HANDEDNESS, PREGNANCY AND BIRTH COMPLICATIONS, AND POSITIVE SCHIZOTYPY

by

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Handedness, Pregnancy and Birth Complications, and

Positive Schizotypy

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Abstract

Bakan's Neurodevelopmental Theory states that for any condition manifesting a link with pregnancy and birth complications (PBCs) and thereby earning inclusion to the "continuum of reproductive casualty," a secondary association with an increased incidence of nonright-handedness (NRH) should be more likely. There exists a substantial literature in which a schizophrenia-PBCs and a schizophrenia-NRH relationship is prominent. More recently, a dichotomization of schizophrenia has been proposed, whereby negative and positive forms are considered distinct entities. This study investigated the relation of positive schizotypy to PBCs and the frequency of NRH. In order to assess this relationship, 523 questionnaires providing laterality and birth history information along with the Rust Inventory of Schizotypal Cognitions (RISC) were analyzed. Although the placement of NRH on the continuum of reproductive casualty was supported for males, positive schizotypy was found only to relate to the NRH of females. PBCs were not related to the positive symptomatology of schizotypy for either males or females. Results suggest that positive schizotypy is a sexually dimorphic disorder: females being more prone than males, possibly due to a trend showing differential gender response rates to the RISC - males with self-reported PBCs being less likely to answer any of the RISC. Perhaps a gender bias exists in the
willingness of males and females to admit vulnerability to socially less desirable traits.
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Dedication

Til mine forældre, især min mor, som hjalp mig med
noget af det kedelige arbejde. Endelig er det overstået.
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Introduction

Of the many theories attempting to explain left-handedness (LH) among humans are those detailing a link with pathology. These theories see LH or nonright-handedness (NRH) as expressive of pathology. Bakan (1990; Bakan, Reed, & Dibb, 1973) proposed a Neurodevelopmental Theory of LH in which LH is considered to result from neurological reorganization associated with pregnancy and birth complications (PBCs). To the extent that any disorder manifests an association with PBCs and LH, such a disorder merits consideration within the scope of the Neurodevelopmental Theory. Examination of the schizophrenia literature reveals it to be replete with accounts of LH and PBCs. Schizophrenics have a rate of LH or NRH higher than that found in the normal population.

Recently, a questionnaire - the Rust Inventory of Schizotypal Cognitions (RISC) - was designed to tap the positive schizotypal cognitions of a sample drawn from the normal population (Rust, 1987, 1988; Rust & Chui, 1988; Rust, Moncada, & Lepage, 1988). Utilizing the RISC, this study seeks to assess the relationship between positive schizotypy, NRH, and PBCs in a sample of introductory psychology students.
The Origin of the Handedness Asymmetry

Although left-sided biases are evident in some animals, the left/right functional asymmetry among bilateral organisms is generally considered to be exclusively a human characteristic (Annett, 1985). Others have argued that manual preferences are already present in nonhuman primates, albeit the researchers concede that only 8 of 181 nonhuman primate species had ever been known to demonstrate a handedness asymmetry (MacNeilage, Studdert-Kennedy, & Lindblom, 1987). Of the simians that exhibited an intra-species handedness asymmetry, there was a left-hand preference shown for reaching, and a right-hand preference for manipulating an object. MacNeilage and his co-investigators suggested that these handedness patterns had evolved as feeding adaptations, and that these adaptations were precursors to hemispheric specialization in humans.

Warren (1977) in his review of primate handedness — including those primates most closely related to humans — did not find any evidence of manual-preference asymmetry. Other researchers disagree with the conclusions of MacNeilage et al. (1987): Satz (1988) questions the methodology, while Hardyck (1988) challenges the conclusions drawn from MacNeilage et al.'s statistics. Ettlinger (1987) questions the validity of MacNeilage et al.'s operational definition of reaching in conjunction with other variables in the study. The most scathing critique is that of
Denenberg (1988), who claims that the central theme of the study by MacNeilage et al. - namely, that primate handedness patterns led to hemispheric specialization - is flawed. Denenberg notes that some of the so-called lower animals, for example, the canary, demonstrate hemispheric specialization. This attenuated the contention by MacNeilage and co-workers that handedness preceded hemispheric specialization in phylogeny.

The asymmetry of manual preference is quite apparent in humans. Handedness usually assumes a J-shaped distribution in which the frequency of left-handedness (LH) is approximately ten percent in the population (Hardyck & Petrinovich, 1977; Porac & Coren, 1981). How did this lateral asymmetry arise? There are several theories concerning the etiology of hand-preference asymmetry in humans. Basically, these theories can be classified as being either environmental, genetic, biological, or pathological.

Environmental Theories

Some environmental theories view the excess of right-handers as being due to living in a "right-handed world". According to this view, the world has been constructed so that most contrivances are designed for the use of right-handers. Even our writing tools reveal this right-handed bias, as labels, appropriate when the writing instrument is
held in the right hand, suddenly appear upside-down when it is held in the left hand.

This right-handed world hypothesis leaves unresolved the question of primacy: which came first, right-handedness (RH) or the right-handed world? A study of laboratory mice seems to indicate that paw preference is established before exposure to a laterally biased world (Collins, 1975). Mice raised in an unbiased environment evidenced a U-shaped distribution for pawedness preference. When placed in either a right- or left-biased environment the distribution assumed a J-shape. Right-pawed mice had difficulty adjusting to a left world as did the left-pawed mice to a right world, nevertheless, both did adapt. Thus, Collins (1975) concludes that the environment exerts only a modifying capacity for a pre-existing lateral bias.

Dawson (1977) used an anthropological perspective in his appraisal of handedness in various societies. Low levels of LH were found in agricultural societies, and relatively higher levels of LH were found in hunting societies. Dawson proposes, on the basis of this evidence, that the frequency of handedness in a society is a product of both the environment and genetics acting together. Others have since failed to replicate Dawson's notion of a societally-based handedness distinction (Ardila, Ardila, Bryden, Ostrovsky, Rosselli, & Steenhuis, 1989).
Genetic Theories

Genetic theories consider hand preference to reflect a person's heredity. Although such evidence as the greater influence of biological parentage versus adoptive parentage has been reported (Carter-Saltzman, 1980); in general, Mendelian patterns of inheritance have not been found. Bakan (1975) acknowledges that when one parent is left-handed, or even more so, when both parents are left-handed, the offspring are also more likely to be left-handed. However, as Bakan notes, genetic accounts of handedness encounter difficulty in explaining: why 84 percent of left-handed children have two right-handed parents (Annett, 1973); why the incidence of LH is higher in boys (Oldfield, 1971); why the greater influence of maternal handedness (Carter-Saltzman, 1980; Porac, Coren, & Searleman, 1986); and why the higher incidence of LH among twins, both monozygotic and dizygotic twins (Carter-Saltzman, Scarr-Salapatek, Barker, & Katz, 1976). Scheinfeld (1972) concludes that: "The possible role of heredity in producing left-handedness is not clear, for one reason because of its simultaneous appearance in identical twins is scarcely more frequent than in fraternal twins" (p. 208).

One particular genetic version, the Right Shift Theory of Marian Annett (1985), apparently accounts very well for the observed distribution of handedness in the population. Annett proposes that all people are genetically programmed
for right-handedness, but that in the case of some people, an intervening variable prevents expression of the Right Shift gene. People with the nullified Right Shift gene are hypothesized to be equally likely to fall anywhere along a handedness continuum. This implicates NRH, rather than LH per se, as important to the Right Shift Theory.

The Biological Origin of Handedness

It has been proposed that laterality is strictly a biological phenomenon and not a genetic one (Corballis & Morgan, 1978; Morgan & Corballis, 1978). Corballis and Morgan contend that handedness results from a left/right maturational gradient in the developing oocyte. Thus the code for handedness resides in the cytoplasm rather than in the genes.

Annett (1985), however, views the implicit universality of the model of Morgan and Corballis as problematic. She questions the lack of a rightward bias outside the human realm. Interestingly, Morgan and Corballis (1978) acknowledge the induction of LH following pregnancy and birth complications.

Pathological Left-handedness (PLH)

Pathological theories view LH as the result of some neurological insult to the fetus or newborn. Typically, noxious factors present during the pre- or perinatal period
increase the likelihood of damage to the central nervous system (CNS). Three researchers, namely Paul Satz, Norman Geschwind, and Paul Bakan, have each proposed theories which purport to account for the incidence of PLH. As well, all three pathological theorists have indicated some measure of support for Annett's (1985) notion of a Right Shift Factor (Bakan, 1990; Geschwind and Galaburda, 1985a; Satz, Fennell, and Jones, 1969). The PLH theories differ on the specific nature of the mechanism interfering with the right shift. Thus, it is the shift away from RH, that is NRH, which is important for PLH theories.

The Pathological Left-handedness Syndrome

Satz (1972, 1973) proposed a PLH model to explain the increased frequency of manifest LH in brain-injured populations. Early trauma to the left hemisphere is said to induce "a mild hypofunction of the contralateral hand, in natural right-handers, which in turn causes the child to switch to the opposite hand for manual activities" (Satz, 1972, p. 121). Indeed, Gordon (1921) had many years earlier, speculated about the induction of LH, in some cases, following insult to the left hemisphere. Satz (1973) considers that most LH is genotypically normal, and that only a small percentage of LH is of the pathological variety. Further validation of the model was provided by cross-cultural results (Satz, Baymor, & Vander Vlugt, 1979).
More recently, Satz and his colleagues have delineated a PLH syndrome (Orsini & Satz, 1986; Satz, Orsini, Saslow, & Henry, 1985). Subjects with this syndrome reveal certain consistent traits, including atypical speech lateralization, motor impairment of the non-dominant or right hand, and hypoplasia of the right foot (Orsini & Satz, 1986). These traits are implicated as the distinguishing features of the PLH syndrome in which other traits are also observed to occur in an erratic fashion.

The Testosterone Theory

In 1982, Geschwind and Behan reported an association between LH and autoimmune disease, migraine, and developmental learning disorders. Their data consisted of 500 questionnaires distributed in a left-handed shop in London, England. Of the returned questionnaires, 253 responses were from individuals with a laterality quotient of -100 (pure LH) as measured by the Edinburgh Handedness Inventory (EHI) of Oldfield (1971). A control group of 253 people with a laterality quotient of +100 (pure RH) was matched for age and sex with the left-handed group. The results indicated a level of immune disease that was 2.7 times higher for the left-handed group in comparison to the control group. Particularly salient were thyroid and bowel disorders.

Geschwind's theory was posthumously published as a
series of Archives of Neurology articles. The male sex hormone, testosterone, was identified as the triggering factor in the subsequent manifestation of LH (Geschwind & Galaburda, 1985a, 1985b, 1985c). Geschwind and Galaburda presented evidence of brain asymmetry, in particular, sex differences in brain anatomy. Sex differences, understandably, play a crucial role in the Testosterone Theory, since testosterone is a male hormone, and as mentioned earlier, there is a higher incidence of LH among males (Oldfield, 1971). Other congruent evidence was reported, such as the later development of the male brain together with the later maturation of the brain in left-handers.

Geschwind has also expounded elsewhere on the pivotal role of testosterone as the etiological agent in LH (Geschwind & Behan, 1982, 1984b). The theory noted that high prenatal testosterone levels have a retarding effect on the growth of the immune structures. Therefore, it was hypothesized that LH would be associated with immune deficiency, particularly in males.

Wofsy (1984) criticized Geschwind and Behan (1982) for not reporting sex effects of LH or autoimmune disease. He commented on one mouse study in which high androgen sensitivity and low immune responsivity were reported to be correlated with a larger thymus. Wofsy considered it feasible that testosterone might affect the immune system
indirectly through the hypothalamus. While agreed that LH was commoner in males than in females, Wofsy nonetheless, claimed that females were at greater risk for autoimmune disease. Wofsy remained unconvinced of the validity of the Testosterone Theory, having stated that there is no experimental evidence that heightened antepartum levels of testosterone affect autoimmunity in an adverse manner.

Geschwind and Behan (1984a) responded to Wofsy's critique by noting a number of errors and misinterpretations. They did not concur with Wofsy that prenatal androgens might modify immune activity through the hypothalamus. Geschwind and Behan also regarded Wofsy's assertion that females are more susceptible to most autoimmune diseases as unsubstantiated; they believed that males might be bestowed protection from autoimmune disorders by their own testosterone at puberty.

