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INTELLIGENCE, COGNITIVE STYLES, AND BRAIN LATERALIZATION

Philip E. VERNON *

University of Calgary, Canada

The concept of intelligence as a kind of mental power is criticized, since it is essentially static. Many authors wish to substitute the concept of processes or styles of thinking and learning, which might be developed by appropriate training. But there is no consensus as to which styles are of major importance in intellectual growth, and few of those suggested can be assessed objectively. They resemble the historical notion of types; and like types, they may be weak in internal consistency and generalizability. Some types which are defined by psychometric variables or factors are more promising.

Currently the contrast between left brain and right brain functions is over-popularized. But it is associated both with verbal vs visuospatial abilities, and with analytic-sequential vs holistic processing. The right brain has been credited with a wide range of other functions for which there is little evidence, e.g., intuition, creativity, meditational trance states, etc. Findings from studies of brain-damaged or commissurotomized patients, and experiments with normal subjects, are outlined. The dichotomy is not the same as Das' simultaneous vs successive, Freud's primary vs secondary processes, Witkin's field independence, or Guilford's convergent vs divergent. Certain implications for education, for mental testing, and for cross-cultural research are discussed.

Most of the controversies over the nature, and testing of intelligence have centered around 3 main themes: (1) Nature vs nurture, (2) Cultural bias of tests, (3) Factorial structure of intelligence. However in two recent collected volumes on intelligence, edited by Resnick (1976), and Freedman et al. (1981), several of the papers raise a new theme. That is: intelligence is an outdated, even moribund, conception. I would agree that we have outgrown the notion (current in the 1920s) of intelligence as a kind of power, possessed in various amounts by different individuals, which is responsible for their intellectual growth, educational and occupational achievements. Whether we think of abilities in terms of a general factor, *g*, or as a hierarchy, or a collection of

* Author's address: P.E. Vernon, Dept. of Educational Psychology, University of Calgary, 2500 University Drive N.W., Calgary, Alb., Canada T2N 1N4.

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primary and second-order factors, makes little difference. All of these, the critics say, merely provide a static picture of an individual's mentality, and give no information on what led up to this state, nor what can be done to remediate weaknesses. What we need is a more dynamic approach which throws light on the cognitive and motivational processes underlying growth and adjustment, and will enable us to understand the individual, and help his future learning. Piaget's and other work on child development have played an important part in this revolution, together with cognitive psychology and information theory.

Processes, styles and strategies

If we are going to abandon, or at least reduce, our use of the concept of intelligence and ability factors when diagnosing children, what are we going to put in their place? Apparently processes is the answer. But these are unsatisfactory as basic units of child development and learning. It is difficult to observe them, and distinguish them from innumerable other processes; and they are hardly measurable except perhaps in terms of the efficiency of their outcomes. We would have to rely mainly on verbal descriptions, which would be both vague and subjective.

Now educational psychologists are chiefly interested in individual differences, and might prefer to work with groups of similar processes, which are called styles. Thus Messick (1969) defines styles as habitual modes of processing information. Bruner et al.'s (1956) work on concept formation described alternative styles or strategies.

The terms style and strategy are almost interchangeable, though strategy usually seems to refer to broader or more inclusive sets of processes, which also commonly emphasize motivational components, as well as cognitive. For example Stott (1971) rejected the attribution of backwardness among school children to any global cause such as low intelligence; and proposed that they have developed inefficient or maladaptive strategies, e.g., working impulsively rather than stopping to think, or avoiding difficulties by withdrawal or 'playing dumb'. He believes that these strategies can be overcome, and more efficient ones learned, by behavior modification techniques. Most authors insist that styles or strategies can be modified or developed by appropriate methods of training, whereas intelligence was conceived as essentially untrainable, except perhaps by long-term stimulation in a superior home environment.

Another important point is that most styles which contrast groups of students, regard these groups as qualitatively different, not just quantitatively. Thus Piaget's four main stages from sensorimotor to formal, do not imply that each stage is better than the one before; they represent different ways of looking at the world. However we shall see that there are some styles which can be located on a bipolar continuous variable or dimension.

Unfortunately there is little consensus among psychologists or educationists as to which styles most greatly affect school learning, nor just how they can be defined and assessed. Among the many published lists, there is the popular one by Dunn and Dunn (1978). They claim to have surveyed the relevant literature, and come up with a list of 16 major styles. A few examples show that they are very heterogeneous, ranging from:

- Preference for subdued vs bright lighting, and
- Fixed seat classrooms vs informal, to
- Prefer working under teacher, or with peers, or alone.

