Design Education Research Note 12

The Role of Art and Design in Cognitive Development:
A Neurological Basis

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January 1984

Introduction

Our understanding of certain cognitive capabilities which are clearly implicated in Art and Design thought and behaviour has been significantly enhanced during the past ten to twenty years by experiments and reflection on cerebral lateralisation. An extensive body of research work has accumulated which examines the ways in which the activities and capacities of the cerebral hemispheres develop and function in relation to each other. This body of work has confirmed a previously unfashionable view that the right cerebral hemisphere plays an important and specialised role in cognitive functioning. At the same time it explains how the right hemisphere's functioning abilities have been effectively eclipsed by the peculiar and dominating manifestations of left hemisphere activity. In providing these understandings this body of work contributes greatly to the justification of Art and Design activities within the school curriculum. It further provides insights into the nature of non-verbal thought processes and the role which Art and Design media play in progressing and externalising that thought.

Neurological Research

Bogen's (1969) comprehensive review of neurological studies associated with right hemisphere functioning, indicated that since the 1930's there has been a growing awareness, based upon scientific data, of the non-verbal, imaging and perceptual abilities of this organ. Early studies between 1930 - 1950 on brain damaged or diseased patients pointed to the right hemisphere's ability to comprehend visual information, spatial dimensions, musical interpretation and rhythm, kinaesthetic experience and non-verbal perceptions in general.

However, it is since the 1950's that spectacular breakthroughs in understanding of this hemispheric ability have occurred. Beginning at the University of Chicago, and later at the California Institute of Technology, a team of neurologists headed by

Drs. R. W. Sperry and J. E. Bogen began a series of investigations on both animals and humans in which the two hemispheres of the brain were surgically separated to varying degrees. The brain was effectively 'split' into its two halves by severing the bundles of connecting nerve fibres, or commissures, notably the corpus callosum.

Sperry (1964) explains that the purpose of performing this surgical procedure (commissurotomy) on animals was (in the tradition of research) to separate the united hemispheres anatomically in order to study the performance of each hemisphere in isolation. By doing so, it was hoped to establish what the nature of the role of the corpus callosum was in mediating between the two halves of the brain. In performing the surgical procedure on human patients the primary purpose was to treat cases of severe epilepsy. The theory underlying such a drastic remedy was that by severing the corpus callosum which united the two halves of the brain, electrical activity in epileptic seizure could be confined to that half of the brain in which it originated. The operation was extremely successful and at the same time it provided the opportunity to study the effects which the operation had upon human behaviour.

Hemispheric Differences

Subsequent investigations produced a great number of studies which revealed extensive differences between the mental functions of each of the disconnected hemispheres. See, for example, Bogen and Vogel (1962), Bogen and Gazzaniga (1965), Gazzaniga (1967, 1970), Levy, Trevarthan and Sperry (1972) and Kinsbourne (1978).

In particular the right hemisphere functioning abilities were shown to play a specialised role in visual, spatial, non-verbal and constructional tasks such as arranging, building and drawing. The left hemisphere functioning abilities demonstrated a specialisation in language functions. Furthermore, each hemisphere demonstrated a capacity to exercise a dominating control over the response to a particular task, according to the nature of the task being examined. For example, in situations where no language was involved, such as pointing to a matched stimulus, the right hemisphere dominated. In

situations demanding a verbal response, the left hemisphere dominated even when verbal description was difficult (such as a description of a face).

The subject's response was determined by the type of response demanded by the examiner. Perception with the right hemisphere was not accessible to a verbal response, and in these cases a manual response was more appropriate. When non-verbal responses were demanded of the subject, perception and understanding proved to be as capable in the right hemisphere as it is in the left, and more capable in some tasks.

However, these experiments revealed that when verbal responses were demanded, they were given, even when they were inappropriate. The right hemisphere, although more capable in particular tasks, remained unexercised and unproductive.

The normal lateralisation or specialisation of the brain is for verbal language to be present in the left hemisphere. This generally applies to right-handed people. (The left hemisphere controls the right side of the body, and the right hemisphere controls the left side in a cross-over fashion.) Many but not all left-handed people have reversed lateral specialisations of the cerebral hemispheres. Despite these irregularities, these tests confirmed earlier findings of experiments with animals, and indicate that learning in one hemisphere is not available to the other when the commissures are missing. After bisection of the brain each hemisphere was able to function independently, preserving its own integral organisation.