**The Neurodevelopmental Theory**

Bakan (1990) speculates that the main etiological agent in his PLH theory, namely hypoxia, may itself also be responsible for antepartum fluctuations in testosterone levels. There is evidence that oxygen insufficiency encountered during gestation also influences hormonal functioning (Dawes, 1976). Bakan (1990) does not restrict his theory solely to hypoxia, but proposes that any adverse factors impinging upon the pregnant mother, and thereby
affecting the developing fetus, might also influence the child's subsequent handedness.

Bakan (1990) is also critical of the duality of LH in the model of Satz (1972, 1973). In comparing his theory to that of Satz, Bakan (1990) states that his model has the advantage of being more parsimonious. Furthermore, Bakan's Neurodevelopmental Theory is unique, in that, unlike both Satz and Geschwind, he proposes that all NRH is pathological.

Bakan (1971b, 1975, 1977, 1978, 1990; Bakan et al., 1973) has promulgated a theory whereby NRH is viewed as a sequel to PBCs. Although Bakan (1990) acknowledges the primacy of Pasamanick and Knobloch (1966) in linking NRH with PBCs, it was Bakan who first published results confirming the relationship (Bakan et al., 1973). Bakan et al. (1973) found that among university students, nonright-handers were twice as likely as right-handers to report PBCS. Bakan proposed that NRH is the result of birth stress, particularly of oxygen insufficiency experienced pre- or perinatally. Following an interruption of the fetal or newborn's oxygen supply, necrosis of the pyramidal cells of the left hemisphere is hypothesized to occur. The susceptibility of the pyramidal cells to hypoxia has been addressed by Lassek (1954). This shortage of oxygen, in utero, is identified as the commonest cause of cerebral damage in the fetus or newborn (Fenichel, 1983; Myers, 1975;
Towbin, 1978). Less severe hypoxia has been found to lead to focal necrosis of the cells (Towbin, 1978). Even mild hypoxia has salient ramifications, as the fetal metabolism is particularly dependent on oxygen for brain metabolism (Fenichel, 1983). Furthermore EEGs show the left hemisphere to be more active than the right hemisphere; and therefore, it is possibly more reliant upon an uninterrupted supply of oxygen (Bruens, Gastaut, & Gioveg, 1960; Riklan & Levita, 1970). In summary, the more specific form of Bakan's theory states that hypoxic conditions have a deleterious effect upon the developing pyramidal system of the left hemisphere, thus precipitating a shift from right-hand preference.

The NRH-PBCs link reported by Bakan et al. (1973) has since been replicated by other investigators (Ashton, 1982; Coren, Searleman, & Porac, 1982; Ross, Liper, & Auld, 1987; for an extensive review see Searleman, Coren, & Porac, 1989). While corroborating the association of birth stress with an increase in the incidence of NRH, Coren et al. (1982), nevertheless, disagree with the emphasis on hypoxia as the preeminent gestational complication, a position they iterate in their review article (Searleman et al., 1989). Coren et al. (1982) claim that difficult labor and low birth weight are more important than respiratory difficulties in relation to NRH. Hypoxia, however, is considered to underlie such PBCs as lengthy labor and prematurity (Browne & Dixon, 1978; Dawes, 1968; Gilbert & Harmon, 1986; Newton,
1989). Newton (1989) states that, "most perinatal complications have the risk of utero-placental insufficiency with subsequent death or long term neurological morbidity from the asphyxial insult" (p. 522).

Bakan and colleagues (1973) found evidence of a familial trend for NRH in their subject sample; nonetheless, they consider the concept of a LH gene as too simplistic. An association of increased incidence of NRH with subject self-reports of PBCs was found; therefore, it was reasoned that it was equally likely that a familial trend to PBCs had contributed to the higher levels of NRH, rather than being the direct influence of heredity.

Bakan (1990) also expresses the view, that the Right Shift Theory of Annett (1985) is quite compatible with the Hypoxia Theory, in that PBCs represent the nullifying factor in the non-expression of the Right Shift gene. Thus Bakan considers the Right Shift Theory as merely another pathological theory which suffers from its failure to explicitly account for the mechanism which prevents the Right Shift Factor. More recently, Annett (1988) has implicated delayed neurological maturation as the causal agent interfering with the gene for the right shift.
Pregnancy and Birth Complications

NRH, per se, is claimed to be the most benign effect of pre- or perinatal hypoxia (Bakan et al., 1973). Moreover, Bakan (1975, 1990; Bakan et al., 1973) confirmed the initial suspicion held by Pasamanick and Knobloch (1966) that NRH constituted a sub-lethal component at one end of the "continuum of reproductive casualty". Benjamin Pasamanick and his colleagues (Lilienfeld, Pasamanick, & Rogers, 1955; Pasamanick & Knobloch, 1960, 1961, 1966; Pasamanick, Rogers, & Lilienfeld, 1956; Rogers, Lilienfeld, & Pasamanick, 1955) conducted numerous studies on the relationship of PBCs to various medical disorders and consequently hypothesized the existence of a continuum of reproductive casualty. This continuum of reproductive casualty is represented by a lethal component (composed of abortions, still births, and neonatal deaths) and a sub-lethal component. Unfavorable conditions, in utero, may result in the death of the unborn or newborn child. Those infants who manage to survive the noxious antepartum factors, may wind up manifesting varying degrees of sub-lethal injury depending on the CNS damage sustained (Lilienfeld et al., 1955). Pasamanick and Knobloch (1961) have delineated a basic set of propositions as follows:

(1) Since prematurity and complications of pregnancy are associated with fetal and neonatal death, usually on the basis of injury to the brain, there must remain a fraction so injured who do not die. (2) Depending on the degree and location of the damage, the survivors
may develop a series of disorders. These extend from cerebral palsy, epilepsy, and mental deficiency through all types of behavioral and learning disabilities which are a result of lesser degrees of damage sufficient to disorganize behavioral development and lower thresholds to stress. (3) Further, these abnormalities of pregnancy are associated with certain life experiences, usually socioeconomically determined and consequently (4) they themselves and their resulting neuropsychiatric disorders are found in greater aggregation in the lower strata of our society (pp.74-75).

Pasamanick and Knobloch (1961) noted, that the distinction between cases and controls regarding PBCs "was found to be greater in the more severe clinical conditions ... and to decrease as the handicap became milder" (p. 78). In addition, males were found to experience a higher susceptibility to PBCs and the clinical conditions addressed in the study than were females.

In clinical cases where PBCs were not known to have occurred, a genetic trend was non-apparent for these disorders. This led Pasamanick and Knobloch (1961) to question, whether a familial trend for a disorder was not merely a familial trend to PBCs.

Nesbitt (1959) agreed that there was a continuum of reproductive casualty. Of the reproductive complications, Nesbitt emphasized the importance of adequate oxygenation of the developing fetus as "certain fetuses and infants with insignificant pathologic findings may have been insulted by anoxia or trauma over a short period of time without being left with detectable signs" (p. 125). Nesbitt considered,
that it was "only a matter of degree and duration of insult" which determined whether a child died or was only damaged (p. 125).

**The Biology of Handedness**

PLH theories assert that the biological integrity of nonright-handers is at greater risk than that of right-handers. Therefore, if NRH is of pathological origin, then one would expect to find biological markers or correlates of NRH, at least in the CNS. One group of researchers hypothesized that such anatomical asymmetries might indeed help to explain handedness asymmetries (Galaburda, LeMay, Kemper, & Geschwind, 1970). Certain biological variations between left- and right-handers have been established. Perhaps the commonest difference between handedness groups is that of cerebral organization. Beaumont (1974) proposes that the cerebral organization of the left-hander is more diffuse than that of the right-hander. Thus, the left-handed individual is a beneficiary when engaged in problem solving tasks, which require complex multi-faceted operations. This conclusion seems paradoxical considering that left-handers are identified as a group possessing at least minimal brain damage (Bakan, 1975, 1990; Bakan et al., 1973). Under some circumstances, however, the performance of brain-damaged individuals may be favored relative to normal individuals (Diller & Birch, 1964).
Cerebral Organization

Cerebral organizational differences are most obvious for the lateralization of speech to one hemisphere. Rasmussen and Milner (1977) determined the handedness of 396 epilepsy patients with an 18-item questionnaire (based on Crovitz & Zener, 1962). The patients were then divided into two groups: one group of 262 patients who did not exhibit signs of early, left-hemisphere lesion, and another group of 134 patients who had suffered left-hemispheric insult prior to the age of six years. Both of the groups were assessed for the hemispheric lateralization of language by the sodium-amytal method. In the early lesion-free patient group, 140 were right-handed and 134 (96%) of these right-handers were found to be left-hemisphere dominant for language. Of the 122 nonright-handers, 86 (70%) also exhibited left-hemisphere dominance for language, while another 36 (30%) patients were distributed evenly between right-hemisphere and bilateral representation for language. Examination of the 134 patients with early lesions to the left-hemisphere revealed a slight trend away from left-hemisphere speech dominance. Thirty-four of the 42 (81%) right-handers were left-hemisphere dominant, while only 49 of the 92 (53%) nonright-handed patients were so classified. The data of Rasmussen and Milner indicate left-hemisphere language dominance to be the norm for right-handers and somewhat less so for nonright-handers; although
the shift away from left-hemisphere dominance increases with the presence of early, left-hemisphere insult.

**Neuroanatomical and Neurophysiological Asymmetries**

Witelson (1980) describes a number of neuroanatomical asymmetries related to handedness. In general, nonright-handers tend to manifest less or reversed asymmetry neuroanatomically in relation to right-handers. Witelson identifies these asymmetries in the parieto-opercula, the occipital region, prefrontal region, and in the circulatory system of the brain.

**Asymmetry in the Parieto-operculum**

LeMay and Culebras (1972) on the basis of arteriographic measurements on the brain concluded that left-handers have less asymmetry than right-handers in the parieto-operculum. The results showed that in 15 of the 18 left-handed subjects, the right parieto-operculum was equivalent in size to the left parieto-operculum. For right-handers, the left parieto-operculum exhibited greater development than the right parieto-operculum in 34 of the 44 cases. Based on CT scans, LeMay and Kido (1978) corroborated the opposite asymmetry of left-handers vis-à-vis right-handers in the frontal, occipital, and parietal lobes of the brain.
Occipital Asymmetry

Bear, Schiff, Sauer, Greenberg, and Freeman (1986) examined the computed tomographic (CT) scans of 66 consecutively referred out-patients at two Boston hospitals. The patients were being examined for dizziness or headache and had no history of CNS damage or EEG abnormalities. Handedness was determined by the EHI (Oldfield, 1971). Nonright-handers, as a group, exhibited reduced or reversed occipital asymmetries when compared to right-handers.

LeMay (1976) found that in right-handers, the left-occipital lobe is more likely to be wider than the right-occipital lobe. This asymmetry is not so readily apparent in left-handers, as the right-occipital lobe is often wider than the left-occipital lobe - a finding opposite that found for right-handers.

Ventricular Asymmetry

McCrae, Branch, and Milner (1968) examined 100 consecutive pneumoencephalographic studies of typical neurological and neurosurgical patients, with a slight excess of patients suffering from epilepsy. In right-handers, the occipital horn of the lateral ventricle was much more likely to be longer on the left side than on the right side. In nonright-handers, the length of the horn was equally likely to be longer on either side. McCrae and colleagues suggested that the ventricular-handedness
asymmetry indicates altered brain development perinatally.

**Sinus Deviation**

In another study, Hochberg and LeMay (1975) measured the Sylvian point angles of 134 patients (106 right-handed and 28 left-handed) bilaterally via carotid arteriograms. A mean difference was found among the right-handed patients in favor of a greater Sylvian point angle on the right side. In only six of the left-handed patients was the Sylvian point angle greater on the right side than on the left side by more than 10 degrees. Of the remaining 20 patients, the mean difference between the Sylvian point angles were within 10 degrees. In total the mean difference for left-handers was 6.6 degrees.

