Creation of the Sinister: Biological Contributions to Left-handedness

by Monica Watkins

We live in a right-handed world. Left-handedness has been, and in some cases still is, considered an inconvenience, a bad habit, or a symbol of the "sinister". Studies still attempt to link left-handers with socially undesirable behaviors, such as psychosis or criminal activity. The social implications of these stigmas are immense. "Left-handers may be one of the last unorganized minorities in our society, with no collective power and no real sense of common identity," says Stanley Coren (1992).

Past research has emphasized the physical, mental, and social consequences of being left-handed. However, scientists are now beginning to focus on the biological basis for this "sinister" preference. The Geschwind-Behan-Galaburda (GBG) Theory of Left-Handedness was presented in 1987 (Geschwind and Galaburda, 1987a; Geschwind and Galaburda, 1987b; Geschwind and Galaburda, 1987c). The GBG Theory proposes that right-handed children have developed normally; they exhibit leftward symmetries in language areas. In contrast, left-handed children have suffered complications, which have led to anomalous cerebral dominance. Subsequently, motor coordination shifts to the left side in these children. Though comprehensive alternative has been advanced, the GBG Theory has been a subject of much debate.

The GBG Theory holds that genetics is a minor factor in the determination of left-handedness. Influences outside a strict genetic program exert the most control over determination. Studies have shown that injury to the developing brain at specific developmental stages can cause significant changes. It is possible that variations in the chemical environment of the fetus may cause such changes, and lead to a certain cerebral dominance. These chemical variations also influence the development of the immune system. Later in life, the effects of these chemical influences may manifest themselves as immune disorders and abnormal brain structures.

According to the GBG Theory, the chemical variation and its effects account for the following: why left-handedness is more common in men (Oldfield, 1971), why language disorders are more prevalent in men (Heceaen, 1984), why left-handedness is linked with developmental disorders of childhood (Porac and Coren, 1981), and why immune disorders and other diseases are more common in left-handers (Geschwind and Behan, 1982, 1984). In other words, left-handedness is the common thread among problems thought to be unrelated.

Definition of Left-Handedness

Basic to any analysis of left-handedness is a working definition of handedness. Left-handedness and right-handedness must be defined in standard terms. The layperson tends to focus upon handedness as the sole factor of sidedness. It is important to realize that left-eyedness, left-footedness, and left-earedness exist. Therefore, sidedness is a function of all these factors, and scientists use questionnaires that measure sidedness. For example, one question might be: which eye would you use to look through a keyhole? Research on the validity of these questionnaires suggests that the accuracy of the questionnaire depends on how the question is phrased. The most widely used test is the Edinburgh, Oldfield, Handedness Inventory. The test is concise set of 10 to 15 questions that concern handedness exclusively. One limitation of these questionnaires is that they do not address social forces that may have influenced left-handedness. The only way to guarantee validity is to combine standardized questionnaires, behavioral tests, and interviews regarding social influences.

The Road to the GBG Theory: Incomplete Genetic Continuance and Developmental Orchestration

There are many areas of research that led to the GBG Theory. The inability to show direct genetic linkage of left-handedness between parent and child or between identical twins was the most influential precursor to the theory. Porac (1976 as reviewed in Coren 1992) completed a three year study of 459 Canadian families. Results were similar to eleven former studies ranging from 1913 to 1982. If neither parent is left-handed or if only the father is left handed, the child has a 1:10 chance of being left-handed. However, if only the mother is left-handed, the ratio is 2:10. Finally, if both parents are left-handed, the chance rises to 4:10. Therefore, as Porac states, even under "genetically optimal" circumstances, the chance of right-handedness is still much greater than the chance of left handedness.

Twin studies provide a further complication to theories concerning the genetic basis of left-handedness. Identical twins have the identical genes. If left-handedness were determined completely from genetics, both twins would show the same handedness. Porac (1992) analyzed thirteen identical and fraternal twin studies, ranging from 1933 to 1985. The composite shows that only 76% of the expected 100% identical twins are both left-handed.

Incomplete genetic continuance for left-handedness has forced researchers to explore other biological causes of left-handedness If humans are genetically destined to be right-handed, then left-handedness is a failure to become right-handed. This would explain the small percentage of left-handers. The GBG Theory considers what type of developmental "mistake" has been made. Studies have shown that focal injury to the developing cortex can lead to reorganization of both the cortical architecture and the pattern of connectivity. This reorganization occurs not only in the area of damage, but also in distant, related regions (Goldman-Rakic and Rakic, 1984, as described in Geschwind and Galaburda, 1987a). These changes may produce enlargements in certain brain regions, and disrupt the natural asymmetry of the brain, making the brain more symmetric (LeMay, 1977). Thus, destruction of normal development in the left-brain causes a shift to the right-brain. The right-brain becomes more dominant ,and left-handedness results. Furthermore, the factors causing this developmental change are most likely chemical since a complex mix of hormones, including sex hormones, orchestrate brain development, (as reviewed in Geschwind and Galaburda, 1987a).

