Bringing a Balance to Hemispheric Asymmetry

Julia Claxton

In fulfilment of the full requirement for a Doctor of Philosophy Degree at the University of Liverpool, England.

Dated: 18 May 2006

Abstract

This is a study to attempt to find the balance between the reliable facts that state that the right hemisphere and left hemisphere support different cognitive processes and the widely promulgated idea that individuals are either 'left brained' or 'right brained' and what the consequences of this might be. This is attempted by using a cross disciplinary study involving neurological, neuropsychological and psychological literature and also reviewing some of the thinking tools and questionnaires used in education and business organisations today to try to transfer knowledge across these boundaries.

The methodology is mainly one of experimentation with both quantitative and qualitative techniques used for analysing data. The studies involving idea generation, problem solving and stress management were of a more qualitative nature. Having both approaches allowed, on the one hand, for testing of discreet thinking processes linked to each hemisphere, eg verbal repetition for the left hemisphere, unfamiliar face recognition for the right hemisphere, positive emotional perception for the left hemisphere and negative emotional perception for the right hemisphere, and on the other hand, the opportunity to analyse more complex thinking processes such as idea creation, problem solving and stress management.

The findings were that a link could not be established between the use of fine motor control skills, used in manipulation, tracing or handwriting and the arousal of particular types of thinking; verbal repetition, unfamiliar face recognition, idea generation, problem solving and stress management. Also, that the left hemisphere and the right hemisphere did not perceive

a difference in emotional tone. This means that using manipulation, tracing or handwriting to try to bring about arousal does not work.

The conclusions are that the language of right brain/left brain, an option of two sets of thinking strengths, being used in management development, learning and education environments is not appropriate and can be limiting for individuals. However, it is acknowledged that it is a language that has, at least, brought the idea of there being many different thinking skills for individuals to access, to the fore and that this can be useful if used in this wider context. A suggestion of the way forward, to use the knowledge we have concerning hemispheric asymmetry, to enhance individual development and not stifle it, is provided.

Acknowledgements

There are many people to thank for encouraging me to finish this research. Firstly, I would like to thank Howard, my husband, for taking on the extra workloads needed to give me the time to work on the PhD. Also for keeping me going on the many occasions I felt like giving up. Also, thanks to my son Joshua who has not been able to use the computer when he wanted to and for Lydia who was born during this time and has therefore grown accustomed to the explanation "Mummy is busy doing her PhD" with whatever understanding she places on that. Thanks also to my Mum and Dad who have always encouraged me in everything I have done to do my best, work hard and plod along, never giving up until the end.

I would like to thank Richard Latto for his time, encouragement and support, and honest feedback to my work over all these years. Also to Graham Wagstaff who gave guidance and encouragement in particular areas of the experimental work.

Lastly, I would like to thank all those who took part in the research who gave their time to carry out tasks I asked them to do, often without any real benefit to themselves.

Contents

List of Tables

Chapter 9

Chapter 10

List of Figures

Chapter 6

Chapter 7

1 Introduction

1.1 Broad Area of Research

Today there is a lot of emphasis on thinking skills and a general awareness in society and in business that there are different ways of thinking. There are numerous tests that individuals can do to find out what are their thinking preferences and strengths. Some of these tests are based on the concept that there are two main areas of thinking associated with the two hemispheres of the brain. This current research is concerned with hemispheric asymmetry and whether there are, in fact, differences in the cognitive processes of the left and right hemispheres. There is a popular idea that it is possible to link handedness with preferred thinking strengths. Whilst this has not been established, neurological research (Abernethy et al 1997, Peters 1995, Bullock et al 1992) supports the fact that fine motor skills are controlled contralaterally. This research is particularly interested in finding out whether the established relationship between use of hand for fine motor control skills and the contralateral hemisphere can be exploited to stimulate other thinking abilities. If a link can be found then this may lead to ways to help people to stimulate mental processes, not normally their preference since they generally do not use one of their hands. Therefore, the present research attempts to find out, through experimentation, whether stimulation of the contralateral hemisphere using a fine motor task will arouse or interrupt particular thinking skills supported by that hemisphere. It will also provide, a test of the widely promulgated idea that there are distinct left and right hemisphere modes of thinking.

