# Biology and the Right Brain

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Humans begin their existence as a right hemisphered, spatially perceiving animal (Sperry 1975). Within four weeks after birth, infants are able to visualize spatial dimensions of objects within their environment (Aronson and Rosenbloom 1971). Recently, Yonas, Cleaves and Petterson (1978) found that infants as young as 26 weeks old were able to record pictorial depth perceptually. Vurpillot (1976) suggested that hapatic exploration is well coordinated with spatial perception by three months of age. During this time, alpha rhythms from the occipital lobe are frequently recorded and neural differentiation within the cortices emerges. Indeed Molfese (1977) recorded strong electroencephalograph (EEG) readings from the right hemisphere when "nonspeech" sounds were aroused in four month old infants. Basic speech sounds elicit similar responses from the left hemisphere.

As the child ages, greater and greater asymmetry of the neural hemispheres are noted. The expanding environmental scene is appreciated more by cortical centers on the right side while linguistic well-ordered stimuli are directed to centers on the left. By the time an individual has reached adolescence the brain hemispheres have become highly specialized in performing most of the cognitive tasks. Contemporary psychoneurological studies indicate that verbal, linear, and analytical phenomena are analyzed in the left hemisphere while nonlinguistic, spatial, and experimental phenomena are processed in the right hemisphere. Roger Sperry, a recent Nobel laureate and pioneer in split brain experimentation, has classified the reasoning of the right hemisphere as "holistic and unitary rather than analytic and fragmentary, orientational more than focal, and concrete perceptually insightful rather than abstract, symbolic and sequential" (Sperry 1964, p. 11).

The two hemispheres are in close consultation, continuously exchanging information across a wide band of neurons that cross the lower third of the sagittal sulcus. Brain researchers term this band the corpus collosum. (Figure 1) Neuroanatomists have found that this commissural connection is composed of more than 200 million myelinated nerves that traverse the two corticas making it the largest fiber bundle in the brain (Cotman and McGaugh 1980).

Perhaps even more interesting is the fact that although humans begin their existence perceiving spatially, they rely more and more heavily on verbal-analytical information processing as they get older (Dean 1976). Many suggest that the shift is primarily the result of social and educational requirements placed on the child by the culture (Vurpillot 1976; Gardner 1975) while others argue that it is innately built into one's maturation process (McFee 1973; Gibson and Walk 1961). At any rate, by the time an individual is 10 years old, she/he will tend to favor either a verbal-analytical or a holistic-spatial ap-

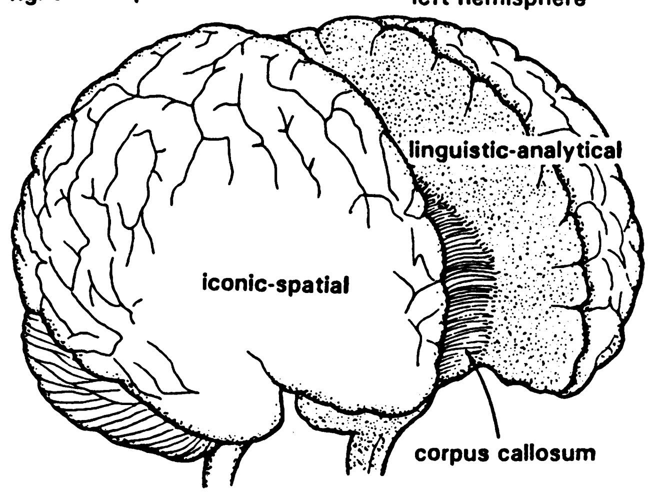


FIGURE 1.

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TABLE 1. Two-Way Analysis of Variance on the Right Hemisphere Tests for Group and Sex