Cueing Strategies

In everyday situations cueing strategies are learned by split-brain patients which compensate for loss of interhemispheric communication via the corpus callosum. These strategies can and do become extremely refined. Different types of communication can occur because both hemispheres are directly connected to the motor system and sensory organs of each side of the body. Some feedback therefore from body activity is perceived in both hemispheres although it seems likely that differing degrees of perception are involved. For example,

when an action is performed by one hand, producing primary perceptions, it necessarily involves adjustments in posture and muscle activity which are 'picked up' by the other side of the body and make themselves known to the controlling hemisphere of that side.

An illustration of the skill involved in these compensatory strategies is given by Gazzaniga (1970). Tactile information transmitted from the left hand to the right hemispheres cannot be verbalised, i.e. the patient cannot name or describe the object which is being held. But, since some tactile information is in fact conveyed to both hemispheres, the left hemisphere can respond to certain features of the stimulus such as whether it is there or not. It can also discern such things as length and size, and by manipulation strategies it notes such things as edges and curves, and also weight. In experiments such as these, the left hemisphere could (when the choice of answers was limited) discern sufficient information to be able to make an answer.

Graphic Ability

In experimental situations, cueing strategies are prevented in order to isolate and examine hemispheric abilities. Bogen (1969a) provides evidence for claiming that the right hemisphere is vastly superior and dominant for certain non-language functions. The phenomenon which he noticed in these split-brain patients was an inability to write in the left hand, together with an inability in the right hand for copying geometric figures.

In eight detailed case studies the patients were tested for their ability with each hand to write spontaneously and to dictation and also to copy print, cursive writing and geometric figures. In all the patients examined each was able to write sensibly and legibly with the right hand, whereas the left hand could draw but not write. Bogen's results show that 'agraphia' (the inability to write) can be separated into two main types:

(a) Dysgraphia - an inability for spontaneous writing which is a language dysfunction, and

(b) Dyscopia - an inability to copy which is a dysfunction of spatial comprehension.

Bogen further links these disabilities in split-brain patients to the differing and specialised abilities of the hemispheres in the disconnected condition. His discussion of the results of these tests makes it quite clear that the inability of the left hand to write simply cannot be a result of disconnection from the language areas of the left hemisphere, since the right hemisphere has some language function. For example, although patients cannot name objects placed in the left hand, most of them can retrieve a named object from a bagful of dissimilar objects. That is, even though it cannot command speech or writing the right hemisphere can recognise words. Bogen suggests that the inability to write in the left hand is more likely to be a lack of functioning connections between elements in the right hemisphere. He further suggests that the attraction of this hypothesis is that it may be possible to find a specific method to enable the right hemisphere to communicate after left hemisphere damage. He writes:

> 'This notion implies that as a particular function comes to be progressively more active in one hemisphere it is progressively more inhibited in the other and it is conceivable that release from the inhibitory process would uncover a capacity which has been suppressed rather than lost.'

Bogen is therefore suggesting that the establishment of dominance for verbal expression in one hemisphere is accompanied by the progressive inhibition of verbal expression in the other, although the capacity may remain. Similarly one can suppose a complementary inhibition of visuo-spatial activity in the verbalising hemisphere.

Action and Language

Bogen's documentation of case histories of split-brain patients identifies a considerable period of time after the operation during which the left hand of patients is severely limited. The essential feature of this phenomenon is that the patient does not carry out an

act at a time when s/he has indicated

(a) that what is required is understood,
(b) that it is his/her intention to do it, and
(c) that s/he can perform the act in other circumstances.

For example, the patient is unable to follow a verbal command such as 'stick out your left little finger!' although s/he can perform the act if shown by demonstration what is expected. Similarly, actions such as using scissors or turning door knobs can be performed if placed in the patient's hand, but not under verbal instructions.

It is important to note that this inability (to translate verbal comprehension into action) is not present in the right hand of the patient and therefore cannot be responsible for the inability to copy geometric figures with the right hand. Furthermore, when an inability to copy with the right hand is present, the right hand can draw to verbal instructions. Inability to draw with the right hand may be considered therefore as an inability in the left hemisphere to comprehend and follow visuo-spatial instructions or cues.

Bogen's conclusions in this series of investigations support an accumulating body of evidence which suggests that right hemisphere functioning abilities play an important and specialised role in constructional tasks and capabilities. Where disturbances have been found to abilities related to activities such as arranging, building and drawing, the role of the right hemisphere is emphasised - although both hemispheres are often implicated in the disturbances.

Piercy (1964) writes:

> 'It is now clear that failure on constructional tasks under visual control occurs more commonly and takes a more severe form with right rather than with left hemisphere lesions.'

In Bogen's experiments the distinction is drawn between disabilities associated with verbal instructions for a given task, and disabilities associated with visuo-spatial instructions for a given task. This

distinction is believed to underline a dichtomy in functional abilities between the hemispheres, and each hemisphere can only respond to an appropriate instruction.