The authors provide a 100-item True–False test for measuring these style differences, and say that it is applicable from grades 1–12. It seems unlikely that children aged, say 6–10, will obtain reliable scores; and surely one would expect very different styles among 18-yr.-olds than those relevant with 6-yr.-olds. However the tests can be supplemented by observation of individual children. The aim in classifying children is to provide individualized education to meet each one's needs and preferences. Possibly the authors' system could be applied in an Open Plan school, with team-teaching, but it appears quite unrealistic for a single teacher of perhaps 30 children in one classroom.

At adult student level, Entwistle's (1981) book gives a comprehensive account of the styles that can be observed among college students and their teachers. One of the most important is the contrast between students who are mainly passive-receptive as against the active-adventurous. Passive listeners learn as much as they can of the lecturers' utterances and the textbook, and try to reproduce what they have learned when examinations come along. The active are those who think and criticize in discussion periods, search for more information, and develop further ideas of their own. It is this quality which university teachers look out for. Another somewhat similar style contrasts surface levels of study vs deeper levels.

Entwistle also makes use of Pask's (1976) work on the strategies observed among students engaged in computer-monitored problem solving. He distinguished 'serialists' who proceed with the task step by step, concentrating on detailed facts, from the 'holists' who use a more global approach. There are resemblances here with Guilford's convergent and divergent thinking, and with left and right brain processing. Pask adds a third type, the 'versatiles', who are more flexible in their thinking, and apply serialist or holist strategies according to the nature of the task.

Entwistle provides a 30-item self-rating inventory, which yields scores on 3 main, and 4 subsidiary approaches to study. These combine cognitive with motivational characteristics.

(1) Achievement-oriented students, with well organized methods.
(2) Surface learners who try to reproduce; more dependent on extrinsic than internal motivation.
(3) Deep learners who aim for understanding; academically and intrinsically motivated.

A major implication is the need for teachers to be aware of their own styles of instruction, and to try to vary these to suit the needs of students with diverse learning styles.

Previous work on styles and types

Another word for style is type, which may be regarded as the most general scheme for categorizing people. A number of type theories have been put forward, especially by German psychologists in the 19th–20th centuries, e.g.:

- Kretschmer's cyclothyme-schizothyme, linked to pyknic, athletic-asthenic physique.
- Jung's extraversion–introversion, linked to Gross' flexible vs perseverative thinking.
- Jaensch's integrate–disintegrate, linked to Aryans vs Jews.
- Kulpe's form vs color reactors.

The following criticisms are more fully discussed in Vernon (1973). Note that types are usually dichotomous or trichotomous classifica-

tions. They ignore the fact that most human attributes generally conform to a near-normal distribution. However one can accept that the types represent extreme cases, and neglect the middle majority. Frequently they claim to span two or more domains, like Kretschmer's physique and personality classifications. But there is seldom satisfactory evidence of the strength of the association. Thus the correlations between Kretschmer's variables are positive, but quite low; and the same holds for Sheldon's more recent somatotypes and temperaments. Even within a single type-attribute, different tests often give near-zero correlations with one another. This has been shown for Kretschmer's dissociative–integrative thinking (Payne 1960), for perseveration, and for cognitive complexity. In other words, they lack both reliability or internal consistency, and generalizability to daily life characteristics. Unfortunately this applies too to the careful studies of several cognitive styles by the Menninger Clinic psychologists, Klein and Gardner (Gardner et al. 1960). The only typologies which do show a fair degree of generalizability are those where the attributes do in fact consist of continuously-distributed variables, or psychometric factors, such as:

- Jung's extraversion–introversion, converted into personality inventories.
- Spranger's 6 values, converted into the Allport-Vernon-Lindzey test.
- Witkin's field independence–dependence.
- Guilford's convergent vs divergent types of thinking.

We seem to lack any adequate methodology for handling qualitatively distinct syndromes or patterns attributable to styles or types. This is not to say that they do not exist, but they should probably be based more on experimental studies of cognitive processes than on psychometric measurements. The technique of cluster analysis has also shown some promise, as in S.N. Bennett's (1976) study of formal-structured vs informal-permissive styles of teaching.

Actually the German conception of types closely resembled the social psychologists' stereotypes. The latter represent combinations of attributes which are believed to characterize such special groups as athletes, hippies, Jews, mothers in law, etc. These stereotypes are often condemned by psychologists as expressions of prejudice; yet they do help us to cope with the extreme complexities of human nature, by classifying or pigeonholing people into relatively simple categories. The

type or style psychologist seems to be doing the same thing at a rather more sophisticated level.