| *Source of Variation* | *Sum of Squares* | *Mean Sq.* | *F value* |
|---|---|---|---|
| Spatial Visualization | | | |
| Main Effects | 38.77 | 9.69 | 6.26** |
| Group | 33.88 | 11.29 | 7.29** |
| Sex | 6.43 | 6.43 | 4.15* |
| 2-Way Interaction | .512 | 0.17 | 0.11 |
| Explained | 39.28 | 5.61 | 3.62* |
| Residual | 345.14 | 2.23 | 1.54 |
| Perceptual Orientation | | | |
| Main Effects | 86.49 | 21.62 | 8.50** |
| Group | 40.47 | 13.62 | 5.30** |
| Sex | 50.86 | 50.86 | 20.00** |
| 2-Way Interaction | 0.65 | 0.21 | 0.08 |
| Explained | 87.14 | 12.45 | 4.89** |
| Residual | 567.14 | 2.54 | |
| Flexibility of Closure | | | |
| Main Effects | 33.34 | 8.33 | 4.09** |
| Group | 30.75 | 10.25 | 5.03** |
| Sex | 3.69 | 3.69 | 1.81 |
| 2-Way Interaction | 0.12 | 0.04 | 0.02 |
| Explained | 33.46 | 4.78 | 2.34* |
| Residual | 454.15 | 2.03 | |

*Indicates significance of .05
**Indicates significance of .01

proach to cognition. Harris (1978) found that women more often favor linguistic processing while men lean toward visuo-spatial cognition.

Theorists have found that one's cognitive style also affects one's interest, and therefore involvement, in specific subject areas. Individuals talented in linguistic processing tend to excel in the humanities and fine arts while holistic-spatial processors favor the technical and scientific professions (McGee 1979). For example, many aspects of mathematics require the visualization and comprehension of three-dimensional geometric relationships among various parts of a figure (Mitchelmore 1980).

Contemporary studies find right hemisphere cognitive functions strongly related to the sciences. Siemonkowski and MacKnight (1971) suggested that most all successful college science majors are effective holistic-spatial conceptualizers based upon their research. They also suggested that science majors as a group are significantly different from liberal arts students in their ability to conceptualize three-dimensional models. Researchers have already found a strong correlation between physics and right hemisphere visualization (Siemonkowski and MacKnight 1971; Anderson 1976). Stanford University professor R.S. Shepard (1978) described the early insights of the German chemist Friedrick A. Kekule into the nature of chemical bonding and molecular structure as spatial imagery. Baker and Talley (1972) found that spatial ability is very important in conceptualizing chemical reactions. Astronomy and meteorology require high level topological aptitude (Bishop 1978) as do the disciplines of geography and geology (Carrier and Clark 1977; Yakemanskaya 1971).

Of particular interest, however, is the apparent dearth of empirical investigation into right hemisphere cognitive ability and the biological sciences. Perhaps the rationale for the apparent void stems from several early investigations. Studies performed by Holzinger and Swineford (1946) in America and I. McFarlene Smith (1964) in England found little correlation between right brain aptitude and success in the biological sciences. This was enough to convince researchers that to investigate areas within the biological sciences for holistic-spatial-manipulative practices would be useless. This premise was further reinforced by finding that a large number of women, who are suspected of having low spatial discriminating ability, were seeking careers in the biological sciences in greater and greater numbers (Gardner 1975).

In recent years, however, research is beginning to emerge that suggests a strong linkage between the right hemisphere and mastery of the biological concepts. Colin Wood-Robinsin (1981) found that holistic ability greatly influences a student's success at interpreting microslide cross sections in botany. Julie Bishop (1978) reported a similar finding in her study of zoological sections.

What has happened to the biological sciences in recent times that makes the right hemisphere important for success? A response involves an evaluation of the biological sciences curriculum over the last



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three decades. The reorganization of the teaching methods in the 1950s and 1960s plus the advances in various biological fields in the last quarter century has had a greater effect on the biological sciences than any other science discipline. The taxonomical approach to teaching biology has been discarded and the conceptual approach implemented. Class demonstrations have been scrapped for student directed laboratory sessions. Instructors have evolved from lecturers to teachers encouraging students to discover the meanings behind the concepts. Lessons have shifted from rote memorization to inquiry, and laboratory sessions have encouraged hands on experimentation.

Book publishers have also responded to the new curriculum. Prospective clients have been treated to splashy layouts and multi-hued designs. Artists have been commissioned to display and promote the new biology curriculum in ways never before attempted. The use of colors and three-dimensional art have become commonplace in biology textbooks. Complex new discoveries in the field are often graphically depicted to assist student comprehension as well as to hold the textbook size down to a reasonable level. The biological sciences have become a discipline requiring holistic as well as analytical skills.