**Negative Findings**

Not all researchers have been successful in detecting the aforementioned neuroanatomical asymmetries in association with handedness. Koff, Naeser, Piendiadz, Foundas, and Levine (1986) failed to establish any asymmetry in the frontal and occipital regions related to hand preferences. The results of Chui and Damasio (1980) concur with Koff et al. (1986). In addition, Chui and Damasio reported no sinus deviation as did Hochberg and LeMay (1975). Luchins (1983) states that, in general, there is a consensus in favor of frontal and occipital brain asymmetry
between left- and right-handers, but that, no other statistically significant results have been replicated by two independent groups. Luchins ascribes this to methodological problems in the research, such as small sample sizes, incorrect statistical procedures, and the absence in some cases of a blind procedure.

Asymmetry in the Circulatory System of the Brain

Neurophysiological differences in relation to hand preference have also been described. One study ascertained the distribution of gray matter in the two cerebral hemispheres by the Xenon\textsuperscript{133} inhalation technique (Gur, Packer, Hungerbuhler, Reivich, Obrist, Amarnek, & Sackheim, 1980). They found more gray matter relative to white matter in the left hemisphere, especially in the frontal and precentral regions. In a study published two years later, Gur, Gur, Obrist, Hungerbuhler, Yonken, Rosen, Skolnich, and Reivich (1982) reported on the handedness differences in regional cerebral blood flow as determined again by the Xenon\textsuperscript{133} inhalation method. This investigation measured the blood flow in 62 healthy volunteers. Left-handers, as well as females, were discovered to "have a higher rate of hemispheric blood flow and a greater percentage of fast-perfusing tissue" considered to be gray matter (p. 660).

Carmon and Gambos (1970) tested 110 healthy adolescents in an Israeli hospital. Left- versus right-ophthalmic-
artery-pressure measurements and left-/right-brachial-blood-pressure assessments were performed by two independent examiners prior to handedness determination. Another blind examiner determined the subjects' handedness. A correlation was found between handedness and systolic- (and to a minor degree diastolic-) ophthalmic-artery pressures, such that the pressures were generally higher on the right side of the right-handers, and higher on the left side of the left-handers. This difference failed to appear for brachial-artery-pressure differences.

In another study five Swedish right-handers (with a laterality quotient of +100) were compared to five other right-handers (with a laterality quotient less than or equal to +75) for interhemispheric differences in regional cerebral blood flow (Prohovnik, Haakanson, & Risberg, 1980). A statistically significant difference emerged between the two laterality groups. This was particularly manifest in the frontal and posterior parts of the brain.

In a finding perhaps functionally related to that of Prohovnik et al. (1980), hemispheric-blood-flow differences while performing a spatial task, were found to be related to handedness (Brooks, Wyper, & Lennox, 1975). Five left- and five right-handed, normal, volunteer subjects were administered a modified-hidden-figures test. Answers were given by way of a bimanual-tapping code. In order to prevent vocalization, a rubber mouthpiece was inserted into
each subject's mouth. Results indicated that in right-handers, right-hemispheric blood flow increased significantly in comparison to the left hemisphere; for left-handers, left-hemispheric blood flow increased significantly more than blood flow in the right hemisphere. This was viewed as evidence of basic neuro-organizational differences between left- and right-handers.

The Corpus Callosum and the Interhemispheric Transfer of Information

A further discrepancy between right- and nonright-handers was described for the connective-tissue bundle between the two hemispheres. Witelson (1985, 1986) found the corpus callosum to be approximately 11 percent larger in nonright-handed subjects. This size difference was confined to the anterior and posterior ends of the corpus callosum.

Potter and Graves (1988) tested 48 subjects at the University of Victoria for interhemispheric transfer (IHT) of information on five tasks: two motor, two tactile, and one visual. Nonright-handers performed significantly better than right-handers on one motor and one tactile task. Potter and Graves attribute the enhanced IHT of nonright-handers to Witelson's (1985) report of increased callosal size in nonright-handers.

Are nonright-handers really superior in the IHT of information? With regard to visual information, it appears
that right-handers exhibit superior performance in IHT (Haude, Morrow-Tlucak, Fox, & Pickard, 1987). Witelson (1986) states that there is no significant difference related to handedness in the splenium, the part of the corpus callosum which connects the occipital and the inferior temporal visual areas.

The Immune System

The preeminence of the left hemisphere has also been delineated for immune functioning (Biziére, Guilbaumin, Degenne, Bardos, Renoux, & Renoux, 1985). Biziére and co-investigators demonstrated that depression of the immune system occurs following a lesion of the left hemisphere in mice. Diminished activity of the T-cell mediated response is observed in mice, as well as a sharp decline in natural killer cell activity.

Neveu, Barnéoud, Vitiellos, Betancur, and Le Moal (1988) emphasize the importance of animal studies in trying to learn about human hand preferences and immune system functioning. Their research with mice indicates that, among left-paw preferring creatures, there is a greatly increased lymphocyte proliferation in response to T-cell mitogens. Neveu et al. contrast this finding with that of Geschwind and Behan (1984) in stating: "In left-handed people, the high incidence of autoimmune and especially allergic diseases could result from the higher immune reactivity" (p.
An asymmetry of immunological functioning has also been observed between right- and left-handed human subjects (Yokoyama, Hara, & Shiotsuki, 1987). Utilizing the method of one- or two-parameter flow cytometry, a difference in the peripheral lymphocytes was discovered, whereby the proportion of suppressor inducer cells was found to be significantly lower in the left-handed subjects.

Electrophysiological Evidence

While the literature is sparse, EEG differences have been documented between left- and right-handers. Provins and Cunliffe (1972) examined the EEG records of ten left-, and ten right-handed, normal, male subjects for percentage of alpha activity, beta activity, and total activity from the right- and left-parietal lobes. Significant differences in EEG activity were observed between left- and right-handed groups regardless of which side of the brain was measured. Others have identified the brain-wave activity of nonright-handers as being abnormal compared to that of right-handers (Silva & Satz, 1979; Subrirana, Corominas, Puncernau, & Oller-Daurella cited in Penfield & Roberts, 1959).

Bakan (1971a) states that the two hemispheres of the brain exhibit differential activity levels, with the left hemisphere being the more active of the two. EEG records, however, show this hemispheric activity level to be the
converse for left-handers as they manifested greater right-than left-hemisphere activation (Flor-Henry & Koles, 1982). It has been suggested that decreased activation of the left hemisphere may be due to hypoxia (Bruens, Gastaut, & Gioveg, 1960). NRH, by inference, stems from hypoxia which alters left-hemisphere metabolism.

Cranial Asymmetry

Some studies have reported a relationship between handedness and skull asymmetries. LeMay (1977) found that asymmetries of the skull were less marked for left-handers. Myslobodsky, Ingraham, and Weinberger (1987) assessed skull asymmetry in 20 right- and 15 nonright-handed adults via CT scans. For nonright-handers a reliable flattening of the occipital bone was evident.

Dermatoglyphics

Dermatoglyphics involves the study of the papillary ridges of the skin. Dermatoglyphics has relevance to the Neurodevelopmental Theory in that the symmetry of the papillary ridge patterns serves as a marker of previous exposure to birth stressors (Achs, Harper, & Siegel, 1966).

Dvirskii (1976) notes several concomitants of LH, among them being the finding of increases in the digital ridge count on the left hand, or absence of bimanual differences in respect to this feature. While the difference between
left- and right-handers in ridge counts is minuscule, left-handers as a group exhibit less asymmetry than do right-handers but show greater within individual variation (Jantz, Fohl, & Zahler, 1979; Rife, 1955). As well, Rose, Reed, and Bogie (1987) found that asymmetry of the palmar a-b ridge counts was associated with an increased resistance to PBCs. Therefore, one might surmise, that if LH reflects a person previously exposed to PBCs, their palmar a-b ridge counts should be more asymmetric than the ridge counts of right-handers.

Micle & Kobyliansky (1986) state that there are two types of asymmetry of note: directional and fluctuating. Fluctuating asymmetry is described as random, nondirectional, and nonsigned. Fluctuating asymmetry is further considered to represent previous exposure to noxious factors. Kobyliansky and Micle (1986) found that left-handers had greater fluctuating asymmetry than did right-handers.

**Summary**

There are many studies consistent with a relationship between handedness and atypical biological organization. The anatomical, physiological, and functional research reviewed suggests a relationship between CNS, electrophysiological, circulatory, immunological, dermatoglyphic, and cranial asymmetries, and hand
Schizophrenia and the Neurodevelopmental Theory

If NRH represents a sub-lethal component of Pasamanick's continuum of reproductive casualty, then NRH itself, ought to be correlated to some degree with other disorders that have been linked to PBCs. In fact, Harris (1980) in his historical review of LH notes an association with a myriad of disorders, among them epilepsy, mental retardation, homosexuality, delinquency, dyslexia, and cognitive deficits. Recent research corroborates the historical accounts, as epilepsy (Bingley, 1958), mental deficiency (Bradshaw-McAnulty, Hicks, & Kinsbourne, 1984; Soper, Satz, Orsini, VanGorp, & Green, 1987), homosexuality (Lindesay, 1987), delinquency (Ellis & Ashley-Ames, 1989), dyslexia (Geschwind & Behan, 1982), and cognitive deficits (Harshman, Hampson, & Berenbaum, 1983), in addition to various other disorders such as alcoholism (Bakan, 1973), gastrointestinal disorders (Geschwind & Behan, 1982; Searleman & Fugagli, 1987), and dementia (Seltzer, Burres, & Sherwin, 1984), have all been reported to be associated with an increased incidence of LH.

Of particular interest to the present study is the proposed relationship between an increased incidence of NRH and schizophrenia. Schizophrenia as a general concept is accepted universally (Goldstein, Baker, & Jamison, 1980).
However, Goldstein and his colleagues do acknowledge the existence of disagreement as to the definition of schizophrenia; some consider it too subjective a term for what may simply represent deviant behavior. While some choose to disagree, a consensus has emerged among North American psychiatrists concerning a diagnostic scheme for schizophrenia (American Psychiatric Association (APA), 1987). According to the DSM-III-R:

The essential features of this disorder are the presence of characteristic psychotic symptoms during active phase of the illness and functioning below the highest level previously achieved (in young children or adolescents, failure to achieve the expected level of social development), and the duration of at least six months that may include characteristic prodromal or residual symptoms. At some phase of the illness Schizophrenia always includes delusions, hallucinations, or certain characteristic disturbances in affect and the form of thought. The diagnosis is made only when it can be established that an organic factor initiated and maintained the disturbance (p. 187).

**Handedness and Schizophrenia**

Annett (1985), based upon her review of the literature, suggested that schizophrenia was unrelated to manual preference. Nonetheless, of the 40 studies on the relationship between NRH and schizophrenia, 22 reported a positive relationship (Boklage, 1977; Chapman & Chapman, 1987; Chaugule & Masters, 1981; Cuff, 1930; Das cited in Blau, 1946; Dvirskii, 1976; Green, Satz, Smith, & Nelson, 1989; Gur, 1977; Hallett & Green, 1983; Katsanis & Iacono, 1989; Lewis, Chitkara, & Reveley, 1989; Lishman & McMeekan,

A further 15 studies reported no statistically significant increase of NRH - a few even reported an increase in RH - in schizophrenia (Bolin, 1953; Chandler, 1934; Fleminger, Dalton, & Standage, 1977; Goldfarb, 1961; Kallman, 1986; Kameyama, Nirva, & Saitoh, 1983; Krynicki & Nahas, 1979; McCreadie, Crorie, Barron, & Winslow, 1982; Merrin, 1985, Oddy & Lobstein, 1972; Shimizu, Endo, Yamaguchi, Forii, & Isaki, 1985; Taylor, Brown, & Gunn, 1983; Taylor, Dalton, & Fleminger, 1980; Taylor, Dalton, Fleminger, & Lishman, 1982; Wahl, 1976). Three studies were ambiguous in their assessment of handedness (Gottesman & Shields, 1972; Hauser, Pollock, Finkelberg, McGrail, Voineskos, & Seeman, 1985; Horkovič, 1972). This survey of the literature appears to support a majority of studies linking schizophrenia with an increased tendency to NRH.