Styles and brain lateralization

We are now faced with the problem of which styles, or psychometric factors, are most pervasive, most consistent across tests or processes, and most generalizable to cognitive functioning. A very strong candidate for primacy would be the differences in functioning between the left and right brains (L and R). A good deal of scientific research has been carried out on these functions, and they provide a dichotomy or dimension firmly grounded in neurology. Since 1861, when Broca located the area of the brain most important for speech production, it has been established that all verbal processing, together with control of the R side of the body, including handwriting, are located in the L brain of practically all R-handed people, and in about 65% of L-handed. Since conscious awareness seems to pertain only to the L brain, it is often called the 'dominant hemisphere'. The 'minor' or R hemisphere controls the L side of the body, and contains the speech centres of the other 35% of L-handed people. Little interest was taken in this hemisphere until the 1930s, but we now realize that it plays a major part in cognitive activities, particularly in visuospatial functions. Thus the two hemispheres are asymmetrical, having specialized for different purposes. These are better distinguished by sequential and analytic processing in the L brain, and holist or synthetic in the R, than they are by the verbal vs nonverbal content. This is what is called brain lateralization.

Unfortunately the term has become over-popularized, and over-simplified by the press, science magazines, and by some psychologists and educationists. Many teachers have absorbed the jargon and, when referring a child to the school psychologist for assessment, may ask: "Johnny is right-brained. What can I do about it"? Also a great many functions are being attributed to the R brain for which there is little, or no, evidence (Gardner 1978; Springer and Deutsch 1981).

Evolution of lateralization

How and why did this asymmetry evolve? It is found only in man, though to a small extent in the great apes, possibly some birds. But it

must have had some biological advantage. With the evolution of vertebrates, the main neural cord moved up to the spine, and decussation took place (crossing of sensory and motor nerves to the opposite hemisphere). Monkeys and baboons show some specialization, using one paw mainly for exploratory-manipulatory behavior, the other for grasping; but it seems to be a matter of chance which side does which. With the achievement of upright posture, and the enormous growth of the cerebral cortex, man developed much finer skills in one hand than the other, and began to communicate by means of noises which also needed fine musculature and brain control, and which later developed into speech. Lateralization had survival value because of the incompatibility of the two kinds of processing. It was more effective for sequential-verbal and synthetic-nonverbal processing to be carried out in different hemispheres. But what gave the R-side-L-brain combination the advantage? A possible explanation is that the most vital organs are located in the left of the body, hence they could be better defended by carrying a shield with the L hand, and leaving the R for attacking, throwing, etc.; but this is only speculation. However we know from cave paintings and other evidence that about 90% of prehistoric humans were R-handed-L-brained. Even in normal foetuses there is some anatomical asymmetry, the L temporal lobe, where Wernicke's area for language is located, being larger than the R.

Children at birth do not possess any clear lateralization, but when orally stimulated they do emit larger Evoked Potentials on the left side of the brain. By about 3 months, the R hand tends to grip more firmly, and by the end of the first year the handedness preference is strongly developed. However brain lateralization is incomplete until between the 5th and 10th year, when all the nerves to the corpus callosum become myelinated.

Lateralization investigations: brain damaged

Lack of space prohibits giving details of investigations of lateralization. Useful surveys of the whole field are given in multi-authored books by Dimond and Beaumont (1974), and Kinsbourne (1978). Other major references include Gazzaniga (1970), Fincher (1976), Hilgard (1977), Ornstein (1977), Dimond and Blizard (1977), de Renzi (1982), and Beaumont (1982). Springer and Deutsch's book (1981) is the most

readable, and probably the most objective in evaluating the evidence.

The bulk of our knowledge of L- and R-brain functions has been obtained from observation or testing of adults or children who are unilaterally damaged as a result of physical injury, strokes, tumours, or circulatory disorders. Large numbers of such patients are available, but it is often difficult to determine the precise location and extent of damage without a post mortem. Also when a certain area is injured, and a certain function impaired, this does not prove that the function is controlled by the area in normals.

More extreme damage occurs with lobectomy, where a complete lobe of the brain is excised, or even a whole hemisphere. Commissurotomy or split-brain operations are sometimes used with severe epileptics; they involve severing the two hundred million nerve fibres in the corpus callosum, connecting the L and R brains.

L-brain lesions produce a wide variety of aphasic disorders – speech production, word recognition, reading comprehension, forming sentences, learning concepts, and solving logical or mathematical problems. However the R brain also possesses some simple verbal capacities (especially among females), namely using concrete nouns, occasional phrases, or doing simple addition sums. Moreover if the L brain is damaged before the age of 5 years, the R brain takes over all language functions. Such children appear to develop quite normally, though there may be some lowering both of verbal and nonverbal skills. L-damaged tend to score lower Verbal than Performance IQs on the WISC or WAIS, R-damaged the opposite. But the differences are not very reliable indicators, partly because Verbal IQ is not identical with speech and language development, and partly because several nonverbal tests like Kohs Blocks and Raven Matrices can be solved largely by verbal analyses. Reitan (1966) and Halstead's Aphasia battery is preferred for more thorough diagnoses.