## Methodology

In an effort to learn if students entering the biology professions are higher in holistic-spatial-right hemisphere aptitude than nonscience oriented students, a study was conducted on 125 freshman biology majors. One hundred and twenty liberal arts majors were also sampled. No statistical differences in verbal or math competencies were found between the students of either population. All 245 students took a series of pencil and paper tests designed to measure several right hemisphere aptitudes. The measures were taken from the Educational Testing Service's *Kit of Factor Referenced Cognitive Tests* (Ekstrom et al. 1976) and all possessed excellent Livingston reliabilities. The tests included tasks of perceptual orientation to measure an individual's ability to rotate, orient, and realign a mental image; flexibility of closure to measure a student's ability to disembed an image from its environment and ignore extraneous information; and spatial visualization to measure an individual's ability to formulate, control and manipulate an image in the mind.

A two-way analysis of variance was run between the various populations and sexes within the group (Table 1). Among other things, the analysis revealed that the biology group performed significantly better on the tests for perceptual orientation, flexibility of closure and spatial visualization. When the means of the three tests are plotted as histograms, the superiority of the biology group may be seen more readily (Figure 2).

Before conclusions concerning a right hemisphere-biology hookup can be drawn, however, an explanation of why a large proportion of women annually attempt careers in biology related occupations must be undertaken. Indeed, several investigators have inferred that men are significantly higher in right brain abilities than women (Buffey and Gray 1972; Waber 1977; Harris 1978; McGee 1978). To explain why men, on average, seem to display more visuo-spatial understanding, researchers proposed several hypotheses. Genetic involvement was proposed by Stafford (1963) and Deaux (1976). Broverman, Klaiber, Kobaysski and Vogel (1968) and Peterson (1976) suggested the endocrines were responsible for the difference, while Waber (1977) favored linking spatial abilities to neurological development. An overwhelming amount of information, however, is consistent with the hypothesis that right brain, visuo-spatial understanding is directly linked to the

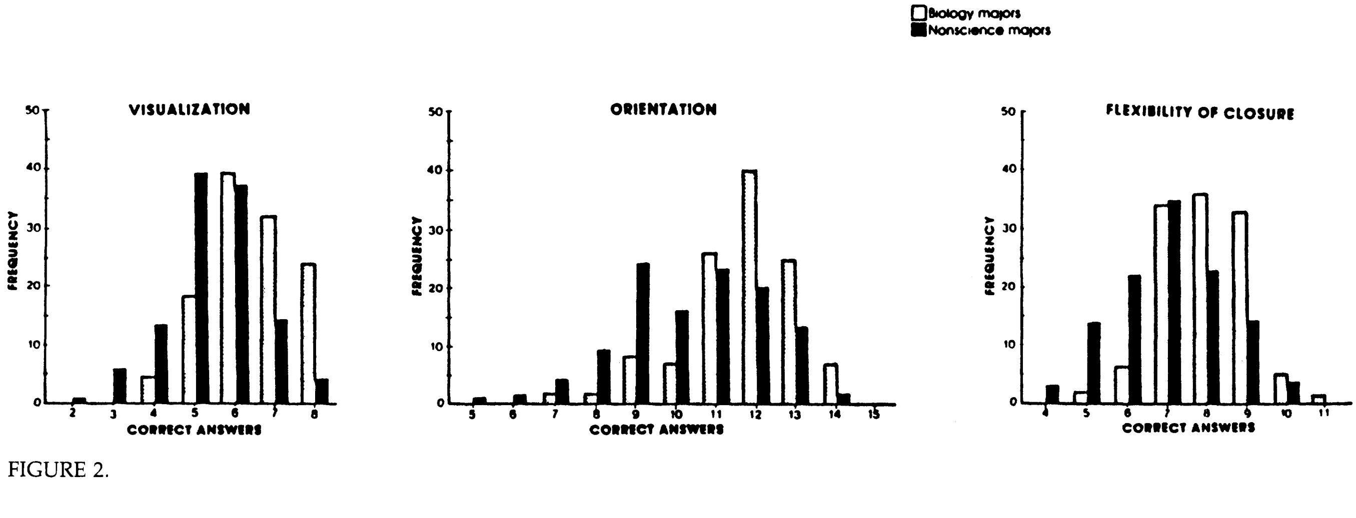


FIGURE 2.