Cuff (1930) in an early study of laterality and psychopathology, found that mixed-handers tended more toward psychopathology than the more lateralized subjects. Cuff interpreted his results as indicating that those persons without dominant dexterity are more likely to have mental
pathology.

Chapman and Chapman (1987) administered three psychosis-proneness scales to 7457 introductory psychology students at the University of Wisconsin. An excess of mixed-handedness was revealed for the psychosis-prone group. Chapman and Chapman consider their result consistent with other reports of a greater incidence of LH in schizophrenics; since, they note, most schizophrenia researchers "treat left-handed and ambilateral subjects as a single group, typically called 'left-handed'" (p. 91).

Oddy and Lobstein (1972) administered a five-item handedness battery (after Annett, 1970) to 70 male and 70 female schizophrenics, all without known cerebral injury. The results indicated no statistically significant relationship of handedness to schizophrenia, albeit they noted a higher degree of mixed-handedness among younger schizophrenics. In addition, a higher proportion of schizophrenics exhibited crossed hand-eye dominance. A similar negative outcome for a schizophrenia-NRH relationship was found in the study by Merrin (1985), in which subjects were selected on the basis of being free of known cerebral injury. Other studies found a positive relationship for schizophrenia-NRH despite the stipulation that subjects be without sign of brain trauma (Gur, 1977; Hallett & Green, 1983; Lishman & McMeekan, 1976; Shan-Ming et al., 1985; Walker & Birch, 1970).
Krynicki and Nahas (1979) measured the handedness of 25 young male schizophrenics and 25 non-psychotic young men on the EHI (Oldfield, 1971). They discovered an incidence of 20 percent LH in the schizophrenic group, whereas the incidence was only 4 percent in the non-psychotic group. Despite this manual preference disparity, a chi-square analysis failed to reach statistical significance due to an inadequate sample size. Other studies have recorded statistically significant levels of NRH among schizophrenics, such as the 16 percent in the study by Gur (1978), 18 percent by Nasrallah et al. (1981), and an enormous 31 percent - using writing hand as the sole criterion for handedness - by Manoach et al. (1988).

Two large sample studies of handedness among schizophrenics were completed in Japan (Kameyama et al., 1983; Shimizu et al., 1985). Kameyama and colleagues (1983) determined the handedness of 584 schizophrenics, 688 normal adults, and 1041 children. Their data revealed no significant difference between the groups due to handedness. Shimizu et al. (1985) distributed 2077 handedness questionnaires to schizophrenic in-patients at psychiatric hospitals to which they received 1774 completed returns. In addition, a control group of 4282 subjects who had completed the handedness inventory were included. The frequency of LH was 3.4 percent for the schizophrenic patients in comparison to the 3.2 percent for the control group. In both of the
Japanese studies, the authors acknowledged the existence of forced handedness attempts. Shimizu et al. (1985) report that 80 percent of the nonright-handers had experienced pressure to convert to RH at an early age. No information, however, is provided as to whether or not any of the right-handers in their study represent converted left-handers. This presents a potential confound, as high levels of forced RH have previously been delineated in Oriental populations (Teng, Yee, Yang, & Chang, 1976). Indeed, it is therefore not surprising, that the proportion of LH has been found to be lower in Oriental populations (Hardyck, Goldman, & Petrinovich, 1975; Teng et al., 1976).

The negative finding by Wahl (1976) contains a few methodological problems. First, the sample of 26 schizophrenics is quite small. Second, the schizophrenic patients tended to be relatively older - from ages 40 to 55 - and the control group, comprised of hospital staff, was much younger - about 25 to 40. LH is documented to diminish with increasing age (Brackenridge, 1981; Porac, Coren, & Duncan, 1980). As well, no breakdown by sex was provided.

McCreadie and co-researchers (1982) observed no overall handedness difference between schizophrenics and a control group. Yet a noteworthy distinction did occur when the schizophrenics were classified according to the need for hospitalization. Significantly more of the nonright-handed schizophrenics tended to be in-patients than did right-
handers. Furthermore, McCreadie et al. found that nonright-handed schizophrenics were more likely to suffer adverse reaction to neuroleptic drug treatment than are right-handers. Of the 19 nonright-handers, 13 (68.4\%) subsequently developed tardive dyskinesia, whereas only 19 of 66 right-handers (28.8\%) contracted the movement disorder. Reynolds (1983) noted an increased amount of the neurotransmitter dopamine in the left hemisphere of schizophrenics. Dopamine depletion precipitated by neuroleptic treatment has been implicated in the onset of tardive dyskinesia (Goldstein et al., 1980). Irwin (1985) reported in his study, that left-handers exhibited greater drug sensitivity than did right-handers.

Lishman and McMeekan (1976) analyzed the handedness patterns of 130 psychiatric patients via the Annett (1970) questionnaire. A small but significant shift toward LH was found, this being most prominent in younger patients and confined mainly to males.

Several studies on the relationship between schizophrenia and handedness reveal a positive relationship. Fewer studies report a negative relationship. Due to the modest proportion of left-handers in the general population, it is necessary to sample a sufficiently large population in order to demonstrate a statistically significant association between any disorder and an increased incidence of LH. Moreover, the age of the clinical population is of paramount
concern as LH is rarer in the older age brackets. Some of the negative findings for a schizophrenia-LH relationship have failed to adequately account for some of these major considerations.

**Pregnancy and Birth Complications and Schizophrenia**

Further evidence congruent with the Neurodevelopmental Theory and relevant to schizophrenia is found in the literature detailing an association between schizophrenia and PBCs (Bender, 1953; Knobloch & Pasamanick, 1962; Mednick, 1970; Mednick, Mura, Schulsinger, & Mednick, 1971, 1982; Mura, 1969; Pasamanick & Knobloch, 1961; Pollack & Woerner, 1966; Pollack, Woerner, Goodman, & Greenberg, 1966; Pollin & Stabenau, 1968; Pollin, Stabenau, Mosher, & Tupin, 1966; Slater & Shields, 1953; Taft & Goldfarb, 1964). Some studies have failed to corroborate the schizophrenia-PBCs relationship (Boklage, 1977; Gottesman & Shields, 1972).

In her examination of childhood schizophrenia, Bender (1953) stated that: "The etiological factor which is most important in precipitating the schizophrenic illness is a physiological crisis, such as birth, especially with damage such as anoxia..." (pp. 667-678).

Knobloch and Pasamanick (1962) sought clues to the causation of early infantile autism and childhood schizophrenia. They found a high incidence of gestational difficulties, such as prematurity, twinning, and abnormal
neurological signs associated with the disorders. Pasamanick and Knobloch (1961), however, did "not feel that schizophrenia is due to brain injury but rather that this may be an indication of a lowered threshold to stress serving as an additional organic precursor to breakdown in the individual who is already genetically predisposed" (p. 91).

Twinning and the multiple birth process have been linked with certain unfavorable birth consequences: for example, prematurity and low birth weight (Bulmer, 1970; Kringlen, 1969). Moreover, it has been shown that the multiple birth baby which has suffered the greatest birth trauma or was the lightest of the neonates was more likely to be afflicted with schizophrenia in later life (Mura, 1969; Pollin & Stabenau, 1968; Pollin, Stabenau, Mosher, & Tupin, 1966; Rosenthal, 1963; Rosenthal, Raphling, & Quinn, 1963; Slater & Shields, 1953). Clementson (1959) presented data which indicated that oxygen deprivation was greater in the lighter of same birth siblings; in general, the oxygen saturation in the umbilical cord of monozygotic infants was lower than in dizygotic infants.

**Biological Correlates of Schizophrenia**

The biology of schizophrenia in many ways mirrors that of nonright-handers. A striking example, of a possible link with the Neurodevelopmental Theory, is the discovery of
irregularities in the pyramidal tract of schizophrenics (Scheibel & Kovelman, 1981). In addition, structural similarities can be found in the corpus callosum, ventricular region, and frontal and occipital brain regions.

**Left Hemisphere Dysfunction in Schizophrenia**

Numerous studies cite the involvement of left hemisphere dysfunction and/or left hemisphere overactivation in schizophrenia (Flor-Henry, 1969, 1974, 1983; Gur, 1978; Raine & Manders, 1988). Gur (1978) compared 24 schizophrenic subjects to 24 matched controls on two tachistoscopic tasks involving verbal and spatial information processing. In general, the left hemisphere is considered dominant for verbal material while the right hemisphere is more specialized for spatial information (Springer & Deutsch, 1985). Gur found that schizophrenics exhibit right hemisphere superiority for both tasks; this she interprets as indicating left hemisphere dysfunction of verbal information processing.

Bakan (1976), in noting that the right hemisphere is active for dreaming, thought that schizophrenia might represent a condition where dreaming perverted waking consciousness. Schizophrenic research has described a similarity between dream states and schizophrenia (Fischman, 1983).
The Corpus Callosum and Interhemispheric Transfer of Information in Schizophrenia

Bakan (1976) implicates the corpus callosum as playing an important role in schizophrenia. Rosenthal and Bigelow (1972) found that the corpus callosum was significantly larger in schizophrenics, specifically the middle portion of the corpus callosum. Nasrallah, Andreasen, Coffman, Olson, Dunn, Ehrhardt, and Chapman (1986) employed magnetic resonance imaging to compare, in vivo, corpora callosa in schizophrenics and healthy control subjects. They found increased thickness of the corpus callosum - not only in the midsection but also in the genu and splenium. Further corroboration of the possible involvement of the corpus callosum comes from the finding that surgical incision into the corpus callosum provides alleviation from schizophrenic symptoms (Laitinen & Vilkki, 1973).

Beaumont and Dimond (1973) provide functional support for the notion of an irregular corpus callosum in schizophrenics. They contrasted the performance of schizophrenics with two control groups - normal and psychotic - on various tasks as presented tachistoscopically. Schizophrenics performed worse than the normal controls in the left hemisphere task of matching letters and worse than the psychotic controls in the right hemisphere tasks of matching digits and shapes. Green, Glass, and O'Callaghan (1979) state that, overall, the
literature tends to implicate poor IHT of information in schizophrenics. Based on the result of alleviation from schizophrenic symptoms following anterior mesoloviotomy, Green and co-workers agreed with Laitinen & Vilkki's (1973) explanation that hyperactivity - as opposed to hypoactivity - of the corpus callosum may be responsible for the poor IHT of information. Reports of enlarged corpora callosa in schizophrenics relates well to Witelson's (1985) account of increased callosal size in nonright-handers.

**Ventricular Anomalies in Schizophrenia**

In addition, other researchers' investigations reveal neuroanatomical findings for schizophrenics that are comparable to the neuroanatomical results found for left-handers. In fact, several researchers report the presence of ventricular abnormalities in schizophrenics (DeLisi, Goldin, Hamouit, Maxwell, Kurtz, & Gershon, 1986; Pearlson, Kim, Kubos, Moberg, Jarayama, Bascom, Chase, Goldfinger, & Tune, 1989; Reveley, Reveley, Clifford, & Murray, 1982; Schulsinger, Parnas, Petersen, Schulsinger, Teasdale, Mednick, Møller, & Silverton, 1984; Weinberger, Bigelow, Kleinman, Klein, Rosenblatt, & Wyatt, 1980; Weinberger, Cannon-Spoor, Potkin, & Wyatt, 1980). McCrae et al. (1968), as mentioned earlier, had delineated handedness asymmetries as they relate to ventricular size.

With regard to structural abnormalities in
schizophrenia, Pearlson et al. (1989) claim that structural brain-image studies tend to support differences being found in schizophrenics, "with the most frequently replicated observation being one of nonspecific lateral ventricular enlargement visible on CT scans compared with controls" (p. 690). Pearlson and co-investigators had the CT scans of 50 schizophrenic in-patients blindly judged with the result that schizophrenics again exhibited enlarged ventricles compared to 87 normal control subjects. Moreover, Katsanis and Iacono (1989) report that left-handed schizophrenics have larger lateral ventricles than do right-handed schizophrenics, as determined from CT scans. Importantly, Pearlson and colleagues (1989) observe that, PBCs as well as LH are significantly associated with greater ventricular size.