R-damaged patients show a greater variety of impairments, including difficulties in scanning, attention, size discrimination, depth and distance perception, orientation (finding one's way about), interpreting the meaning of pictures and recognizing faces, and sometimes visuomotor coordination. In general these functions involve the perception of spatial relations or Gestalts. One of the most affected tasks is drawing objects or copying figures. The reproductions are highly distorted, incomplete, and lacking in understanding of the relations of parts. Some R-brain patients seem to be unaware of objects on their L-side;

thus they may leave food on the side of a dinner plate, or, when asked to describe the buildings and shops in a familiar street, they mention only those on the R side. (A corresponding deficiency in the R side is not found with L-damaged.)

Split-brain or lobectomized patients are very rare freaks; obviously their cognitive processes have little relevance to the working of normal human brains. Yet they do highlight some of the L and R brain differences (Sperry 1968; Gazzaniga 1970). It is remarkable how little their everyday behavior seems to be affected, even when they have lost half a brain. Many compensatory mechanisms can develop in other uninjured parts of the brain. However appropriate tests readily reveal their deficits. With commissurotomy the R brain is no longer connected to the L, hence its activities cannot be reported by the conscious L brain. Yet it carries on an independent existence at quite a high level of cognitive functioning, which can be demonstrated by asking patients for nonverbal responses, such as picking out from a number of pictures the shape or object which it has felt in the L hand. The R hand cannot do this, and, though it can write, it cannot draw as the L hand can.

Investigations of normals

Much research on normals as well as brain-damaged has been based on stimulating the L or R side of the body, or either ear or both (dichotic listening), or either visual field, and recording the responses. R and L eyes are not used, because the left halves of both eyes go to the R brain, and the R halves to the L brain. But the LVF (Left Visual Field) or RVF can be stimulated separately or simultaneously.

Dichotic listening tests indicate that noises and musical stimuli, including simple melodies, are better recognized and recalled with the L ear (R brain). But among trained musicians music is heard analytically, as a series of relations between sounds, and this is more a L-brain process.

It is generally agreed that tests of L–R functions with normals give results in accord with those found in brain damage cases, though much less extreme. Thus in number processing, the L brain does better when digits are presented orally to the R ear, but if presented visually to the LVF, the R brain is better. If different verbal stimuli are shown in the two fields, the LVF takes precedence, probably because of our L to R reading habits. Yiddish subjects, who normally read R to L, do the

opposite. Hatta (1978) showed that among Japanese children, the basic phonetic symbols, known as *Kana*, are more readily processed by the L brain, while the more complex idiographs or *Kanji*, which involve recognition of shapes, are more R-brained. Some studies indicate that different processes may be used at different times in learning to read English – holistic in the early stages of whole-word recognition, but analytic-sequential in breaking words into phonics or letters (Bakker 1981).

Half visual field tests show the L to be superior in counting and locating dots, and in recognition and recall of faces. But some other visual stimuli are better handled via the RVF, such as capital letters, and pictures of objects which can be named.

Tactile, kinesthetic and somesthetic sensations are sometimes stated to be processed in the R brain. Thus R-brain injured patients have difficulties in telling where they have been touched, or recognizing patterns or objects by feeling them. Many bodily activities (e.g. playing tennis) depend on integrating the visual situation with information from the muscles as to the position of one's limbs. Similarly in acquiring new skills, e.g. hitting a golf ball, verbal descriptions and instructions are notoriously inefficient. However, so much of our kinesthetic and somesthetic processing takes place outside conscious awareness, that it probably depends more on midbrain than cortical areas.

Another approach to studying normals is the recording of EEG waves, or the more accurate evoked potentials, from various parts of the skull. It has been found that, when thinking out a spatial problem, the L brain shows more alpha waves, i.e. less activity than the R. Again the amplitude of evoked potentials is greatest on the L side when verbal stimuli are given. A simpler, but less reliable, indicator is that people tend to turn their heads and eyes to the R when carrying out some verbal or numerical task, but to the L when engaged on a spatial problem.

EEG waves in the R brain are also disturbed during periods of REM (rapid eye movements) in sleep, and this is when a greater number of dreams of greater vividness occur. R-brain patients sometimes complain that they no longer have dreams, though not necessarily lacking imagery while awake. Daydreams and fantasies are also largely R-brained; they tend to be fleeting, imprecise and flexible because they are not tied to verbal labels. However the relation between R-brain processes and

visual imagery is obscure. Paivio and te Linde (1982) conclude that the use of imagery for short-term learning and recall is predominantly R-brained. But visual memories needed for recognition of objects, or long-term (semantic) recall, are available to both hemispheres.