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TABLE 2. Scheffe Contrast for the Right Hemisphere Tests for Male and Female Biology and Non-Science Majors

| | N | Mean | SD | SE | | Differences Between |
|---|---|---|---|---|---|---|
| Spatial Visualization | | | | | | |
| Biology Males | 60 | 6.1 | 1.11 | 0.14 | > | Non-Sci* |
| Biology Females | 65 | 5.8 | 1.17 | 0.14 | > | Non-Sci Females* |
| Non-Sci Males | 64 | 5.4 | 1.27 | 0.15 | < | Bio Males* |
| Non-Sci Females | 56 | 5.01 | 1.38 | 0.18 | < | Bio Pop.* |
| Spatial Orientation | | | | | | |
| Biology Males | 60 | 11.9 | 1.27 | 0.16 | > | Non-Sci* |
| Biology Females | 65 | 11.0 | 1.51 | 0.18 | > | Non-Sci Females* |
| Non-Sci Males | 64 | 11.2 | 1.73 | 0.21 | < | Bio Males* |
| Non-Sci Females | 56 | 10.2 | 1.75 | 0.23 | < | All other pop.* |
| Flexibility of Closure | | | | | | |
| Biology Males | 60 | 7.9 | 1.26 | 0.16 | > | Non-Sci Females* |
| Biology Females | 65 | 7.6 | 1.40 | 0.17 | = | All other pop. |
| Non-Sci Males | 64 | 7.2 | 1.50 | 0.18 | = | All other pop. |
| Non-Sci Females | 56 | 7.0 | 1.47 | 0.19 | < | Bio Males* |

*Indicates significance of .05

environmental history of the individual (Keaves 1973; Walford 1980; Kelly and Kelly 1978).

According to this hypothesis, once a child realizes to what sex he/she belongs, the child values that sex more than the other and tries to behave appropriately. The maternal parent meanwhile tends to direct the individual's development toward society's expectations for the sex (VanLeeuwen 1978). In western civilizations the stereotype for the female is toward conformity, dependence, and socialization—directly opposite to the qualities which seem to enhance the development of spatial understanding. Women, therefore, are encouraged to develop such traits as consideration and cooperation, and they are generally less aggressive and more affected by minor failures than their male counterparts (Goldberg and Lewis 1972). People reared under such biases are in conflict with the typical scientist stereotype of independence, self-confidence, and nonsocial ability. However, females that do manage to develop independence and aggression find careers in the sciences more appealing (Maccoby 1966; Hoyenga and Hoyenga 1979). And since the biological sciences tend to encompass people-related aspects (i.e. ecology, medicine, genetics), females often find it a permissible alternative from lower status and lower pay ing women's occupations (Gannon 1980).

The biological sciences then may tend to appeal to the more self-reliant, self-confident female. Not only are these women more independent, but they are also more highly spatial than the average (Lord 1983). These women fall within the 25 percent of all females tested that score higher than the median for men on tests for visuo-spatial accuracy (Maccoby and Jacklin 1974). Eisenberg and McGinty (1977) noted that women found in occupations traditionally seen as men's (i.e. accounting, physics) scored significantly higher on spatial tests than their male counterparts. Interestingly, women of communist countries constitute a much higher proportion of science professionals in their country than their western counterpart. It has been suggested that this is due to specific educational schemes used to develop spatial aptitude in the early childhood schooling in these countries (Kelly 1976; Dodge 1966).

Women majoring in the biological sciences scored significantly higher on the right hemisphere tests than the female liberal arts majors in my study. When a Scheffe contrasting statistic was run on the data, I found that female biology majors were statistically better on the tests for spatial-visualization and perceptual orientation (Table 2). I infer that women majoring in biology are better able to manipulate, maneuver, and orient a mental image than are the liberal arts women.

Equally as interesting, I found that the women biology majors were not significantly different in right hemisphere aptitude from their male counterparts. In only the perceptual orientation test was the main difference between the biology sexes greater than three tenths of a point. Hence, I suggest that women who major in biology are as spatially expedient as men.

According to my study, biology, like the physical sciences, tends to attract students who are comfortable with right hemisphere cognitive aptitudes. Students who have difficulty maintaining mental image constancy or filtering out extraneous perceptual information tend not to seek careers in the science professions. It is important as science educators to encourage right hemisphere thinking in the classroom. Students interested in biology as a career will be expected to think with their right as well as their left hemisphere.



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