The susceptibility of the periventricular region to hypoxia - particularly late in the second trimester - has been described by Myers (1975). One investigation found that in neonates who had suffered perinatal asphyxia, there was a correlation with ventricular ballooning (Flodmark, Guiseppe, & Harwood-Nash, 1981). Schulsinger and colleagues (1984) observe that the offspring of schizophrenic mothers evince a trend toward difficult births, with low birth weight being associated with enlarged ventricles. The evidence can be construed as indicating that ventricular enlargement is directly connected with schizophrenia rather
than being an aftermath of schizophrenia.

Frontal and Occipital Reversals in Schizophrenia

The presence of frontal and occipital reversals was noted in case of left-handers (Bear et al., 1986; LeMay, 1976; Luchins, 1983). As well, a greater frequency of both frontal and occipital reversals has also been noticed in schizophrenic patients (Luchins, Weinberger, & Wyatt, 1979).

Electroencephalographic Results in Schizophrenia

EEG readings have also been observed to be abnormal in schizophrenics (Itil, 1975; White, DeMyer, & DeMyer, 1964). Indeed, one investigation found the EEG's of schizophrenics to be similar to that of healthy left-handers (Shaw, Colter, & Resek, 1983). On the basis of the EEG likenesses between schizophrenics and left-handers, Shaw and colleagues propose a corresponding brain organization for the two groups.

The Proposed Schizophrenia-Epilepsy Link

Abnormal EEG readings are indicative of epilepsy, a disorder some claim is linked with schizophrenia (Flor-Henry, 1969, 1974, 1983; Slater & Beard, 1963a,b; Taylor, 1975). Slater and Beard (1963b) view schizophrenia as an organic psychosis to which a person with pre-existing epilepsy is predisposed. While Flor-Henry (1969) is not in agreement with the emphasis on the organic nature of
schizophrenia, he nonetheless concurs on the schizophrenia-epilepsy link: specifically, a link with left temporal lobe epilepsy. Evidence of temporal lobe structural alterations have been found in schizophrenia (McCarley, Faux, Shenton, LeMay, Cane, Ballinger, & Duffy, 1989).

Dermatoglyphic Evidence in Schizophrenia

Markow and Wandler (1986) scrutinized the a-b ridge counts of 81 DSM-III (APA, 1980) diagnosed schizophrenic patients, a control group of 49 DSM-III diagnosed patients with affective disorder, and a second control group of 69 faculty and staff at the Maricopa Medical Center in Phoenix. Results indicate that the schizophrenic patients were distinguished by significantly greater fluctuating asymmetry than either of the two control groups. The greater fluctuating asymmetry is similar to that noted for left-handers (Kobyliansky & Micle, 1986).

In their literature review, Torrey and Peterson (1976) noted that abnormal dermatoglyphic patterns were characteristic of schizophrenia. The dermatoglyphics of over 4000 schizophrenics worldwide revealed patterns that were highly unusual in the normal population.
Seasonality

Seasonality of birth is also regarded as being related to the occurrence of schizophrenia (Dalén, 1975; Mura, 1969; Pasamanick, 1986; Siva Sankar, 1969). Dalén (1975), based on his encompassing research, stated that: "There can no longer be any reasonable doubt about the reality of the seasonal deviations found in most of the large series of schizophrenics" (p. 57). Not all researchers agree. Lewis (1989) maintains that the season of birth effect is a "superfluous explanation" for schizophrenia and that the seasonality effect is better explained by the age of incidence in schizophrenia. A study by Ede, Templer, Brown, and Corgist (1985) of 2271 schizophrenics admitted to an Alberta hospital in Edmonton from 1923 to 1979 found no statistically significant relationship between monthly temperature and the number of births of those who later became schizophrenic. Pasamanick (1986) in a very critical rebuttal to Ede et al. (1985), states that, of course, northern Canada does not reveal any seasonality of birth effect in schizophrenia; it is, after all, hot summers rather than cold winters that are responsible for the seasonality phenomenon observed in schizophrenia. The summers in northern Canada are known to be relatively mild.

Pasamanick and Knobloch (1961) implicated climatic factors with PBCs, rather than the season of birth, per se. Summer heat was hypothesized to stress the fetus, thereby...
damaging it. Another element described as stemming from hot summers is decreased nutrition to the fetus, supposedly, because caloric intake decreases during hot weather (Knobloch & Pasamanick, 1958). Masland (1961) considered nutrition very important in the development of the fetus. Indeed, Masland claims that hypoxia could be considered a "specialized form of nutritional deprivation" (p. 53). Thereby, the hot summer months can facilitate conditions, in utero, that lead to oxygen insufficiency.

The time of the season also appears to have a bearing on PBCs; as PBCs were reported to be more likely to occur during the winter months (Pasamanick & Knobloch, 1961; Pasamanick, Dinitz, & Knobloch, 1959). As well, an increased frequency of LH has been reported in Blacks from warmer climates (Saunders and Campbell, 1985).

**Schizophrenia-NRH Relationship and Other Disorders**

The similarity of NRH and schizophrenia to various biological and gestational factors has so far been delineated. This is by no means an exhaustive survey of the possible links of NRH with schizophrenia. Analogous findings have been found for the presence of sleep anomalies in nonright-handers (Coren & Searleman, 1987) and schizophrenics (Snyder, 1969). Halpern and Coren (1988) reported on the shorter life span of the left-handers. Allebeck (1989) expounded on the life-shortening causes of
schizophrenia, in which suicides were identified as a major cause of mortality among schizophrenics. Interestingly, suicides are also documented to have a higher occurrence in left- than in right-handers (Chyatte & Smith, 1981). As well, an association between suicides and the more frequent occurrence of PBCs has also been delineated (Salk, Lipsitt, Sturner, Reilly, & Levat, 1985).

**Autism**

Similar evidence can also be found for the related disorder of autism. First and foremost, it must be recognized that the distinction between autism and childhood schizophrenia is often confused (Goldstein et al., 1980; Knobloch & Pasamanick, 1962; Pollin & Stabenau, 1968; Rutter, 1972). DSM-III-R (APA, 1987) elucidates the autism-childhood schizophrenia distinction, claiming that childhood schizophrenia is very rare and that it differs from autism, in that conspicuous symptomatology includes hallucinations and delusions. Petty, Ornitz, Michelman, and Zimmerman (1984), though, do not consider schizophrenia and autism to be entirely distinct, since a certain subgroup of autistic children has been identified as being at risk for later contracting schizophrenia.
Handedness and Autism


The study by Wetherby et al. (1981), however, is severely hampered in interpretability due to an extremely small sample size of only six autistic subjects. Of these six subjects, only one was assessed to be a pure right-hander with the rest possessing varying degrees of NRH.

Pregnancy and Birth Complications in Autism

Knobloch and Pasamanick (1962, 1975) have demonstrated a strong relationship between PBCs and autism. Knobloch and Pasamanick (1975) assert that everyone of their 50 autistic patients manifested organic CNS disease. PBCs such as low birth weight, toxemia and/or bleeding, and other neonatal complications are implicated in autism. As well, subsequent empirical evidence gathered from another large group of
young children with overt autistic behavior yielded similar results to the first autistic patient sample.

**Biological Correlates of Autism**

As with schizophrenia, EEG abnormalities manifest themselves in autism. Small (1975) researched the literature on EEG and neurophysiological studies in autism, which led him to conclude, "that autistic children have a high incidence of abnormal EEGs, providing objective indication of central nervous system dysfunction" (p. 396).

Since a language disorder usually accompanies autism, left hemisphere dysfunction is also implicated; however, many researchers indicate that autism appears to manifest bilateral dysfunctioning (Fein et al., 1984; Hauser et al., 1975; McCann, 1981; Small, 1975; Tsai & Stewart, 1982).

Neuroanatomical observations tend to be similar to those reported for schizophrenia. Damasio, Maurer, Damasio, and Chui (1980) analyzed the CT scans of 17 patients with autistic behavior and reported mild ventricular abnormalities. Hier et al. (1979) found that autistic patients, when compared to two other groups, differed in the pattern of the parieto-occipital region: the right parieto-occipital region being larger than the left side in autistics. In addition, Hauser et al. (1975) note that pneumoencephalograms disclose several cases of pathological enlargement of the left temporal horn in their autistic
sample. In a similar vein to Flor-Henry (1969, 1974, 1983), Hauser et al. (1975) suggest that temporal lobe dysfunction may underlie the disorder of autism.

**Summary**

As with schizophrenia, evidence supportive of the Neurodevelopmental Theory is also provided by the related disorder of autism. The presence of PBCs, the increased incidence of NRH, and neurophysiological and neuroanatomical aberrations are often reported.

**Hypothesis**

According to the Neurodevelopmental Theory, it is expected that among the asymptomatic introductory psychology students, those students who display positive schizotypal cognitions - as assessed by the RISC - should report higher levels of PBCs than those students not manifesting positive schizotypy. Secondly, the positive schizotypes should also reveal a trend to a higher rate of NRH than those subjects without positive schizotypal cognitions.

The present study seeks to determine the laterality and birth history of those individuals identified as having positive schizotypal cognitions. To this end 1017 questionnaires with items concerning laterality, birth history, and the RISC (Rust, 1987, 1988; Rust & Chui, 1988; Rust, Moncada, & Lepage, 1988) were distributed to students
enrolled in introductory psychology at three British Columbia post-secondary institutions.

The RISC is a succinct 26-item forced choice questionnaire psychometrically designed to access the positive cognitive thought patterns of schizotypal or eccentric subjects according to DSM-III-R (APA, 1987) category A of schizophrenia and DSM-III-R categories 1 (marked social isolation or withdrawal), 3 (markedly peculiar behavior), 4 (poor personal hygiene and grooming), 5 (blunted or inappropriate affect), 7 (magical thinking), and 9 (listlessness) of schizotypal personality disorder (Rust, 1988).

Earlier scales of schizoid thought were adversely affected by a number of drawbacks including a deviant distribution, poor discrimination between schizophrenics and normals, and poor validity (Rust, 1987). The RISC scale includes 13 positive items and 13 negative items with split half reliability reported as 0.77 (Rust et al., 1988). The RISC has been standardized according to the normal population distribution - no item received less than 20 percent acceptance in the normal population - and features a high level of discrimination between acute schizophrenics and normal control subjects (Rust, 1987). The RISC has been designed for use on the normal population, specifically to tap the odd ideational system of schizophrenic type persons as viewed on a continuum. Moreover, RISC scores indicate not
only symptomatology and location on the continuum, but also indicate susceptibility for schizophrenic-like affliction (Rust & Chui, 1988). Lastly, the RISC has also been demonstrated to be relatively unaffected by cultural bias (Rust, 1987; Rust et al., 1988).

Generally, the positive symptomatology of schizophrenia has been neglected in favor of studying negative schizophrenia (Rust, 1988). Addressing this issue, the present study analyzes the positive schizotypal symptomatology of introductory psychology students. At least one group of researchers had concluded that there is evidence of an NRH link with positive symptomatology (Shan-Ming et al., 1985). Particularly pertinent to the present study is the investigation by Chapman and Chapman (1987) which also determined the handedness of introductory psychology students. Three psychosis-proneness scales were employed: the Perceptual Aberration-Magical Ideation Scale (Chapman, Chapman, & Raulin, 1978; Eckblad & Chapman, 1983), the Impulsive Nonconformity Scale (Chapman, Chapman, Numbers, Edell, Carpenter, & Beckfield, 1984), and the Physical Anhedonia Scale (Chapman, Chapman, & Raulin, 1976).

Highly significant levels of NRH were reported for the Perceptual Aberration-Magical Ideation and Impulsive Nonconformity Scales. Importantly, magical ideation is one of the dimensions tapped by the RISC (Rust, 1988), while presumably the Physical Aberration Scale taps delusional
ideation.

Method

Subjects

Questionnaires were distributed to students enrolled in the Autumn 1989 semester of introductory psychology at three British Columbia post-secondary institutions: Simon Fraser University in Burnaby, and the University of Victoria and Camosun College in Victoria. Of the 1017 questionnaires circulated, 523 (51.4 %) were returned - 342 by female students and 181 by male students.

Insert Table 1 about here

Table 1 provides the age distribution of the sample. Sex ratios by age were approximately equal with 93.9 percent of the male correspondents and 98.2 percent of the female correspondents indicating their age to be 30 or less. Two male subjects failed to indicate their age.