In explaining what the research is about it is helpful to explain what it is not specifically about:

◊ It is not about permanent handedness, how it comes about or what affect it has although background knowledge is useful because it is expected that handedness will affect experimental results

◊ It is not research into gender differences in thinking though it uses current debate in this area to inform the research and is careful to consider differences that gender may make to the experimental results

◊ It is not research into classification of thinking styles or cognitive differences in men and women, or left and right handers

◊ It is not about graphology although handwriting and tracing are used as tasks in the experiments as they induce fine motor control

The research does:

◊ assume that handedness may affect thinking preferences - it uses handedness to classify people into groups for experimentation where possible

◊ use the 'fine motor control skills' of precise manipulation, handwriting and tracing to ensure contralateral hemispheric control

This research also hopes to address an imbalance in the way the right brain/left brain concept is being used in management development and education today. On the one hand, there is an imbalance of 'not believing' the concept has any factual base so that it is immediately dismissed and on the other hand, an imbalance where it is so generalised that it is used to categorise people. This research clarifies what the evidence is for assigning different thinking processes to the right brain and left brain by reviewing the literature and then carrying out experiments concerning specialisation of particular tasks.

Other classifications similar to that of right brain/left brain are personality styles, learning styles and thinking styles and there are debates concerning whether these distinctions are helpful or not. Certainly they show people that there is natural diversity. However, it also attributes people to categories which can be limiting. The left brain/right brain notion is more distinct than some others eg learning styles, in that there are only *two* categories into which someone can be placed. This latter means of categorisation has been used widely in training and development programmes and of particular interest to the author is the way in which information which is not well researched, but generalised, could be misleading learners. This is further discussed in Section 1.3.2.

Using the concept of 'right brained' or 'left brained' can suggest to individuals that they may have a natural propensity to favour the thinking skills more associated with one hemisphere over the other ie to have a 'dominance' in one hemisphere. There are three assumptions here which can be misleading.

The *first* assumption is that there is indeed an associated list of thinking skills for each hemisphere. That is, that one hemisphere has one set of complete thinking processes and the other has a different set and that these can be identified for each. This research will review what the literature argues on these points.

The *second* assumption is that if an individual has some of the thinking skills associated with one hemisphere that they should also have a natural tendency for the other thinking skills associated with that same hemisphere. Therefore, if someone is shown to be 'logical' they are assumed to be good 'sequential' thinkers too because both these are often associated to the left brain. Conversely, if someone is shown to be 'intuitive' there may be the assumption that they must be 'creative' too as both these are associated with the right brain.

The *third* assumption is that if they show a tendency for a number of the processes in *one* hemisphere that they are 'unlikely' to be strong in those associated with the *other* hemisphere. That is, if someone is 'logical' which is attributed to the left hemisphere then they are probably *not* 'intuitive' which is attributed to the right hemisphere. With the left brain/right brain concept becoming more common in the management and education arena it is the author's view that these three assumptions are being made with increasing regularity.

Along with the above it is important to consider the 'origin' of the left brain/right brain concept as this alone highlights a problem with the use of it. As we shall see in Section 1.4.1 the discovery that the two hemispheres of the brain work in a different way came about through observing people who had had the connecting tissue (corpus collusum) of these two hemispheres severed so that the brain had effectively become two separate processors rather than one whole processor. Numerous experiments then went on to show that there are differences in processing abilities of the left and right hemisphere. Although it is therefore likely that in 'normal' brains there will be similar differences in the preferred processes as in split-brained patients, normal brains have no restriction on the communication between each side. Additionally the speed of communication has been shown to be extremely fast. One consideration is whether the concept of two different brains is therefore just an illusion.

In order to increase understanding, the approach to this research is interdisciplinary, covering the areas of cognitive psychology and cognitive neuroscience and also including other related areas such as neuropsychology, neurobiology and behavioural psychology. The particular skills explored in the experiments are 'verbal recall', 'face recognition', 'idea generation', 'problem solving', 'stress management' and 'perception of emotional intonation'.

Verbal recall was chosen because of all the skills pertaining to left hemisphere dominance this is the one that the research literature (Wada 1960, Sperry 1968, Rasmussen et al 1977 and Loring et al 1990) most convincingly supports as a left hemisphere task – that is the left hemisphere is crucial to its functioning. This is Experiment 1.

Face recognition was chosen because of its association with the right hemisphere, at least in the dimensions in which it is used in the experiment. This is Experiment 2.

The skill of *perceiving emotions* was used because this is an area that is in debate at the moment concerning hemispheric dominance. Research has reported that the right hemisphere has a dominance for perceiving emotions (Ley & Bryden 1982). However, newer literature is providing evidence to support a right dominance for negative emotions and a left dominance for positive emotions (Hellige 1993). This research aims to add evidence to this debate to bring some clarity by testing whether using a different ear makes any difference to the perception of emotions. This is Experiment 3.

