

Regardless of the reason(s) for the progesterone-induced decrease in the number of delayed implantation blastocysts recovered, it is now important to determine if progesterone causes a selective loss of blastocysts which are metabolically different from those that survive. If progesterone causes the selective loss of less viable embryos which appear to be more metabolically active, then administration of this hormone may not alter all delayed implantation blastocysts in utero as suggested by previous data²⁻⁴. It would be advantageous if only those embryos that could develop into normal fetuses implanted in the uterus following delay of implantation. If progesterone treatment causes the selective loss of less viable embryos then this could help insure that

energy is invested for the production of more normal fetuses. It is interesting that the proposed loss of less viable embryos is coincident with the progesterone-priming of the uterus required before estrogen can induce nidation of diapausing blastocysts⁴. However, since we can know nothing about embryos that may have been lost because of progesterone treatment, further studies are required to determine if this population of 'lost' embryos is different from the embryos obtained. If they are different, it also remains to be determined whether they would enhance or diminish the differences previously observed²⁻⁴ for embryos obtained from mice which had or had not received progesterone.

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What is a lefthander?

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Summary. Attributes of lefthanders and lefthandedness were examined and 3 etiologies of lefthandedness were proposed.

The etiology of handedness has been the subject of scientific and quasi-scientific investigation for at least a century², and yet handedness remains one of the few behaviors for which the nature-nurture controversy has not been put to rest. Recent opinions as to its etiologies have included a single gene³, polygenic inheritance⁴, gene-environment interactions⁵, and environmental influences⁶. We believe the major obstacle in this investigative area is the assumption that there is an archetypic 'lefthander'.

There are 'righthanders'. There is agreement that between 85 and 90% of adult humans use the right hand for most digital manipulations and for all verbal activity, that between 90 and 95% of humans perform verbal processing in the left cerebral hemisphere, and that muscle control takes place in the hemisphere contralateral to the side being controlled^{7,8}. Typical righthanders are examples of efficiency of operation which may be parsimoniously explained: They write with the right hand because they are left hemisphere verbal processors⁹ i.e., no interhemispheric transfer required, and they perform non-verbal digital manipulations with the right hand because it receives the most practice in fine motor movements. Human behaviors are not rigidly programmed and therefore require initiation and continuous decision-making processes that would be extremely inefficient under simultaneous bilateral hemisphere processing¹⁰.

Lefthanded individuals do not fit into a single, neat, phenotypic or genotypic classification. They are different

from righthanders, but more important, they are different from other lefthanders and should not be lumped into a single category. We realize handedness has been considered a continuum based on the number of tasks performed with each hand, but that assumes a qualitative equality of verbal and nonverbal tasks.

Lefthanders are inferior. It has been known for at least 60 years that lefthandedness is overrepresented in populations of children with 'cognitive deficit'¹⁰⁻¹³. In a longitudinal study of 455 children¹¹, righthanded children performed significantly better than children at 4 years and 6.5 years in several verbal and performance tests. Similar results were obtained with males¹², mean age 20.3 years, but the righthanded subjects only achieved significantly higher scores than inverted lefthand writers, those who write with the hand curved inward; righthand and noninverted lefthand writers were not noticeably different. Lefthanders who are forced to use the right hand for writing may account for at least 50% of the stammerers in our society⁹, and lefthanders comprise close to 20% of the total mentally retarded population and 28% of the severely and profoundly mentally retarded population, compared to slightly less than 10% of general populations¹³.

Lefthanders are superior. There are few studies of gifted or superior subjects, in part because these individuals rarely congregate in groups. One exception is Mensa, the organization for individuals scoring in the 95th percentile or above on standardized IQ-tests. Hand preference of mem-

bers of Mensa was investigated¹⁵ and found to contain 20% non-righthanders, double that of the general population ($p < 0.001$). The proportion of lefthanded architects is considerably higher than expected¹⁶, as is the proportion of lefthanded artists¹⁷. Lefthanders were found to be superior in pitch recognition¹⁸, and Annett found that among better students, lefthanders' verbal IQ was somewhat higher than righthanders¹⁹.

Lefthanders are the same. Most current research seems to indicate that overall, lefthanders and righthanders perform similarly on various tasks^{7,14,20}. In studies using subjects drawn from normal populations, those not institutionalized, hospitalized, nor under treatment for dysfunction of any type, mean scores achieved by lefthanders on verbal, spatial, and/or performance tests did not differ from mean scores of righthanders. In a comprehensive review of studies of reading disabilities, Satz concluded that reading disability is not related to handedness²¹. Swanson et al.²² found no significant differences in IQ between left- and righthanders and Oldfield²¹ found lefthanders present in the same proportion in professional musicians as in the general population, and noted that they possessed the same general musical abilities as righthanders. It is safe to state that the majority of lefthanders are not different from the majority of righthanders on various mental and physical tasks. It is important to note however, that the variance of lefthanders on most tasks is considerably greater than the variance of righthanders²⁴.

