979. Cognitive abilities and sex-related variations in the maturation of cortical functions. *In* M.A. Wittig and A.C. Petersen (eds.). *Sex-Related Differences in Cognitive Functioning.* New York: Academic Press.

Ward, L.O. 1977. Variables influencing auditory visual integration in normal and retarded readers. *Journal of Reading Behavior* 9:290–295.

Warren, G.H., and Lura, Z. 1972. Evaluation set and creativity. *Perceptual and Motor Skills* 34:436–438.

Wozencroft, M. 1967. A comparison of the reading abilities of boys and girls at two grade levels. *Journal of Reading Specialist* 6:136–139.

Yule, W., and Rutter, M. 1968. Educational aspects of childhood maladjustment: Some epidemiological findings. *British Journal of Educational Psychology* 38:7-13.