The skill of *idea generation* and *problem solving* are more complex skills and very useful skills in business today. Experiment 4 aims to find out if the ability to generate ideas increases or decreases with the use of the non-preferred hand for handwriting. Experiment 5 aims to find out if there is a change in the problem solving approach of individuals who have been writing with their non-preferred hand. The concept of creativity, which is often attributed to the right hemisphere (Springer & Deutsch 1998, Goldberg & Costa 1981) is explored here as the skills of 'idea generation' and 'problem solving' involve creativity.

Stress management was chosen because the experience of stress can be due to mental processes which will not 'switch off' and this research will test whether changing use of hand has an effect of altering or interrupting a thinking process. Experiment 6 aims to find out if individuals experience more or less mental stress whilst writing with the non-preferred hand for short periods of 6 months. Experiment 7 is an extension of Experiment 6, and aims to establish whether writing with the non-preferred hand can alleviate an 'already stressful' condition.

There is much research about the two hemispheres and the 'supposed' thinking styles of each. Much of this research is confusing and contradictory. This is partly because there are different academic approaches to analysing the data – there is the 'neurobiological' approach which has advanced a lot in recent years and the 'psychological' approach.

Concerning the neurobiological approach, this now has the advantage of 'PET' scans and these can clearly show which parts of the brain are being aroused for any particular task. This has led some to say that a certain area of the brain is 'specialised' to perform a certain thinking task. However, it is not quite as simple as that. It may show that a particular area supports a thinking task in some way to enable execution of the task but it may only be one small system of a series of systems. For instance, in brain operations, surgeons may ask a patient to speak while the surgeon is electrically stimulating parts of the patient's brain. When the patient stops speaking this alerts the surgeon to the fact that he has touched an area of the brain which, in some way, 'supports' the control of speech. The conclusion to draw is not necessarily that speech is 'controlled' by that part of the brain or is 'specialised' in that area of the brain – it may just be that this area of the brain forms part of the link which is crucial for the task to be executed.

Concerning the psychological approach, this looks at the way people respond to stimuli and observes behaviours and also perceptions. Experiments are designed to collect and compare responses from individuals who have 'normal' brains to then compare this to the literature concerning participants who have had surgical procedures. This present research takes into account literature from both approaches with the methodology, in particular, using the latter approach.

1.2 Left-Handed, Right-Handed, Ambidextrous And Everything In Between

Cross-cultural studies show that around 90% of people are right-handed (Springer & Deutsch 1998, p119). This presumes a particular classification of the terms 'right handed' and 'left handed' as many people are in fact 'mixed handed' and some are 'ambidextrous'. Classification depends on the task being performed. The more precise and controlled the task done with the hand the more *that* hand is said to be the prominent one. The best example is writing as this is a controlled action requiring precision. Another example would be threading a needle and another, using a screwdriver. However, the task of using a screwdriver involves strength to some degree as well as precision. It is generally the case that the dominant hand is the stronger hand and is often slightly larger in size. For tasks involving strength, such as lifting or turning something heavy, the wrist and arm may be used so this type of task is not so useful in determining handedness. For classification purpose the emphasis has to be on the fingers. This is because of the way the hemispheres contralaterally control the body, that is the right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body. The more extreme the part of the body is from the trunk the more the control is by the contralateral hemisphere. The nearer the trunk the greater degree of ipsilateral control. This is further discussed in Chapter 3. Therefore, in order to ensure the left hemisphere is being used, an individual needs to be carrying out a task using the fingers on the right hand. It also needs to be a precisely controlled task so that the hand and wrist are not being used as much as they might be in a task involving lifting a heavy object or making a more general action such as waving. So, in order to classify an individual as right-handed, left-handed, mixed-handed or ambidextrous an inventory is taken of which hand is used to carry out particular tasks. For the purpose of this research an inventory was created by using the main aspects of the Edinburgh (Oldfield 1971) and Annett (1970) published inventories and by adding a few additional items to give additional information. More detail on the inventories is given in section 5.4.1.

1.3 Origins Of Different Kinds Of Thinking

The research described in this thesis came about because of the experience of the author, who is ambidextrous, finding that using the right hand for handwriting, aroused different thinking strengths from using the left hand and that these thinking strengths 'appeared' to relate to the so-called specialisation of the two hemispheres. This led to the question of whether thinking strengths relating to each hemisphere could be aroused by fine motor manipulation.