The etiology of lefthandedness. Based on performance, and perhaps etiology, there are at least 2, and probably 3 subpopulations which are lumped together as lefthanders, confounding research. Some researchers have recently been including cautionary notes as to the possible existence of more than 1 type of lefthander^{22,24,25}. We acclaim this trend, but suggest more than a caveat is required. We believe that there are at least 3 groups who use the left hand for writing and perhaps one or more nonverbal tasks, who perceive themselves and are perceived by others as lefthanded, but who should not be considered homogeneous during research. The 3 groups of lefthanded writers are pathological lefthanders, natural lefthanders, and learned lefthanders.

The pathological lefthander is well described in the literature^{25,26} and can be the result of prenatal or perinatal events leading to brain hypoxia, a massive prenatal or postnatal insult to the left cerebral hemisphere, or perhaps a prenatal nutritional disturbance resulting in left cerebral hemisphere abnormality. Birth stress has been suggested, and therefore birth order and maternal age are implicated in the search for perinatal events^{27,28}; though not all investigators agree, see Hubbard²⁹. It is reasonable to expect that if a normal fetus or neonate experiences relatively severe injury to its left hemisphere, verbal processing will be transferred to the right hemisphere which, for efficiency, will be used to control the verbal hand; in this case, the left hand. This is not very different from the manner in which bird song transfers to the right hemisphere after left hemisphere lesioning³⁰.

Natural lefthanders appear to be completely normal, that is, possessing no known pathology, birth traumas, or cognitive insult, but they are the reverse of righthanders in brain function, at least to the extent to which it can be measured. They have a left rather than right ear advantage in dichotic listening tasks, a left eye advantage in tachistoscope tests, and right parietal lobe activity during verbal tasks³¹⁻³⁴. The architecture of natural lefthandedness is unknown at this time, but there is reason to suspect the situs inversus phenomenon, associated with monozygotic (MZ) twinning, may sometimes be involved. The mirror-image effect noticed in some MZ twins could account for a natural

lefthander³⁵. Rife³⁶ found 20.7% of a sample of 343 MZ twin pairs to be discordant for handedness (one twin righthanded, the other lefthanded) and also noted that 46% of the MZ twin pairs with lefthanded relatives (parents and/or sibs) were handedness discordant while only 19% of the MZ twin pairs with no lefthanded relatives were handedness discordant. Carter-Saltzman and her associates et al.³⁷ also found a high incidence (25%) of handedness discordance in twin pairs. It should be noted, however, in Rife's research a lefthander was defined as a person using the left hand for any task.

The learned lefthander is the oddity of the 3 subpopulations. This individual writes with the left hand, but usually has poor handwriting³⁸. He may use the right hand as efficiently as the left in many manual tasks, show crossed or no dominance on ear and eye tasks, and indicate dual hemispheric activation during EEG of verbal activity. Because preverbal children are not lateralized for hand use^{9,39}, successful left hand use could prompt lefthand writing even though it is neurologically inefficient. To overcome the inefficiency and reduce the additional time required for interhemisphere transfer, a verbal center develops in the right hemisphere (hence dual hemisphere EEG activation). The social pressures of handedness learning are well documented^{15,25,40,41} and oppose this process, but we believe it to be accurate and the most parsimonious explanation for this group.

The evidence, then, indicates that although most righthanders⁴² fit a typical behavioral and neurological pattern, lefthanders do not. There is variability among lefthanders: EEG and sodium amyl studies show some lefthanders to be right hemisphere verbal processors, some left hemisphere verbal processors, and some appear to use both hemispheres for verbal processing. Some lefthanders use the left hand for almost all tasks (analogous to right hand use by most righthanders), some use the left hand for writing and only one or two other tasks, and others are elsewhere on what seems to be a handedness continuum. In studies using timed tasks, the variability of lefthanders was greater than that of righthanders.

Lefthanders are not a homogeneous group. We believe conclusions based on results that group all left hand users into a single category are difficult to interpret and certainly useless for prediction. We suggest future research include an attempt to differentiate within this relatively small but interesting class of individuals.

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- 42 With the possible exception of trauma-induced righthanded natural lefthanders, an extremely small proportion.

Announcements

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Bürgenstock, near Lucerne, April 24-30, 1983

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