It must be emphasized that all the functions mentioned show considerable variations. Brain patients with apparently identical damage can differ widely in symptoms; and some R-damaged may exceed the typical L-damaged on some spatial tests, and L-damaged do well on some verbal tests (Newcombe 1974). Split-brain patients likewise differ, and normals vary considerably in responses to apparently similar stimuli. Thus most generalizations about R–L brain differences are oversimplified. Further complications occur when sex and handedness are taken into account.

Sex and handedness differences

Girls begin to talk earlier than boys, on average, and tend to score better on many (not all) linguistic functions throughout life. But they average somewhat lower than boys on almost all visuospatial tasks, from locating dots on a screen to playing chess. Indeed tests which load most highly on a general spatial factor are also those which show the greatest sex difference.

The obvious explanation of these differences would be that females are more strongly lateralized in the L brain for verbal development, less strongly in the R. But this does not fit all the facts, and most writers follow Levy (1974) in saying that females are less lateralized. Their L brain does deal with speech and language, but a substantial proportion of their R brains also remains verbal. Hence the potentiality of the R brain for visuospatial functions is reduced. As a result females are less impaired than males by L brain damage, and recover more quickly; fewer of them show aphasic disorders. Again the lowered Wechsler Performance IQ in R-brain damaged males is not found in females. But the difference is more one of processing than of test content; females more often use verbal analysis of items in spatial tests and are therefore less successful. There seem to be no anatomical differences between male and female cortexes. Nevertheless it is highly probable that the difference is to some extent genetic, though this does not deny the impact of cultural norms on boys and girls. It has been suggested that male animals require superior visuospatial abilities to females since they

do most of the hunting, and venture further away from their dens.

Among L-handed people, verbal and spatial functions are less clearly lateralized, and they are less homogeneous than R-handers. Humphrey (1951) found wide variations in the number of hand and finger tasks for which they use the L hand. Any single test, or observation of hand preference may not be predictive for other tasks. L-hand writing is particularly unreliable, since there are still strong pressures to write with the R hand in many countries (e.g., Japan).

There is certainly a strong genetic component in being L-handed. Thus only 2% of children of two R-handed parents are L-handed; 17% of those with one L-handed parent, and nearly 50% of children with both parents L-handed. Newborn children already show some R or L preference in turning, which correlates quite highly with eventual handedness. Thus environmental differences, e.g. in the way the mother carries her baby or trains his movements, probably have little effect. Persons with L-hand relatives are called familials, and they differ in lateralization of speech from the non-familial.

L-handers tend to score somewhat below average on Wechsler Performance IQ, but have the same average Verbal IQ as R-handers. According to Hardyck and Petrinovich (1977) there are no consistent cognitive differences between R- and L-handers, not even in reading. L-handers also do not show the same tendency to turn head and eyes according to the nature of the task.

Nevertheless L-handedness is certainly associated with many kinds of deviant behavior. Considerable numbers are found among the mentally retarded, those with learning disabilities or dyslexia, among epileptics, and delinquents, and they are more liable to neurological damage before and at birth. Thus they seem to have some temperamental instability, and greater sensitivity to stress; though probably the majority show no kind of abnormality. Orton's (1937) theory of lack of cerebral dominance as responsible for reading difficulties did have some truth, though Gazzaniga's (1970) interpretation of it as poor integration of brain functions is preferable. There is no support for Orton's notion of cross-lateralization.

Is there a left versus right brain dimension?

We can take it as proven that the two hemispheres carry out largely different coding functions, also that lesions of either side may abolish,

weaken or disturb those normal functions. Also there are considerable individual differences when tests involving L or R functions are applied to normal adults or children. But this does not entitle us to claim that some normal people are more L-brained, others relatively R-brained. To make such an inference it would be necessary to demonstrate moderately high correlations between a variety of tests – Visual Field, Dichotic listening, Head turning, Evoked Potentials, and EEG in a group of normals. This has not been done, and much of the available evidence indicates the specificity of responses to tests which appear to involve the same functions. On the other hand, we know that, when the *g* or general factor is held constant, there are quite high correlations among varied verbal tests, and among visuospatial tests, and a strong negative correlation between the two types of ability. This I have referred to as the *v : ed* (verbal-educational) and *k : m* (spatial-mechanical) group factors (Vernon 1950). We must ask then whether there is sufficient overlap between this dimension and other aspects of L and R brain functioning to justify the construct of L-brained vs R-brained persons.