Ethnicity of the subjects responding to the questionnaire was 80.3 percent Caucasian, equally represented by either sex. Orientals comprised another 8.9 percent, 2.5 percent were Asian Indian, 0.8 percent of mixed parentage, while 4.1 percent listed their ethnicity as other
than the above.

**Questionnaire**

The questionnaire utilized in the present investigation was composed of 113 items. Items 1-19 were concerned with laterality: 1-10 assessing handedness, 11-13 assessing footedness, 14-16 assessing eyedness, and 17-19 assessing earedness. The handedness inventory included items on writing, drawing, use of a bottle opener, throwing, hammering, brushing one's teeth, use of a screwdriver, playing tennis, use of scissors, and dealing playing cards. The handedness inventory is similar to that used by other researchers, seven of the ten items appearing on the 12-item inventory of Annett (1970) and five on the ten-item EHI (Oldfield, 1971). Subjects could respond either: (a) right, (b) left, or (c) both equally to the laterality items. Subject self-knowledge of their birth history was tapped by items 27-49; these were based upon previous questionnaires of Bakan. The occurrence of various PBCs was assessed, including prematurity, Cesarian birth, low birth weight, breech birth, postmaturity, twinning or multiple births, use of instruments, hypoxia, maternal or fetal blood transfusions, toxemia, maternal bleeding, X-rays, the use of drugs or other medication by the mother during pregnancy, long labor, the induction of labor, asphyxia, early illness, and birth defects. Items 88-113 comprise the 26 statements
of the RISC (Rust, 1987, 1988; Rust & Chui, 1988; Rust et al., 1988). The RISC is a forced-choice scale designed to measure positive schizotypal cognitions where the subject can reply: agreement, strong agreement, disagreement, or strong disagreement with each statement. Half of the items on the RISC are presented in reverse order to protect against response bias.

Procedure

Questionnaires were distributed to introductory psychology students at the beginning of class. At the following class the voluntarily completed forms were collected. A few questionnaires were returned at a later date to an office mailbox.

Laterality scores are determined by assigning scores of zero for a right response, one for a left response, and a half for a both equally response. Thus, for any laterality measure a score of zero indicates pure right-sidedness. For handedness, a score of 0.5 to 1 indicates RH. Scores from 1.5 to 2.5 are indicative of NRH, while a score of three or greater is classified as LH. In some cases a dichotomous classification is used, whereby pure RH and RH combine to form a RH group and LH and NRH combine to form a NRH group. The other laterality measures of footedness, eyedness, and earedness had possible score ranges from zero to three. For these non-handedness categories a score from zero to one
indicates right-sidedness and a score from two to three signifies left-sidedness.

The birth history section is compiled separately for each item and combined for one total result. Subjects could respond to each item either: (a) yes, (b) no, (c) I think so, but I'm not sure, (d) I think not, but I'm not sure, and (e) do not know. Subjects responding affirmatively or "I think so, but I'm not sure" are scored as having the complication and comprise the stress group. Item 31 regarding birth weight had the following possible responses: (a) less than 5 lbs., (b) more than 5 and less than 6 lbs., (c) more than 6 and less than 9 lbs., (d) more than 9 lbs., and (e) do not know. Subjects who replied either (a) or (b) to item 31 were placed in the stress group. Otherwise subjects are placed in the no stress category which constitutes the normal group, similar to Bakan et al. (1973). Though there may be a bias toward under-reporting of PBCs, there is no reason to assume that this should differ between right- and nonright-handers (Bakan et al., 1973).

In scoring the RISC, items 88, 91, 93, 95, 99, 100, 101, 104, 105, 109, 110, 112, and 113 are scored from zero for a response of strongly disagree, one for disagree, two for agree, and three for strongly agree. The other 13 RISC items - 89, 90, 92, 94, 96, 97, 98, 102, 103, 106, 107, 108, and 112 - are scored in the opposite manner. When all items
are tallied, a total raw score is obtained with a possible range from zero to 78.

High RISC scores are then compared to low RISC scores for the presence of PBCs. High RISC scores indicate stronger positive schizotypal cognitions and are defined as being those above 40. In addition, RISC scores are evaluated with respect to the handedness of the subjects. Also tested for is the relationship of handedness to PBCs (Bakan et al., 1973).

Results

Handedness

From Figure 1 and Figure 2 it is seen that handedness follows a J-shaped distribution for both males and females. Each subject is classified as either pure right (handedness score of zero), right (score from 0.5-1.0), nonright (score from 1.5 to 2.5), or left (score from 3-10). Of the males, 27 (14.9 %) manifest LH, 15 (8.3 %) NRH, 103 (56.9 %) pure RH, and 36 (19.9 %) have lesser degrees of RH. For the
female subjects, 49 (14.3%) indicate LH, 15 (4.4%) NRH, 226 (66.1%) pure RH, and 52 (15.2%) lesser degrees of RH.

**RISC and PBCs**

Insert Table 2 about here

Only those RISC inventories answered for all 26 items are used in the study - that being 451 of the 523 returned questionnaires. For RISC categorization a dichotomy is imposed whereby those scoring 40 or higher constitute the high RISC group and those scoring less than 40, the low RISC group. The high RISC group was compared to the low RISC group, separately by sex, for self-reports of one or more PBCs versus a no stress group which did not report any PBCs. Applying the chi-square as a contingency measure, no statistically significant relationship emerged from the data although males did approach significance at the $p < 0.05$ level with low RISC scores being associated with self-reports of PBCs (Table 2).

**RISC and Handedness**

Insert Table 3 about here
Hand preference was compared for the high RISC group and the low RISC group (Table 3). Handedness is displayed according to the four groupings in the table, but all chi-square procedures were performed using the dichotomous classification, whereby pure right- and right-handers constitute the right group and nonright- plus left-handers constitute the nonright group. The chi-squares revealed no statistically significant relationship between hand preference and RISC score for males: $\chi^2 (1, N = 158) = 2.68, p < 0.10$. This relationship becomes significant when pure right-handed males are compared to left-handed males; left-handed males tending to have low RISC scores and pure right-handers tending to have high RISC scores: $\chi^2 (1, N = 114) = 4.18, p < 0.05$. For both analyses with males, the direction of the relationship between handedness and RISC is opposite to the predicted direction. For females, the relationship between handedness and RISC scores is statistically significant and in the predicted direction: $\chi^2 (1, N = 324) = 5.80, p < 0.025$. Nonright-handed females are more likely to have high RISC scores.

**Distribution of RISC Scores**

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Insert Figure 3 about here
From Figure 3 it is apparent that there is a difference between male nonright-handers and male right-handers in the modal distribution of RISC scores. The nonright-handers peak earlier in the 30-34 score range while the right-handers peak in the 35-39 and 40-44 range. The situation is also distinct among females (Figure 4). Here a peak occurs for nonright-handers in the 40-44 range and for right-handers in the 35-39.

Handedness and PBCs

The report of increased NRH in the birth stress group is confirmed by the data. From Table 4 it is seen, employing the dichotomous classification, that nonright-handed males are significantly more likely to report one or more PBCs than are right-handed males: $\chi^2 (1, N = 181) = 6.25, p < 0.05$. For females this trend is not evident. A slightly higher rate of self-reported PBCs is observed for the female subjects (64.3 %) than for male subjects (58.6
Post Hoc Analysis

Insert Table 5 about here

PBCs

Table 5 features a check done for unanswered RISC questionnaires. This revealed a trend among male subjects: those males who reported PBCs were more likely not to answer any of the RISC than were males who did not indicate any PBCs: $\chi^2 (1, N = 181) = 3.59, p < 0.05$. This same trend was also evident for females, although it did not near significance.

Handedness

For handedness there was no statistically significant handedness trend for unanswered RISC questionnaires; this was true for both males and females.
Discussion

The results indicate that the relationship between self-reports of PBCs and RISC score is not significant for either males or females. Both males and females show trends in the direction opposite to that predicted. In general, there appears to be fewer reports of PBCs among subjects with high RISC scores.

Examination of the relationship between handedness and RISC score reveals gender specific results. Again, males approached significance in a direction counter to the hypothesis: male right-handers tended more to high RISC scores than male nonright-handers. This trend was significant only when examining the two extreme groups: pure RH versus LH, \( p < 0.05 \). For females, an excess of NRH is associated with high RISC scores as predicted.

Thus the male subjects behaved in a manner opposite to the hypothesis with respect to PBCs and handedness, that is, males with PBCs and nonright-handed males were both underrepresented in the high RISC group and overrepresented in the low RISC group. Female subjects did not behave according to the hypothesis with respect to PBCs. They did, however, behave according to prediction for handedness, that is, female nonright-handers were overrepresented in the high RISC group and underrepresented in the low RISC group.

A possible contributing factor to this sex discrepancy became apparent after checking for those subjects who did
not attempt to answer the RISC. A relationship with PBCs was found, whereby males with PBCs were found to be more likely not to answer the RISC (the same trend is true for females, albeit at a lower p level) than were those males without PBCs. Thus a potential confound might exist. It is possible that non-responding male subjects with PBCs represent a subgroup who might normally manifest high RISC scores. Their unwillingness to respond to the RISC section of the questionnaire may be reflected in the disparate male/female finding for PBCs. This relationship held only for PBCs, as there was no relationship between handedness and unanswered RISC questionnaires.

The findings indicate a sexual dimorphism is present in the results. There are numerous instances cited of the differential effects of birth stress on males and females (Haas, Moreno-Black, Frongillo, Javier, Gerardo, Jorge, & Luis, 1982; Stinson, 1985; Ward, 1984; Weinberg, Zimmerman, & Sonderegger, in press). Males also differ from females in perinatal mortality rate, this being higher for males (Gruenberg, 1964; Stinson, 1985). It is possible that the male victims of perinatal mortality might otherwise have exhibited certain disorders associated with PBCs and handedness. Therefore, because of their increased resistance to birth stress, females might be more likely to manifest some disorders related to PBCs. However, the legitimacy of this line of reasoning is confused by the non-significant
finding of high RISC score with PBCs.

Sarnoff Mednick (1970) undertook a longitudinal study of children born at risk for schizophrenia. For this purpose, Mednick chose to examine Danish birth cohorts, as Danish birth and medical records are well-known for their meticulousness. Hypoxia during pregnancy was implicated in hippocampal damage, which together with environmental and genetic factors, led to a susceptibility to schizophrenia. Subsequent reports of Mednick and his collaborators (Mednick et al., 1971, 1982) have affirmed the correlation of PBCs with the later onset of schizophrenia. Mednick et al. (1982) found that of 9006 consecutive births at the university hospital in Copenhagen, between 1959 and 1961, certain signs characterized children born to schizophrenic parents. Perinatal distress, especially low birth weight, was evident in children born to schizophrenics. One group of researchers has presented data suggesting a relationship of low birth weight resulting from hypoxic conditions, in which males were found to be lighter at birth than were females (Haas et al., 1982). Yet in the Mednick et al. sample of children at risk, low birth weight was particularly apparent in infant females when the schizophrenic parent was the father. Mednick et al. (1982) explain the higher level of PBCs among girls with schizophrenic fathers in terms of differential perinatal mortality rates. Gruenberg (1964) stated that "the evidence
is so good that male mortality exceeds female mortality ... at every age level and also during fetal life" (p. 124). Thus, it may be that more females are affected with a certain disorder because they are better able to withstand the perinatal distress than are males.

One finding of a male/female PBCs distinction in schizophrenia contrary to that of Mednick and his co-researchers (1982) was previously reported by Taft and Goldfarb (1964), and yet it was explained in the similar manner of greater male susceptibility to PBCs. The earlier study by Taft and Goldfarb (1964) did agree on the greater frequency of PBCs in schizophrenic children, but their data did not concur with the sex by PBCs finding of Mednick and colleagues. The data of Taft and Goldfarb revealed an "unanticipated finding" of a sex difference, one opposite that of Mednick et al. (1982). Schizophrenic boys were found to be more likely to have incurred PBCs than were schizophrenic girls. This, Taft and Goldfarb suggested, was due to the higher occurrence of PBCs in males.