Difficulties in Classifying Lateralisation

In a wide review of the extensive studies and investigations involving brain-injured patients, commissurotomy patients and normal subjects, Bradshaw and Nettleton (1981) discuss the difficulties involved in considering hemispheric differences simply as a verbal/non-verbal dichotomy. Although all the evidence points to a minimal language ability of right hemisphere functioning, it also shows that the right hemisphere is far from uncomprehending or unresponsive to auditory stimuli including speech. The right hemisphere is seen to have considerable receptive capacities for speech even though it has little command of speech for articulation. Right hemisphere superiority in comprehension of acoustic stimuli is recognised in areas of discrimination and judgement involving: pitch, harmony, intensity, timbre, musical chords, melody, environmental sounds, non-verbal vocalisations (e.g. whistling), sonar signals, emotional tones and intonation patterns.

Likewise, left hemisphere functioning is demonstrably not limited to verbal language functions. Order, sequence and rhythm, reading and transcribing musical notation and other abstract symbolic representation, as well as co-ordinated and integrated motor control are all aspects of musical performance which implicate left hemisphere functioning abilities. The verbal/non-verbal dichtomy is thus further confused by the recognition that the right hemisphere is not always - or even solely - responsible and dominant for musical ability, but rather that both hemispheres participate in musical functions. A 'synthesis' in performance is thus suggested in this area.

Nebes' (1978) investigations similarly distinguish left/right differences other than that which the verbal/non-verbal dichtomy can contain. Tests in which the subjects were required to complete designs from partial patterns (e.g. completing an arc of a circle to make a full one) showed a right hemisphere superiority on gestalt perceptions. The left hemisphere was shown to be advantaged on tasks which involve

isolating shapes from an irrelevant background, demonstrating an advantage on conceptual discrimination. Other gestalt tests have demonstrated a superior right hemisphere ability for accurate perceptions and memory of stimuli which cannot be easily labelled, or are too complex or similar to distinguish between with words. Using commissurotomy patients, Levy, Trevarthen and Sperry (1972) tested a variety of perceptual functions involving recognition of photographs of faces, ambiguous solid black figures, line drawings of familiar items and patterns of squares and crosses. Their summary states:

> 'Stimuli having no verbal labels stored in long term memory and which are resistant to feature analysis were found to be extremely difficult for the left hemisphere to identify.'

Generally the findings of the experimental work indicated that the two hemispheres were able to process conflicting information simultaneously and independently in two differing styles. Levy, Agresti and Sperry (1968) suggest that 'the mute (right) hemisphere is specialised for gestalt perception, being primarily a synthesist in dealing with information input. The speaking major (left) hemisphere in contrast seems to operate in a more logical, analytic, computer-like fashion'. The findings suggest that a possible reason for cerebral lateralisation in man is a basic incompatibility of language functions on the one hand and synthetic perceptual functions on the other.

These findings demonstrate a deeper conceptual and possibly structural dichtomy underlying the simpler verbal/visuospatial distinctions of hemispheric differences. Dissatisfaction with the simple verbal/visuospatial dichtomy therefore has led to attempts to distinguish the characteristics of hemispheric differences in more comprehensive terms. Bogen (1969b) suggests that 'the right hemisphere recognises stimuli (including words), apposes or collects data and while receiving the very same stimuli as the other hemisphere, is often arriving at different results'. Citing Teuber (1965), Bogen agrees that this phenomenon can be credited to different <u>modes</u> of organisation and processing of information within the two hemispheres. In other

words, each hemisphere employs a different mode of thinking (in the disconnected condition) which differs in nature from the other. Bogen names these the Appositional and Propositional modes of thinking and the implication made is that in the normal brain, both these modes are available.

Appositional and Propositional Modes of Thinking

Propositional describes the left hemisphere's specialised abilities in a verbal, logical, sequential and temporal mode of thought. Appositional describes the right hemisphere's specialised abilities in a non-verbal, synthetic, visuospatial and manipulospatial mode of thought. However, as Gazzaniga and LeDoux (1978) point out, it is misleading to consider appositional modes of thought as exclusively right brain processes located structurally within this hemisphere. Unlike the related mechanisms for language, which seem to be concentrated in one half of the brain, perceptual, spatial and semantic abilities seem to implicate an involvement of both hemispheres in the functioning process. They suggest that the human brain is organised so that two potentially independent mental systems exist side by side. Each possesses its own capacities for learning, thinking and acting, and in the normal brain these systems work together. The demonstrable differences which exist in the hemispheres of the adult brain are explained in the context of the nature of the co-operation which occurs between them.