The GBG Theory suggests the possible factors that lead to developmental changes. Geschwind and Galaburda suggest that fluctuations in the chemical environment could provide the variability for the characteristic of left handedness (Geschwind and Galaburda, 1985 a, b, c). They observed the apparent difference between the number of male left-handers and female left-handers. Oldfield (1971 as reported in Geschwind & Behan, 1984), using the standard Edinburgh Handedness Inventory, reported that 90% of women are right-handed while 86% of men are right-handed. Oldfield claimed that the 4% difference is significant. Ellis, Ellis, and Marshall (1988) used the very same Edinburgh Inventory and failed to reach any significant sex difference. Their study suggested that any difference in left-handedness and the sexes must be smaller than 1.5%. However, the Ellis et al. study used only a few hundred subjects. Although few other studies have tested the sex difference, it is an important fuel for the GBG Theory. The Oldfield study remains well cited despite the controversy surrounding it.

If we accept that there are more male left-handers than female left-handers, it seems that the chemical which causes the shift to right-brain dominance is male-linked. The authors chose to study the influence of testosterone in high levels. Stress during pregnancy can cause fetal testosterone levels to rise in rats (Ward & Weisz, 1980 as reviewed in James, 1987). In the womb, both males and females share the same maternal and placental hormones. Once the testes develop, testosterone rises to high levels. An increase in testosterone in the womb, combined with the extra testosterone from the testes, could cause slow development in the left-hemisphere. This would explain why left-handedness would be more common in males. The strength of the link between testosterone and slow growth stems not from prenatal studies of

hormone effects on cortical structure, but from postnatal studies. Hormones administered to the rat fetus after birth were able to alter asymmetries in the right brain and change tail posture, an indication of cerebral laterality (Diamond,1984 and Rosen et al, 1983 as review in Geschwind and Galaburda, 1987a). Scientists have not yet proved that prenatal testosterone causes abnormal development.

The Link with Developmental Disorders

A further principle of the GBG Theory concerns a possible connection between left-handedness and the following: dyslexia, attention deficit disorders, learning disabilities, and mental retardation. In 1860, Broca showed that language is usually lateralized to the left side of the brain. However, Goodglass, Quadfasel, and Zangwill (1954, 1960 as reported by Porac and Coren, 1978) confirmed that 50-67% of left-handers have right-brain dominance. GBG hypothesized that excessive delays in the speech controls of the left hemisphere would lead to problems. The normal lateralization of speech would come to a stop. The left-handed person could keep left-brain lateralization for speech, but learning disorders will result. However, the left-handed person might switch to right-brain speech lateralization.

In developmental dyslexic patients, Drake (1968 as reported by Geschwind and Galaburda, 1987c) found excessive neurons in the white matter of parietal region but did not specify any differences in laterality. Galaburda and Kemper (1979 as reported in Geschwind and Galaburda, 1987c) found several abnormalities in the left hemisphere of left-handed dyslexic patients. Neurons were clustered abnormally in patchy clumps., called ectopias. There was also evidence of dysplasia, the alteration of the number of neurons and neuronal architecture. Critics of the above studies state that only a few autopsied cases were used. In addition, Satz et al. (1985) found that dyslexics with hemisphere damage tend to be right-handed. Whereas, left-handers with developmental brain damage in the left-hemisphere are rarely dyslexic.

The link between left-handedness and dyslexia is stated most boldly by Geschwind and Behan (1982). The study reported that very strong left-handers were 11 times as likely to have dyslexia than very strong right-handers. The researches repeated the experiment two more times with different populations. Results similar to the first study were found. However, Satz (1986) points to many examples examining adult dyslexics that have failed to find an association between left-handedness and cognitive disability. In addition, Satz points to studies of children that have yielded no results. In contrast, Porac & Coren (1981) noted that difficulties due to lateral differences often do not become visible until high school or junior high school.

The Link Between Left-Handedness and Immunity

Based on the assumption that developmental speech disorders arise from testosterone induced brain abnormalities, Geschwind and Galaburda move to the final phase of their theory. High testosterone levels have been shown to inhibit the thymus both *in utero* and after birth in both rabbits and rats. (Frey-Wettstein and Craddock, 1970; Behan, 1987 as reviewed in Geschwind and Galaburda, 1987). The thymus is an important link in proper immune development. A faulty thymus will lead to defects in the immune system, which is crucial for the body's defense against foreign substances. Lymphocytes recognize foreign substances and attack them. Many lymphocytes reside in the thymus. If the development of the thymus were hindered, the lymphocytes would also be hindered. Perhaps, they would be unable to recognize foreign matter. GBG suggest that the development of the immune system has been altered in left-handedness. Thus, immune disorders should be more prevalent in left-handers.