With regard to handedness, a study by Taylor (1975) found that nonright-handed female epileptics were more susceptible to developing schizophrenia, a result consistent with the present study's handedness findings. A very recent study by Oyebode and Davison (1990) also notes a sex difference similar to the present study whereby female epileptic patients are more prone to psychosis than are male
epileptic patients. Due to the higher incidence of NRH in
the males free from schizophrenia, Oyebode and Davison
propose that atypical handedness patterns may confer a
protective function to the development of psychiatric
illnesses in general. The authors were unclear as to why
this would be so but insinuated that the differential
cerebral lateralization of males and females might play a
role.

While the overall prevalence of schizophrenia is quite
similar for both males and females (APA, 1987), the onset of
schizophrenia differs along gender lines; in general, males
experience schizophrenia at an earlier age than do females
(Babigian, 1985). This is apparent from the higher
proportion of boys with childhood schizophrenia (APA, 1987).
It has been suggested that the earlier form of schizophrenia
represents a different type than the later form (Bender,
1953). Younger schizophrenic patients have been found to be
more likely to manifest the negative symptoms (Crow, 1989).
Thus the later occurring form of schizophrenia, predominant
in women, might be positive schizophrenia. This is
complicated by the fact that at least one researcher has
identified positive schizophrenia as being earlier in onset
than negative schizophrenia (Johnstone, 1989).

Flor-Henry (1974) agrees that males are more often
afflicted with early onset schizophrenia, while females are
more likely to incur psychosis at a later age. Flor-Henry,
however, sees a separate etiology for the two types, with the early onset form stemming from aberrant left-temporal lobe functioning. Females, on the other hand, are considered to suffer from an affective psychosis precipitated by a non-dominant, temporal-limbic disorganization. This might explain the negative finding for PBCs with high RISC score. Yet this is contrary to what is predicted for handedness by the Neurodevelopmental Theory.

Schneider (1959) considered the positive symptoms of hallucinations and delusions to be secondary to the diagnosis of schizophrenia. Bipolar mood swings and blunted affect were also included among the second-rank symptoms. A strong affective component is claimed to be found for positive schizophrenia, these individuals constituting the so-called "schizoaffectives" (Birchwood, Hallett, & Preston, 1989). While schizoaffectation is not cited by Rust (1987) as being assessed by the RISC, affective blunting is listed as one of the categories tapped by the RISC. It might be that this blunting of affect is being tapped in the female subjects.

The study of Chapman and Chapman (1987) provides some support for the influence of affective symptoms. NRH was found to be more common for those subjects identified by the Physical Aberration-Magical Ideation Scale (Chapman et al., 1978; Eckblad & Chapman, 1983). The Physical Aberration-
Magical Ideation Scale features the merger of the Body-Image Aberration Scale (Chapman et al., 1978) and a magical ideation scale (Eckblad & Chapman, 1983). Eckblad and Chapman (1983) claimed there was evidence that those subjects who manifested magical ideation displayed greater affective symptoms. Affective blunting is, however, considered by most researchers to be a negative symptom of schizophrenia, in which negative symptoms are those which represent a loss of function, and positive symptoms represent the occurrence of some behavior (Andreasen, 1982, 1985, 1989; Andreasen & Olsen, 1982; Crow, 1989; Johnstone, 1989).

The literature is very unclear concerning: sex related differences, the nosology of positive and negative schizophrenia, the involvement of PBCs with either form of schizophrenia, and the relationship of handedness with positive and negative symptomatology (Andreasen and Olsen in a 1982 article declared all their positive schizophrenics were right-handed). Different studies provide contrasting results which make the drawing of a conclusion difficult. The present study further obfuscates the situation by presenting findings indicative of a sexual dimorphism for positive schizotypy. It is possible that the notion of cerebral laterality differences between males and females, alluded to by Oyebode and Davison (1990), may underlie the results of the current study.
Schizophrenia is associated with a substantial mortality rate (Allebeck, 1989) and, as such, would occupy a position more toward the lethal end of the continuum of reproductive casualty. With a more lethal disorder, such as schizophrenia, brain damage might be expected to be more readily apparent. Schizotypy, though, would represent a more benign form of schizophrenia, and therefore should reside closer than the more pernicious forms of schizophrenia to the non-lethal end of the reproductive casualty continuum. It seems ostensible, that disorders juxtaposed nearer to the lethal end of the reproductive casualty continuum imply greater neuropsychiatric dysfunctioning and hence CNS insult. Therefore, NRH would occur with greater frequency in association with these disorders. Thus, one might justifiably foresee greater difficulty in affirming schizotypy in association with PBCs or an increased incidence of NRH.

In the current study, the link between PBCs and increased NRH is found to be statistically significant for males, corroborating earlier findings (Ashton, 1982; Bakan et al., 1973; Coren et al., 1982; Ross et al., 1987; Searleman et al., 1989). Males are identified as being particularly at risk on the continuum of reproductive casualty (Bakan, 1971).

Searleman et al. (1989) delineated the problems incurred when using self-reports of birth history, citing
the papers of Schwartz (1988) and Chamberlain and Johnstone (1975). Schwartz (1988) questions the validity of studies using self-reports of one's own birth history. Yet, from Schwartz's own study, such a bias in maternal self-reporting of PBCs appears to be slightly greater for right-handers when compared to actual hospital obstetric records. Chamberlain and Johnstone (1975) in their investigation of 174 multiparous women found that maternal recollection of earlier birth events was quite reliable. Searleman et al. (1989), however, thought that self-reports of one's personal birth history would be even more suspect, since such information would supposedly be second hand. However, maternal recall of antepartum and postpartum events would presumably reflect upon an individual's own recollection of their births, since it is reasonable to assume, that in most instances, information concerning such an occurrence would be provided by the mother. Nevertheless, validating individual recall of birth history is itself hampered by the unreliability of hospital records (Masland, 1961).

Another possible explanation for this study's finding is the choice of a non-clinical subject population attending institutions which are composed predominantly of the middle economic strata in society. The non-clinical character of the subject sample, though, should not pose too great a difficulty, as one meta-analysis reveals that small but significant results pertaining to PBCs are found (Searleman
et al., 1989). The paramount importance of socio-economic influences, that is, the greater susceptibility of those persons from the lower socio-economic strata to noxious factors, has been delineated both in terms of PBCs (Lilienfeld, Pasamanick, & Rogers, 1955; Masland, 1961; Pasamanick & Knobloch, 1957, 1960, 1961, 1966; World Heath Organization, 1986) and the Neurodevelopmental Theory (Bakan, 1978, 1990). Nonetheless, the profitability of finding positive results in an apparently successful group, such as university and college students, must be questioned. It is possible, that a relationship with pathology may be difficult to establish as selection against certain cognitive types may be expected in a university population, albeit some claim there to be more left-handers in the university population than is commonly found (Annett, 1985; Harvey, 1988). Indeed, a higher level of performance has been reported for left-handers in various academic disciplines (Benbow, 1988; Harvey; Lansky & Peterson, 1985).

The Neurodevelopmental Theory claims that NRH, per se, is a benign disorder which ensues following minimal brain damage, although this brain damage is not necessarily detectable (Bakan, 1990). Pasamanick (1960) stated that "the incidence of minimal cerebral damage frequently disappears or is compensated for in succeeding years and is therefore missed" (p. 78). In fact, undetectable neurological insult is arguably commoner in nonright-than in right-handers
(Levy, 1974).

The present research is somewhat problematic, in that, the reported PBCs have not been verified and that verification of minimal brain damage, regardless, is quite difficult. Birch (1964) states that:

Whether or not the damage they may have sustained is minimal, or whether they are brain damaged at all, is entirely presumptive and can be entertained as an etiologic prognosis only if one assumes that, in the absence of reflex changes and of demonstrable motor deficit, behavioral disturbances occurring in association with antecedent difficulty during pregnancy, at delivery, or in infancy must derive from minimal damage to the nervous system (p. 5).

Yet, Birch adds that:

Despite the fact that "brain damage" is an unfortunate diagnostic label in that it implies both the existence of etiologic knowledge where none exists and the stereotyped view of the consequences of cerebral injury, there is little doubt that the children designated by it constitute an important clinical group (p. 9).

The time lag between the onslaught of noxious factors affecting the fetus or neonate and the subsequent manifestation of a disorder such as schizophrenia is also problematic. This issue was addressed by Masland (1961) who stated that:

an important handicap lies in the prolonged time interval between the causative event and the demonstrable outcome. Under these circumstances, the cause-and-effect relationship is likely to be recognized by ordinary clinical observation only if both the causative agent and the outcome are either unusual or dramatic in their occurrence (p. 56).
It is not clear that positive and negative schizophrenia are entirely distinct from each other. Some confusion reigns in the nosological literature on schizophrenia as to what criteria satisfy negative versus positive symptomatology. It is very feasible that these disorders often co-exist and may epitomize another subtype of schizophrenia (Andreasen, 1985; Andreasen & Olsen, 1982; Johnstone, 1989). Further research, preferably longitudinal studies, are suggested by Andreasen (1985), in order to address this concern.

While the PBCs-NRH relationship was partially corroborated, an association of increased self-reports of PBCs with high RISC scores was unsubstantiated and therefore positive schizotypy as a potential disorder to be placed on the continuum of reproductive casualty must - based on the present findings - be viewed with caution. The unclear status of self-reports of PBCs in conjunction with a specific disorder would best be determined by a prospective study similar to that of Mednick (1970). In addition, accessibility to accurate pre- and perinatal records is preferable. Nonetheless, some support is forthcoming for the Neurodevelopmental Theory from the finding of an increased frequency of NRH paired with high RISC scores for females. Overall the results of this study are suggestive of a sexual dimorphism existing for the disorder of positive schizotypy as determined by the RISC.
References


Table 1

Age distribution of the sample

<table>
<thead>
<tr>
<th>Age</th>
<th>Male</th>
<th>Percent</th>
<th>Female</th>
<th>Percent</th>
<th>Total</th>
<th>Percent</th>
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<td>6</td>
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Table 2

Relationship of RISC score to self-reports of PBCs

<table>
<thead>
<tr>
<th>PBCs</th>
<th>Male (N = 158)</th>
<th>Female (N = 293)</th>
<th>Total (N = 451)</th>
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<tr>
<td></td>
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<td>Low</td>
<td>High</td>
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<tr>
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<td>32</td>
<td>b</td>
</tr>
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<td>57</td>
<td></td>
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<tr>
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<td>35</td>
<td>34</td>
<td>41</td>
</tr>
</tbody>
</table>

a  $\chi^2 (1) = 3.47, p < 0.10$

b  $\chi^2 (1) = 0.55$, no significant difference

c  $\chi^2 (1) = 3.22, p < 0.10$
Table 3  
Relationship of RISC score to handedness

<table>
<thead>
<tr>
<th>Handed</th>
<th>Male (N = 158)</th>
<th>Female (N = 293)</th>
<th>Total (N = 451)</th>
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<tbody>
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<td></td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Pure rt</td>
<td>a 40</td>
<td>48</td>
<td>b 69</td>
</tr>
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<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Nonright</td>
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<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Left</td>
<td>6</td>
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</tr>
</tbody>
</table>

a $\chi^2 (1) = 2.68$, no significant difference  
b $\chi^2 (1) = 5.80$, $p < 0.05$  
c $\chi^2 (1) = 0.78$, no significant difference
Table 4

Relationship of handedness to self-reports of PBCs

<table>
<thead>
<tr>
<th>Handedness</th>
<th>Male (N = 181)</th>
<th>Female (N = 342)</th>
<th>Total (N = 523)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Pure rt</td>
<td>a</td>
<td>51</td>
<td>b</td>
</tr>
<tr>
<td>Right</td>
<td>26</td>
<td>14</td>
<td>29</td>
</tr>
<tr>
<td>Nonright</td>
<td>8</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Left</td>
<td>21</td>
<td>6</td>
<td>31</td>
</tr>
</tbody>
</table>

\[ \chi^2 (1) = 6.25, p < 0.05 \]

\[ \chi^2 (1) = 0.00, \text{ no significant difference} \]

\[ \chi^2 (1) = 2.14, \text{ no significant difference} \]
Table 5

Analysis of completely unanswered RISC by PBCs

<table>
<thead>
<tr>
<th></th>
<th>Male (N = 181)</th>
<th>Female (N = 342)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISC answered</td>
<td>PBCs No PBCs</td>
<td>PBCs No PBCs</td>
</tr>
<tr>
<td>No</td>
<td>a 8 1</td>
<td>b 6 6</td>
</tr>
<tr>
<td>Yes</td>
<td>98 74</td>
<td>215 115</td>
</tr>
</tbody>
</table>

a  $\chi^2 (1) = 3.59, \ p < 0.10$

b  $\chi^2 (1) = 1.16$, no significant difference
Figure 1. Distribution of handedness scores for males
Figure 2. Distribution of handedness scores for females

Number of subjects

Handedness score
Figure 3. Distribution of RISC scores by handedness for males.
Figure 4. Distribution of RISC scores by handedness for females

Number of subjects

RISC score

- Nonright-handers
- Right-handers
Appendix

Laterality, Birth History, and Health Questionnaire

This questionnaire is part of a study of possible causes of handedness. Participation in this study is optional. If you do agree to participate you may withdraw at any time from the study. I appreciate your help in providing the information called for in this questionnaire. Please answer the items to the best of your ability. Your name is not required on the questionnaire.