Table 1 lists some of the functions which have been attributed to the hemispheres by several authors; and these do overlap to some extent with one another. There are positive associations between ear and eye preferences, though the correlations are low (cf. Kimura 1973), especially among females and L-handed individuals. Verbal vs. nonverbal and spatial is one of the main differences in function, but we have seen that that does not always hold. Similarly we cannot accept Verbal vs Performance IQ as measuring L–R brainedness, though large differences, say 15 points either way (and not explicable by foreign language background) are certainly suggestive of greater use of one hemisphere, and may even point to some damage of the L or R brain.

Up to the 1930s, it was common to classify people as visiles, audiles, or tactiles, or as visualizers vs verbalizers. But there were no objective techniques for measuring such imagery, and most normals make use of all of them, depending on the particular input. L and R brain functions, then, are not well differentiated by ability content, but are to a greater extent by sequential vs holistic processing. Neisser (1967), Paivio (1971), Pask (1976), and Bogen (1969) describe essentially the same categorization under different titles.

Das et al. (1979) use similar terms, but follow Luria in distinguishing successive from simultaneous integration or coding. These processes are

said to be located in the frontal-temporal and parietal-occipital parts of the brain, not laterally. Das claims to be studying processing, rather than abilities, yet he applies ordinary tests, and factorizes them to confirm his categorization in various normal samples of children. Nonverbal tests such as Matrices give a clear Simultaneous factor, but his Successive factor is based on rote memory tests, instead of verbal comprehension. Hence his factors are more like Jensen's Levels II and I, than Paivio's Sequential and Synchronous, though Das specifically denies this.

Cattell's (1971) crystallized and fluid g cover similar ground to the processing dimensions. But his underlying theory is entirely different. His g_f is basic general intelligence, which is certainly not lateralized.

Piaget and Bruner (1965) are different again in their specification of the various stages in children's mental development. Nevertheless there

Table 1
Classifications of cognitive styles based on, or overlapping with, Left- vs Right-brain functions.

Source of evidence	Left brain	Right brain
Neurological	Right eyed and eared	Left eyed and eared
Sensory modality	Auditory	Visual and tactile
Main functions	Verbal	Visuospatial
Vernon	*v : ed* factor	*k : m* factor
Guilford	Semantic	Figural
Direction of gaze	Verbal turns to R	Nonverbal turns to L
Processing	Analytic-sequential	Synthetic-holist
Neisser	Serial	Parallel
Paivio	Sequential	Synchronous
Pask	Serial	Holist
Das (Luria)	Successive coding	Simultaneous coding
Cattell	Crystallized	Fluid intelligence
Piaget	Formal operations	Concrete and pre-operational
Bruner	Symbolic	Iconic
Kagan	Reflective	Impulsive
Witkin	Independent	Dependent
Guilford	Convergent thinking	Divergent thinking
De Bono	Vertical thinking	Lateral thinking
Ornstein	Rational, logical, Western thought	Creative, intuitive, Eastern, meditation
Jung	Thinking	Intuition
Freud	Secondary process, conscious	Primary process, unconscious, fantasy
Handedness	Right = good	Left, sinister = bad
R.L. Stevenson	Dr. Jekyll	Mr. Hyde
Ideologies	Established, conservative	Left wing, radical

are considerable resemblances between their concrete-operational, or iconic, levels and R brain functions; also between the formal or symbolic levels and L brain functions.

Kagan et al.'s (1964) reflective-impulsive types also resemble sequential vs synthetic; but they refer more to attitudes and methods of work than to processes or abilities. Witkin et al.'s (1962) field-independent–dependent is quite different. His independents are superior on visuospatial tests, dependents on verbal. But he describes independents as analytic, dependents as more holistic – i.e., the reverse relationship.

Guilford's (1967) convergent–divergent and Bono's (1970) vertical–lateral are regarded as L- and R-brained by some writers, though not by these two authors. It is argued, e.g., by Ornstein (1977) and Galin (1977), that creativity, inspiration and intuition, together with dreams and daydreams are R-brain activities, because they chiefly appear when the L-brain logical thinking is relaxed or dormant. The only direct evidence seems to be the disturbance in EEG waves beneath the right skull during dreaming. But this cannot be taken to demonstrate that the production of creative works of art or music, together with scientific discoveries, are R-brained. Such productivity is obviously dependent also on elaboration or working out and checking, by L-brain processes. What is interesting is that scientific discovery often involves visual shapes (e.g., Kekulé's benzene ring, Crick and Watson's double helix); and eminent physical scientists score very highly on spatial ability tests, according to Roe (1952). On the other hand, Galton commented on the apparent absence of any visual imagery among his scientific acquaintances. In my own study of grade 8 students (Vernon 1972), I found little correlation between a spatial factor and divergent thinking or other measures of creativity, beyond what could be attributed to *g*. Another difficulty is that creative writers must obviously be highly verbal, so that their creativity is mostly L-brained; though some, especially poets, do make considerable use of visual and sound imagery.