From the above assumption, the GBG Theory links immune disorders, language disorders, and left-handedness. Geschwind and Behan (1982) published the first study showing that people suffering from immune disorders and/ or dyslexia were more likely to be left-handed. Five hundred Oldfield

Handedness Inventories were distributed to recruit subjects. Researches recruited applicants from a left-hander's supply shop in London and from the general public around Glasgow. Only people with a perfect score of strong left-handedness or right-handedness were selected as subjects. In the first part of the study, the frequency of disease reported in left-handers was 2.7 times that of right-handers. This was especially true for thyroid and bowel disorders. In addition, left-handers reported learning disorder nine times more often than right-handers. A second part of the study handed the questionnaire to the general public. However, only those who had a hospital diagnosis for an immune disorder were chosen. For this study, the rate concerning left-handers and immune disorders was 2.3 times that of right-handers. Additional studies have been done to replicate these findings.

Discordance with the Autoimmune Theory

A study of the link between left-handedness and immune disease must examine criticisms and contradictions to the theory's principles. An analysis from this viewpoint will show that more research and critical thinking are necessary to nullify questions of statistical reliability and theoretical rationale. Satz and Soper (1986) completed a complex analysis of Geschwind and Behan 1982 study. First, Satz and Soper object to the way that subjects were chosen. Satz and Soper object to the recruitment of subjects from a left-hander's supply shop, since those subjects may be too "eager to please" in the questionnaire..

Satz and Soper also criticize the use of self-reports as evidence of disease. They claim that the first part of Geschwind's and Behan's 1982 study is faulty. It is possible that the subjects are misdiagnosing themselves. The second part of second study tried to correct for the self-reporting bias by choosing only patients whose diagnosis was received in a hospital. However, as Satz and Soper note, this is still self-reporting. Bentancur et al. (1990) eliminated self-reporting in their study. Patients were recruited from an allergy clinic. The control population was of the same sex and age distribution. Bentancur found no support for the GBG Theory.

Satz and Soper (1986) completed an analysis of the statistical tests used by Geschwind and Behan. The authors state that the results of the 1982 study are inconclusive. Other studies also report that the difference between left-handers and right-handers is insignificant Bryden et al. (1994) conducted a statistical analysis of thirty-one studies used to support the GBG link between immune disorder, developmental disorder, and left-handedness. Only 16 of these 31 studies were statistically significant.

Bryden (1991) decided to control for the type of test that would assess left-handedness. He determined left handedness by three following tests: the hand which one writes with, the Edinburgh Handedness Inventory (the same test that Geschwind and Behan used), and self reported left-handedness. For example, 637 said they were right-handed, 72 said they were left-handed, and 32 said they were ambidextrous. 668 wrote with their right hand, while 75 wrote with their left hand. The Edinburgh Test reported that 672 subjects right-handed while 70 were left-handed. No matter how handedness was assessed, there was no evidence of increased immune diseases in left-handedness.

Other Suggested Correlations Concerning the GBG Theory

One of the first offshoots of the GBG Theory is a supposed correlation between talent, left-handedness, and immune disorders. The left-hander is right-brain dominant. Thus, his or her strongest talents should be consistent with the functions of the right brain. The right brain is superior in visual- spatial; such abilities are useful in mathematics and architecture. Therefore, left-handers should be drawn to these fields. In addition, these left-handers would be more likely to have immune vulnerability. The elevated rates of males in mathematics (Benbow, 1986) are supported by the GBG Theory. In addition, Annet and Manning (1990) have shown a link between strong right-handedness and the lack of mathematical ability.

Musical talent has also been linked with immune diseases (Hassler and Gupta, 1993).

Another offshoot to the GBG Theory concerns biological explanations of homosexuality. Coren (1992) reviews some of the biological theories. One theory suggests that homosexuality is the result of a hormonal imbalance. Homosexual males may have a deficiency of testosterone or a surplus of estrogen (the major female hormone). Homosexual females may have an excess of testosterone or a deficiency of estrogen. If the GBG Theory is valid, we would expect to see fewer left-handed homosexuals. Therefore, left-handedness and homosexuality would be directly linked. However, one study with a subject size of 94 homosexual men showed that left-handedness was much more common (Lindesay, 1987 as reported in Coren, 1992). The findings of this study were replicated with 38 homosexual men (McCormick et al., 1990). In addition, 32 homosexual women were studied and the same trend was found.

The GBG Theory has brought a new focus to the issue of AIDS susceptibility. If left-handers are more susceptible to immune diseases and more homosexual men are left-handed, left-handed homosexual men would be more defenseless against AIDS. Becker (1992), using the resources of the Multicenter AIDS Cohort Study (MACS), conducted the largest study of homosexual men. Left-handedness was judged using the Edinburgh Test and self reports. The results failed to show a greater preponderance of left-handed homosexual men with AIDS. This result was replicated by Satz et al (1991). Both studies seem to defeat the assumption that the GBG Theory applies to homosexuality and immune susceptibility.