The term 'culturally disadvantaged' has been used to refer to people whose propositional potential has remained undeveloped for lack of proper schooling. Bogen and Bogen (1969) suggest that on the basis of neurological data which provides evidence for the existence of an appositional mode of thought, it is also a term which can be applied to people whose education consists mainly of reading, writing, arithmetic and verbal expression. This is because education predominantly and emphatically in this mode results in a lack of appositional development. They maintain that there must a free exchange and interaction between propositional and appositional modes of thinking. The difficulty as they see it is that there exists an inbuilt antagonism

between analysis (left hemisphere function) and intuition (right hemisphere function).

> 'Certain kinds of left hemisphere activity may directly suppress certain kinds of right hemisphere activity. Or they may prevent access to the left hemisphere of the products of right hemisphere activity.' (Bogen and Bogen, 1969.)

Clearly formal education has a direct and important role to play in ensuring the development of both aspects of thought and interaction between them.

Thought and Language

Language studies and current theories of cognitive development indicate that thought is progressed, externalised and directed by the acquisition of a suitable medium. Although attention has traditionally and emphatically been focussed upon the role of verbal language and logical procedures in this process, the relationships between thought, language and action is becoming sufficiently explicit to allow serious questioning as to whether verbal language is the only medium which can be instrumental in the progression of particular thought modes.

Evidence such as that reviewed above is demonstrating the existence in human beings of two distinctly separate and differing modes of thought and consciousness. Each has a neurological basis in the brain. This challenges traditional concepts of the meaning of 'intelligence', 'thinking', 'knowledge' and how people learn. Notions of cognitive activity considered in relation to the development of reason, logic and verbal language, explain only one available style of thinking in any human's cognitive repertoire. Marks (1981) has pointed out that theories have yet to be written which fully explain the development of appositional modes of thought. He suggests that central to any such theory will be the importance of brain functioning in which internal representations and encoding of information in one or more languages of thought will feature.

However, questions which relate to the nature of the relationship

between thought and language have long provided a controversial field for investigation in areas of several disciplines. Some linguistic theories consider the role of verbal language in directing and instigating thought (e.g. Whorf, 1956, Lee, 1950). Such theories have drawn attention to the influence of cultural patterns of conceptualisation and suggest that these patterns are contained in and transmitted by the use of a particular language code. Yet another view from linguistics suggests that language is an innate aspect of what we call 'mind': that there may be a cerebral mechanism or language learning device which is genetically determined and which relates to the underlying and universal rules and principles contained in all language systems. (Chomsky, 1968.)

Contrary to such beliefs that verbal language is the essential instrument of thought, determining both the content and structure of thought, theories of child development suggest that thought and its structures are derived from the child's actions. (Piaget, 1955, Vygotsky, 1962a, 1962b.) These theories suggest that it is the child's activities and actions that underlie thinking. Cognitive structures derived from activity are believed to precede the skills which later are used in language learning. Verbal language therefore is seen to be a supportive rather than a determining factor in thinking. In later stages of development, language is seen to play an important directive role in thinking.

These major theoretical positions (only simplistically indicated here) show that understanding of the nature of 'thought', 'language' and their mutual relationship is extremely complex. Disagreement arises when theories are compared because each considers the phenomena of thought and language from differing perspectives. Where there does seem to be agreement (and mystery) is in the acknowledgement of an area of cognitive activity and thinking potential which is inaccessible to representation by speech.

Piaget does not consider this dimension to be thought proper - he describes it as sensori-motor organisation or perceptions which are often subconscious. This is something rather different from 'intelligent' thought which involves acquired and logical systems of representation.

Vygotsky refers to 'wordless inner speech' and pure thought on a plane structurally different to that of verbal thought. Thought within this plane or dimension is inaccessible to direct transposition into speech. Whorf refers to a potential for perceptions of a 'noumenal' reality outside the cultural norms of concepts embodied in any particular language code or system. Finally, Chomsky draws attention to the innate neurological mechanisms underlying the phenomena. He asks whether these mechanisms are language specific and whether they are independent of cultural and environmental influences.

The attraction of the theories which are emerging from the neuro-sciences is that a holistic explanation of cognitive development seems possible. The evidence from this direction indicates that thought, language, sensory perceptions, action, cultural influences and innate neurological mechanisms are complexly interrelated and interdependent. Further, that verbal language is often an inadequate medium to receive and express aspects of thought and perception related particularly to appositional modes of cognition.