Jung's extraversion–introversion does not seem to have any cognitive counterpart; but his four types of mental functions clearly contrast analytic-rational processes with intuitive-holist. MacKinnon's (1962) study of eminent architects showed that the most creative scored highly on intuitive and feeling types in the Myers-Briggs Inventory; whereas more routine architects were more apt to score on thinking and sensation types.

Ornstein's (1977) book is largely devoted to showing that there are altered states of consciousness besides the one we mostly use in everyday life. Dreaming, hypnosis, clairvoyance, drug-induced states, and sensory deprivation, are obvious examples. But Ornstein refers particularly to Yoga, Zen and other mystic practices from the East, together with their Western derivatives such as transcendental meditation and Gestalt therapy. (Jung too was much influenced by Eastern thought and philosophy.) Most of these involve breathing exercises, relaxed postures, and intense concentration on some object, or a verbal phrase. Their aim is to reach greater insight into, and understanding of, self, culminating in the state of Nirvana, or complete detachment from everyday desires and feelings. In effect the L brain is shut off, as in sleep. Moreover L-brain thinking is usually strongly aware of temporal organization and the passage of time, whereas meditational trances are characteristically timeless. Aldous Huxley's (1954, 1956) description of drug phenomena also links them with hypnotic trances and Yoga, which overcome domination by the logical-thinking brain. And Hilgard's (1977) studies of hypnotizability relate it to visual imagination, creativity, and R-brain functions. Thus hypnotizable people are more apt to turn head and eyes to the L when thinking, those with poor hypnotizability turn more to the R. But there is a lack of any direct evidence that meditational trances are dependent on the R brain. Ornstein claims that EEG alpha waves are enhanced during meditation, but this seems to occur chiefly in the frontal areas of the brain, not specifically on the R or L sides. Hence Gardner (1978) concludes that the attribution of intuitive, creative, or trance phenomena to the R brain is wholly speculative.

Bakan (1976), Galin (1977), Fincher (1976), and Regelsky (1978) all subscribe to the view that what Freud called primary process thinking, arising from the Unconscious, is R-brained, while secondary process or reality thinking takes place in the conscious L brain. This seems plausible since we know that the R brain is active in dreams, when L-brain thinking and repression of the Unconscious, are relaxed. Also the incubation and inspiration stages in creative production are often said to arise from the Unconscious. However Ornstein is guarded about this theory, claiming only that L and R brain activities are analogous to conscious and unconscious, not identical. Freud himself was contrasting our primitive, instinctual and emotional processes, which emanate chiefly from the older midbrain and hindbrain, with the secondary

processes that take place in the newer cortex or upper brain centers. Thus, although he implied some localization, he never suggested lateralization, and it is misleading to attempt to mix them up.

However it is interesting that Bakan and others could claim some support from popular lore. It can hardly be accidental that the same word is used for right hand and righteousness, and that the Latin word for left hand is sinister. Robert Louis Stevenson's *Dr. Jekyll and Mr. Hyde*, published in 1866, was clearly a forerunner of Freud's conscious and the repressed Unconscious. Nowadays right and left are applied to political ideologies, again with some implication of the establishment vs the revolutionaries.

Implications and conclusions

A great many educationists and some psychologists (e.g., Sperry 1968; and Ornstein 1977) argue that present-day education is much too verbal or L-brained, and that more attention should be paid to the development of R-brain functions. We are told that we are using only half our brain power, and we possess large resources of untapped abilities. Some go so far as to ascribe the ills of modern civilization, such as vandalism, crime, neuroses, and warlike aggression, to the bias in child upbringing and education. A better balance could be achieved by including art, music, imagination, divergent thinking and creativity, even transcendental meditation, in the curriculum. Now it is true that up till the late 19th century most children were brought up in their families and learnt mainly from practical experience, apart from the few who were trained for the ministry, law, medicine, etc. Even our preschool, kindergarten, and first grade students still follow a curriculum based largely on play, practical and artistic activities. But beyond first grade more and more instruction consists entirely of oral or written words and numbers; everything else is regarded as frills. But to try to base educational reform on R-brain theory seems quite unjustifiable in view of the specificity and inconsistency of cognitive styles, and the dubiety of locating so many disparate functions in the R hemisphere. Also it is absurd to claim that our R brains are becoming atrophied through disuse, when we are constantly using their visuospatial functions in daily living, in TV watching, and many other mental activities.