If you have any queries regarding this project please leave a message with the psychology department for Kim Petersen, or phone 291-3354, and I will attempt to reply promptly. Any complaints can be directed to Dr. R. Blackman, Chairman of the psychology department.

Thank you.

Kim Petersen
Psychology Department
Simon Fraser University
For questions 1–10 please indicate with which hand you would:

1. draw ..................................................a) left b) right c) both equally
2. write ..................................................a) left b) right c) both equally
3. use a bottle opener .....................a) left b) right c) both equally
4. throw a baseball to hit a target ...a) left b) right c) both equally
5. use a hammer ..........................a) left b) right c) both equally
6. use a toothbrush ..........................a) left b) right c) both equally
7. use a screwdriver .........................a) left b) right c) both equally
8. use a tennis racket .....................a) left b) right c) both equally
9. use scissors .....................................a) left b) right c) both equally
10. deal playing cards ......................a) left b) right c) both equally
11. With which foot do you kick a ball? ......a) left b) right c) both equally
12. If you wanted to pick up a pebble with your toes, which would you use? 
   a) left b) right c) both equally
13. If you had to step up onto a chair, which foot would you place on the chair first? 
   a) left b) right c) both equally
14. Which eye would you use to peep through a peephole? 
   a) left b) right c) both equally
15. If you had to look into a dark bottle to see how full it was, which eye would you use? 
   a) left b) right c) both equally
16. Which eye would you use to peer through a telescope? 
   a) left b) right c) both equally
17. If you wanted to listen in on a conversation behind a closed door, which ear would you place against the door? 
   a) left b) right c) both equally
18. If you wanted to hear someone’s heartbeat, which ear would you place against their chest? 
   a) left b) right c) both equally
19. Into which ear would place the single earphone of a non-stereo radio? 
   a) left b) right c) both equally
20. In drawing a circle do you prefer to draw it clockwise or counterclockwise?
   a) clockwise b) counterclockwise c) no preference

21. Were you ever strongly pressured to switch the hand you preferred to write with?
   a) yes b) no c) do not know

22. What is your sex? ................................a) male b) female

23. What is your age?
   a) under 20 b) 20-25 c) 26-30 d) 31-35 e) 35 or more

24. What is your natural hair color (before it was artificially dyed or became gray)?
   a) blond b) light brown c) dark brown d) black e) red

25. What is your sexual preference?
   a) exclusively heterosexual with no homosexual
   b) predominantly heterosexual, but somewhat homosexual
   c) equally heterosexual and homosexual
   d) predominantly homosexual, but somewhat heterosexual
   e) exclusively homosexual

26. Which of these describes your smoking behavior?
   a) non-smoker
   b) pipe or cigar smoker
   c) cigarette smoker/less than 5 per day
   d) cigarette smoker/6-20 per day
   e) cigarette smoker/more than 20 per day

27. Did your mother smoke while she was pregnant with you?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

28. Were you born prematurely (three or more weeks early)?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

29. Were you placed in an incubator at birth?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

30. Did you have a Cesarian birth (i.e. surgical removal through the mother's abdomen)?
31. Which of the following best describes your weight at birth?
   a) less than 5 lbs.
   b) between 5 and 6 lbs.
   c) over 6 but under 9 lbs.
   d) 9 lbs. or more
   e) do not know

32. Was your birth a breech birth (i.e. you did NOT come out head first)?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

33. Were you born three or more weeks late?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

34. Were you born a twin or multiple birth?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

35. Were instruments (e.g. forceps) used at your birth?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

36. Did you have breathing difficulty, delayed breathing, or receive oxygen at your birth?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

37. Did you have a blood transfusion at birth?
   a) yes
b) no
c) I think so, but I'm not sure
d) I think not, but I'm not sure
e) do not know

38. Did your mother require a blood transfusion when you were born?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

39. Did your mother have toxemia during her pregnancy with you?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

40. Did your mother have blood spotting or any other bleeding during her pregnancy with you?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

41. Did your mother require any X-ray during her pregnancy with you?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

42. Did your mother have any illness requiring the taking of medical drugs during her pregnancy with you?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

43. Did your mother have a long labor (24 hours or more) during your birth?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

44. Was labor induced artificially at your birth?
45. Were there any problems associated with the umbilical cord during your birth (e.g. twisting, looping, choking)?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

46. Were you seriously ill within the first few months of your life?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

47. Were you born with any physical defects or abnormalities?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) do not know

48. What was your order of birth to your natural mother?
   a) first born
   b) second or third born
   c) fourth or higher born
   d) do not know

49. In regard to breast feeding which of the following best describes your infancy?
   a) breast fed regularly for the first six months or longer
   b) breast fed irregularly for the first six months or longer
   c) breast fed for less than six months
   d) was not breast fed
   e) do not know

50. During which season were you born?
   a) Spring (April, May)
   b) Summer (June, July, August)
   c) Autumn (September, October, November)
   d) Winter (December, January, February, March)

51. Which best describes your ethnic background?
   a) Oriental
   b)Negroid
c) Caucasian
d) Asian Indian
e) other

52. Are any of your biological parents or siblings left-handed?
   a) yes
   b) no
   c) I think so, but I'm not sure
   d) I think not, but I'm not sure
   e) I don't know

For each of the following conditions or problems, please indicate if you have ever had it, or been diagnosed for it, or have it now.

53. Schizophrenia .................................. a) yes b) no c) do not know
54. Epilepsy ........................................ a) yes b) no c) do not know
55. Asthma or allergic bronchitis ...... a) yes b) no c) do not know
56. Eczema, hives, or skin allergy ..... a) yes b) no c) do not know
57. Food allergy ........................................ a) yes b) no c) do not know
58. Sleep disturbance (insomnia, fitful sleep) .. a) yes b) no c) do not know
59. Peptic ulcer (gastric or duodenal) ...... a) yes b) no c) do not know
60. Colitis (bowel disorder) ............. a) yes b) no c) do not know
61. Anorexia nervosa eating disorder .. a) yes b) no c) do not know
62. Bulimia eating disorder ...... a) yes b) no c) do not know
63. Rheumatoid arthritis .......... a) yes b) no c) do not know
64. Arthritis (non-rheumatoid) .. a) yes b) no c) do not know
65. Hypertension ................................. a) yes b) no c) do not know
66. Thyroid disease ............................. a) yes b) no c) do not know
67. Cardiovascular or heart disease .. a) yes b) no c) do not know
68. Diabetes ....................................... a) yes b) no c) do not know
69. Cancer ........................................ a) yes b) no c) do not know
70. Migraine headaches ....................... a) yes b) no c) do not know
71. Depression ............................................a) yes b) no c) do not know
72. Strabismus (crossed eyed) ........a) yes b) no c) do not know
73. Squinting ...........................................a) yes b) no c) do not know
74. Myopia (near-sightedness) ..........a) yes b) no c) do not know
75. Far-sightedness .................................a) yes b) no c) do not know
76. Cleft palate or harelip .................a) yes b) no c) do not know
77. Other birth related physical defect ......a) yes b) no c) do not know
78. Frequent colds, sore throat, cough etc. ....a) yes b) no c) do not know
79. Sexually transmitted diseases ........a) yes b) no c) do not know
80. Stuttering or speech defect ..........a) yes b) no c) do not know
81. Tics, tremors, or twitches .............a) yes b) no c) do not know
82. Dyslexia or reading problem ..........a) yes b) no c) do not know
83. Hyperactivity or hyperkinesis ..........a) yes b) no c) do not know
84. Other learning disability .................a) yes b) no c) do not know
85. Accident related injury requiring medical attention ....a) yes b) no c) do not know
86. Any hospitalization for injury (not accident related) ....a) yes b) no c) do not know
87. Can you think of any other problem or difficulty related to your mother's pregnancy with you, your birth, or the period shortly after your birth?
   a) yes (please describe on bottom of page)
   b) no
For each of the following 26 statements that follow there are four possible responses: Strongly disagree (SD), Disagree (D), Agree (A), or Strongly Agree (SA). Read each statement and decide which response is most accurate for you. Pay particular attention to making sure that your response describes what you actually think, rather than how you feel you ought to think. When you are satisfied you have the answer which best describes what you think, mark the letters which correspond to that answer.

PLEASE RESPOND TO ALL THE STATEMENTS. If you are not completely sure which response is the most accurate, mark the one you think is most likely. Do not spend too long on each statement.

88. Sometimes I feel I am ugly, and at other times that I am attractive.
   a) SD  b) D  c) A  d) SA

89. I have never embarrassed myself by expressing unreasonable jealousy.
   a) SD  b) D  c) A  d) SA

90. I consider no person or country to be my enemy.
   a) SD  b) D  c) A  d) SA

91. I sometimes tell people too much about myself and almost immediately regret it.
   a) SD  b) D  c) A  d) SA

92. I have never seen anything that looked like a ghost.
   a) SD  b) D  c) A  d) SA

93. Sometimes my thoughts seem so loud I can almost hear them.
   a) SD  b) D  c) A  d) SA

94. I am almost always consistent in what I say and believe.
   a) SD  b) D  c) A  d) SA

95. Most people are too stupid to realize which things in life are important.
   a) SD  b) D  c) A  d) SA

96. In pitch dark I never see any visual images.
   a) SD  b) D  c) A  d) SA

97. I have never "come out in a cold sweat" upon realizing what I have told someone about myself.
   a) SD  b) D  c) A  d) SA

98. There are some people whom I trust completely.
   a) SD  b) D  c) A  d) SA

99. I have, on occasions, tried to reach the very essence of an object with my mind.
   a) SD  b) D  c) A  d) SA

100. When I try to help people they often misunderstand my motives.
    a) SD  b) D  c) A  d) SA
101. I have occasionally had to put my sudden sniffing of a smell down to imagination.
   a) SD  b) D  c) A  d) SA

102. I never use a lucky charm.
   a) SD  b) D  c) A  d) SA

103. Secret organizations have no real power or influence in our lives.
   a) SD  b) D  c) A  d) SA

104. I am sometimes unsure whether I have said something aloud or not.
   a) SD  b) D  c) A  d) SA

105. Sometimes I suspect the real world is nothing like what it seems.
   a) SD  b) D  c) A  d) SA

106. I would not be in the least concerned if a person who believed in magic tried to put a spell on me.
   a) SD  b) D  c) A  d) SA

107. It has never occurred to me that the world may be a figment of my imagination.
   a) SD  b) D  c) A  d) SA

108. I am not a superstitious person.
   a) SD  b) D  c) A  d) SA

109. I don’t really understand why I say some of the things I do.
   a) SD  b) D  c) A  d) SA

110. Sometimes I get a weird feeling that I am not really here.
    a) SD  b) D  c) A  d) SA

111. I never suspected that people I am very fond of may be secretly working against me.
    a) SD  b) D  c) A  d) SA

112. Sometimes people or objects seem to me to glow with an inner light.
    a) SD  b) D  c) A  d) SA

113. Things sometimes go so well for me that I suspect that I may be receiving help from an outside agency.
    a) SD  b) D  c) A  d) SA