Cognitive Style as a Factor in Learning

Investigations into the difficulties many children experience in acquiring verbal and written language is beginning to define aspects of appositional modes of thinking previously unrecognised. Oexel and Zenhausern (1981) point to the child's cognitive style as an important factor in reading ability. In particular they indicate that the phase of transfer from the visual to the auditory signal is an important area of difficulty. They identify at least one type of disabled reader who depends strongly upon right hemisphere functioning and who has difficulty activating the left hemisphere for the auditory encoding of visual stimuli. These findings are consistent with those of Gordon's (1980) neurological tests in which dyslexics performed particularly well at 'right hemisphere' tasks. His conclusions indicated that dyslexics exhibited inefficiency in using the left hemisphere and were 'locked' into right hemisphere functioning styles.

Difficulties in language processing (as a factor in poor reading)

attributable to preferred cognitive style are supported by a number of studies. Leisman, Haupt and Ashkenazi (1979) found that dyslexics were less able than normal readers in confrontation naming of objects, colours, letters and symbols. Vellutino (1978), in an extensive review of available evidence, concluded that poor readers are consistently differentiated from normal readers only when there is a need for verbal encoding. Similarly, Morrison, Giordani and Nagy (1977) have demonstrated that good and poor readers do not differ in the initial perceptual phase of reading; it was in the encoding memory phase that the performance of poor readers showed significant deficit. In studies where a verbal response was demanded of the child, s/he was required to encode the response into speech and this process took longer for the disabled reader.

Leisman and Ashkenazi (1980) provide findings based upon spectral analysis of EEG readings from normal readers and dyslexics. They demonstrate that greater interhemispheric activity occurs in the normal readers, whereas the dyslexic subjects indicated greater shared activity within the same hemisphere. Dyslexic subjects therefore show less of the interhemispheric transfer that is necessary in visual to auditory encoding.

Oexle and Zenhausern (1981) argue on the basis of their own findings and those of other researchers that disabled readers generally show superior right hemisphere performance - a result which they claim has been inadequately explained or investigated. Recent work in other areas points to an understanding of hemispheric activation suggesting that individuals characteristically activate one hemisphere in preference to the other. Gur and Gur (1980) suggest that right hemisphere activators use a holistic, parallel style of thinking, whereas a left hemisphere activator is most efficient using an abstract, sequential type of strategy. This does not mean that somebody with a preference for a particular style of processing/ learning cannot perform in the other. Rather that the task is more slowly and less efficiently performed in the unpreferred style.

Generally what these language studies show is that the type of response demanded or required in a situation will stimulate certain

hemispheric activity. Children with reading difficulties have demonstrated non-significant differences to normal readers in the perceptual phase of reading. Significant difficulties have been observed only when the response has been required to be transposed into speech or the equivalent written verbal symbol.

These studies point to the existence of a perceptual and semantic phase of thinking which precedes the necessary encoding of thought into a suitable medium. In these studies focus has been upon speech and verbal symbols as that medium. Very little work seems to be in evidence concerned with possible difficulties or processes involving the encoding of the perceptual/semantic phase of thought into other forms of representation which (perhaps) may facilitate right hemisphere activators.

Notions that suitable media can be taught (as language is taught) to progress the development of appositional modes of thinking, appear only in relation to therapeutic situations. Virshup and Virshup (1980) present convincing arguments for considering 'art' media the natural languages of the right brain. Therapy used in situations of mental ill health and social maladjustment draw upon techniques for achieving altered states of consciousness through the use of imagery, hypnosis, meditation, diet, sleep deprivation and drugs. What they all have in common are the means of quieting the dominant propositional mode of thinking, and allowing the appositional mode to come into play.

Our educational system has developed upon a sophisticated understanding of only one of the styles of thinking available to human beings. Advantages are therefore given to people who preferentially and habitually think in this style. A less divisive educational process which develops other modes of thought may emerge from the understandings which are being gained from recent and current neurological investigations. These are revealing the characteristic features of an appositional mode of thought. Media which are appropriate for the progression, development and examination of this style might therefore be looked upon as 'languages' of thought and are essential means for the encouragement of cognitive development.

Art and Design media and activities within the school curriculum provide means for direct engagement in and with concrete experience which appears crucial for the development of integrated thought and behaviour. Such provision may be especially significant for those children whose preferred cognitive style is non-verbal. It may be that learners in this style may depend for longer than verbal learners upon the external strategies available to them through action and concrete experience. The debate no doubt will continue, based upon a clear recognition that art and design knowledge, skills and artifacts are not ends in themselves. They can be seen to be means of learning, thinking and expressing, as well as means of receiving communication of other peoples' thoughts.

Acknowledgement

This paper is based on research conducted at the Design Education Unit, Royal College of Art, London, supported by a grant from the Department of Education and Science.

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