I would agree that practice in, and appreciation of, the visual,

musical and other arts are valuable components of a liberal education, but not by dragging in the R brain. Nevertheless one good example of the application of the theory can be cited. Edwards (1979) has shown that drawing ability can be much improved, even among students with mediocre talent, by exercises which relax the hold of the L brain, and ignore the stereotyped notions it possesses of what people, objects, etc. look like. For example, we think we know what a chair should be like, and we can draw it, albeit pretty inaccurately, in accordance with our preconceptions. But if it is placed upside down and one draws, not the object, but the spaces between the legs, seat, background, etc., the L brain is not interested in spaces, and the result is far more successful artistically. If confirmed, Edwards's suggestions would bring about a considerable advance in art education. Another legitimate policy would be to make much more use of visual aids (pictures, diagrams, TV) to supplement oral and printed media in school learning. Also it is definitely valuable for teachers to become aware of individual differences in styles of learning, and to try to allow for these in the classroom. Often the more gifted or creative a student is, the more he is likely to invent and use unconventional styles.

Another common misconception, for which psychologists are partly to blame, is that many learning disabled children are said to be suffering from a 'perceptual deficit', and that improvement in reading or other skills can be brought about by giving a series of perceptuomotor exercises. While admitting that a great variety of approaches to remediation are found useful in individual cases, there is no good evidence that these exercises have any effect on skills such as reading which, in their very nature, are predominantly L-brained.

Torrance (1965), de Bono (1970), and many other psychologists in the area of creativity advocate the use of divergent thinking, or other aspects of Osborn's (1953) 'applied imagination' in the classroom. It is true that many strategies and thinking skills can be increased by carefully planned techniques, for example those described by Feldhusen and Treffinger (1977). However when the effectiveness of such training is followed up, it typically turns out to have very little transfer to other, apparently related, areas. For example, training in scientific method in biology and physics is unlikely to have any effect on rational thinking about social phenomena. And Edwards's training in drawing might increase appreciation of the visual arts, but not other allegedly R-brain functions.

Our general conclusion must be that there are as many difficulties in arriving at a suitable series of cognitive styles as there were with psychological types, particularly if we venture outside the area that can be covered by psychometric factors. My survey seems to indicate that the analytic-sequential vs holistic-synthetic dimension has some promise, though we do not as yet have valid and convenient methods of assessing it; and it is still doubtful whether it would accomplish more than verbal vs spatial factors, or Wechsler Verbal and Performance IQs. Thus it is likely that educational and child psychologists will cling to their Binet and Wechsler for many years to come, though if further styles could be identified and tested, they would welcome such additions to their standard battery.

Finally there are some implications for cross-cultural psychology, since one of the major weaknesses of Western intelligence tests is that they reflect concepts, values and work habits which may be lacking in non-Western cultures. I have put forward some evidence (Vernon 1982) that apparently R-brained processes are more characteristic of Mongoloid peoples – Chinese, Japanese, Eskimos and native Indians, than they are of Caucasians or blacks, though this requires further verification.

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On critique la conception de l'intelligence en tant qu'une sorte de pouvoir mental puisqu'elle est essentiellement statique. De nombreux auteurs veulent substituer la conception des processus par des styles de pensée et d'apprentissage qui pourraient être développés par une éducation appropriée. Mais, il n'y a pas d'unanimité quant à savoir quels sont les styles d'une importance majeure dans le développement intellectuel et rares sont ceux qui peuvent être évaluées objectivement. Ils ressemblent à l'idée historique des types; et tout comme les types, ils peuvent être faibles en consistance interne et aussi en possibilité de généralisation. Quelques types définis par des variables psychométriques ou des facteurs sont plus encourageants.

Aujourd'hui, le contraste entre les fonctions du cerveau gauche et du cerveau droit est trop popularisé, mais, on l'associe, et avec les capacités verbales opposées aux capacités visuospatiales, et avec les processus analytiques-séquentiels opposés aux processus holistiques. On a attribué au cerveau droit beaucoup d'autres fonctions pour lesquelles il y a tant soit peu d'évidence; par example – l'intuition, la créativité, les états de méditation, etc. L'on mentionne sommairement les découvertes basées sur l'étude de patients ayant souffert de lésions au cerveau ou de patients commissurotomisés, ainsi que des expériences sur des sujets normaux. La dichotomie n'est pas la même que le processus simultané opposé au processus consécutif de Das, ni que le processus primaire opposé au secondaire de Freud, ni l'indépendence du champ de Witkin ni la pensée convergente opposée à la pensée divergente de Guilford. L'on discute ensuite des implications pour l'éducation, les tests mentaux et la recherche interculturelle.