A final application of the GBG Theory considers whether left-handed persons are more likely to die young. Coren & Halpern (1991) published a controversial article about the "Elimination Hypothesis," stating that the percentage of left-handers decreases steadily. Thus, there are fewer left-hander's in older age groups. This result has been replicated in various populations. Coren and Halpern suggest that left-handers are dying for one of two reasons. Left-handedness reduces their "survival fitness," making them accident prone. The alternate theory states that the left-hander is prone to immune disease. Low resistance increases the probability of early death. A second theory, the "Modification Hypothesis," states that changing social patterns force left-handers gradually to change to right-handedness.

Coren and Halpern tested the elimination hypothesis. The Baseball Encyclopedia provides information about baseball players from the year baseball was established as a national sport till 1975. Baseball was chosen because a single sex study could be conducted. The age at death was recorded for every player who had died before 1975. Results show that a right-handed baseball player is five times more likely than a left-handed baseball player to reach the age of 90. There seemed to be an equal risk of death for left-handers and right-handers before the age of thirty. A follow-up study was conducted using over 2,875 Californians as subjects. These subjects were asked to report the handedness and age of death of their kin. The study showed that the average age of death for right-handers was 75 years while the average age for left-handers was 66 years. Basically, right handers appear to live nine years longer. Coren (1992) states that the California results are more significant than the baseball study since baseball players do not represent the health of the average American. Although women were reported to live longer than men, right-handed women lived an average of five years longer than left-handed women. However, we must remember that the entire study is based on secondhand reports.

Evidence is accumulating against the early death hypothesis for left-hander. Fudin, Renninger, Lembessis, and Hirshon (1993 as reviewed in Coren & Halpern, 1993), repeated the Baseball Study and found that a longevity advantage was present for left-handers. However, this finding was insignificant under close statistical analysis. It is important to note that the baseball study does not tell us how strongly handed the players were.

Some studies support the modification hypothesis over the elimination hypothesis. The modification hypothesis claims that changing soical patters force left-hander's to switch handedness. Hugdahl et al.

(1993) showed that left-handedness was present in 15% of 21-31 year-olds. Left-handedness was present in 1.67% of all those 80 year-olds or older. However, there was corresponding increase in the number of subjects who switched to the right hand to write. Of the 21-31 year-olds, 2.69% had switched handedness. 6.75% percent of those over 80 had switched handedness. This suggests that left-handedness was discouraged decades ago.

Conclusion: Using Extreme Caution

The aim of this paper was to present enough opposing views to suggest that left-handedness is far to complicated to be ruled exclusively by a biological theory. One must keep in mind the classic nature-nurture controversy as it may apply to left-handedness. Certain characteristics of left-handedness are definitely influenced by the social environment. Every study has confirmed that left-handedness is not a simple genetic trait. Research concerning further genetic study is simply beyond our reach at this point, but not impossible. Current sudies are focused on lower organisms, where the search for genes is more simplistic.

Proposing one sweeping theory upon the characteristics of a group of people is hazardous. The GBG Theory ultimately suggests a decreased survival fitness for left-handers. Speaking from an evolutionary point of view, what possible purpose would this serve? A species evolves to adapt for better survival. Therefore, if left-handedness were less favorable, one would expect the amount of left-handers to decrease over time. This does not appear to be the case. Coren (1992) has addressed issues concerning the evolution of handedness. The author suspects that the ratio between left-hander and right-hander is a constant in human evolution. Thus, left-handedness would be a characteristic of Homo Sapiens. Coren searched university collections of art books from European, Asian, African, and American sources and found 10,000 works spanning the Stone Age to 1950. It is assumed that the artist tells us the handedness of the people around him or her by the way the objects are placed in the picture. Coren claims there has been the same distribution of right-handers for 50 generations. Additional studies have been done by anthropologists who analyzed tools used by man since the Stone Age. These studies report the same handedness distribution (Coren, 1992). It seems that left-handedness either has some benefit or is at least not harmful enough to be eliminated. In other words, there is room for both left-handers and right-handers to survive in our society.

The GBG Theory has been presented to the popular culture without complete confidence or overwhelming statistical significance It appears that we have come full circle in our beliefs about the diversity among humans. The dictionary defines left-handed as "clumsy, awkward, backhanded, or dubious." In most cultures, left handedness was a sign of misforutne. Although these former beliefs may have been forgotten, the GBG Theory has unwillingly encouraged the resurgence of these prejudices. Perhaps, one day the theory will be proven correct. Until such time, restraint is the key to preventing any further discrimination towards the left-hander.

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