1.3.1 Handedness And Occupations

There has been much debate about whether left-handed people have creative, musical and language abilities attributed to the fact that they are supposedly more 'right-brained' and that right-handed people are more logical and linear in their thinking because they are 'left-brained'. However most of these associations have been shown to be inconsistent. Peter (1995) reviews some of the literature for these links, such as, left handedness and inferior intellectual ability, superior intellectual ability, mathematicians, artists and premature death and he states that no consistent conclusions have been forthcoming. As concerns links with particular skills such as mathematics and language these are so complex that it is hardly surprising that definite links cannot be made. One aspect for which there is some evidence is the degree to which the hemispheres show asymmetry; left handers show a smaller degree of asymmetry than right handers.(Bryden 1965)

1.3.2 Handedness and Psychometric Testing

There has also been research which attributes certain job roles with a preference for so called left-brain or right-brain thinking. For example Mintzberg (1976, p 49-58) discusses this notion in relation to management practices of planning which he suggests is a 'left brain' task and managing which he suggests is a 'right-brain' task. Adrian Furnham (1997) suggests that 'right-brained' thinkers are often selected out of organisations and suggests there are good reasons for employing them and that organisations are missing out on important talent.

Psychometric Tests: There are many tests used in management today which aim to help people identify particular attributes about themselves usually covering such attributes as personality type, learning style, leadership style, management style and thinking style and emotional intelligence. Some of these take into account handedness and some do not. Some of them use the concept of being right-brained or left-brained. It is interesting that although these classifications are not 'clear cut' the metaphor seems to have taken on a life and an identity of its own in the sense of a common term to understand different types of thinking. Although looking at all types of thinking is probably the best way to approach any analysis, it is clear that the neurological view takes us to the idea that some types of thinking go together and the two sides theory can help with conceptualising this. Is it possible for someone to be extremely creative and extremely logical? Or for someone to excel in sequential thinking and at the same time excel in divergent thinking? If these *are not* possible, then this polar concept may have some use in highlighting what people can and cannot do. If, however, they *are* possible, then this concept is too limiting.

The Herrman Brain Dominance Instrument and the Myers Briggs Types Indicator (personality types) ask for handedness in their tests. These are robust instruments which are supported by scientific research. There are however, many other instruments in the marketplace which are loose generalisations of the knowledge concerning the differences between the functioning of the hemispheres. These are used in business life, in popular magazines and in school education. Primary school children are having lessons on what the left brain/right brain concept teaches and there are supporting materials on a variety of websites for teachers to develop lessons. Children can study for a GCE AS in Thinking Skills comprising part 1 Problem Solving and part 2 Critical Thinking offered by Cambridge International Examinations (www.tsa.udes.org.uk) or an GCE AS in Critical Thinking offered by Oxford, Cambridge and RSA Examinations (www.ocr.org.uk). Also, the current Thinking Skills Assessment (TSA) project plans to launch a full A level in Critical Thinking. These are all good things in themselves. However, they have fuelled such an interest in thinking skills that the left brain/right brain concept has been grasped as an easy model to use and is in danger of being misused.

<u>Is the concept of 'right brain/left brain' commonly known?</u>

In order to find out whether the concept of right brain/left brain was familiar to a group of managers an informal survey was carried out.

Questions were asked within 'focus groups' and 'action learning sets' at a management development event.

The methodology for collecting the data was to form groups of 4-6 people and ask questions of the group concerning the concept of right brain/left brain. There were 4 groups of 6 people and one group of 4 people giving a total of 28 people. The questions were asked by the researcher and participants asked to give their own free flow responses. There were no suggested responses given. The free flow responses given by the participants were written down on paper.

The methodology for analysis of the data was 'content analysis' where the free flow responses were categorised according to type and then quantified to give the strength of that particular type of response. Once categories had been established for the first two groups the subsequent data was slotted into these categories if appropriate or further categories were created or sub-division of categories took place. This was using some of the characteristics of 'grounded theory'. Participants could offer as many pieces of data as they felt was appropriate.

The actual questions which were asked are given below with the categories of responses formed from the free flow responses.

Q Have you heard the concept 'right-brain/left-brain'?

Yes 100% (28)
All participants had heard of the concept.

Q When/where have you heard about this concept?

Reading material – academic/popular/novels - 100% (28)
TV. media, newspapers – 100% (28)
All participants had read about this concept both in books and through the media

Training and development sessions – 50% (14)
In general work conversations, meetings, appraisals - 39% (11)
Social conversations, friends, children – 11% (3)

Q What does the concept tell us?

That you have a strength for logical thinking or creative thinking but not both – 71% (20)
That if you are left handed you are creative and vice versa – 32% (9)
Not really sure - 21% (6)

Q In what way, if any, does the concept help you to understand differences in thinking?

Another self-analysis tool to add to many others - 96% (27)
It simplifies the complexity of thinking into two broad categories - 96% (27)
Helps you to know your strengths - 89% (25)
It helps you to know what you 'should naturally' be good at - 86% (24)
Helps to separate the two main types and align your own thinking to one of them - 86% (24)
Helps you to see why you find it hard to think in a particular way - 71% (20)

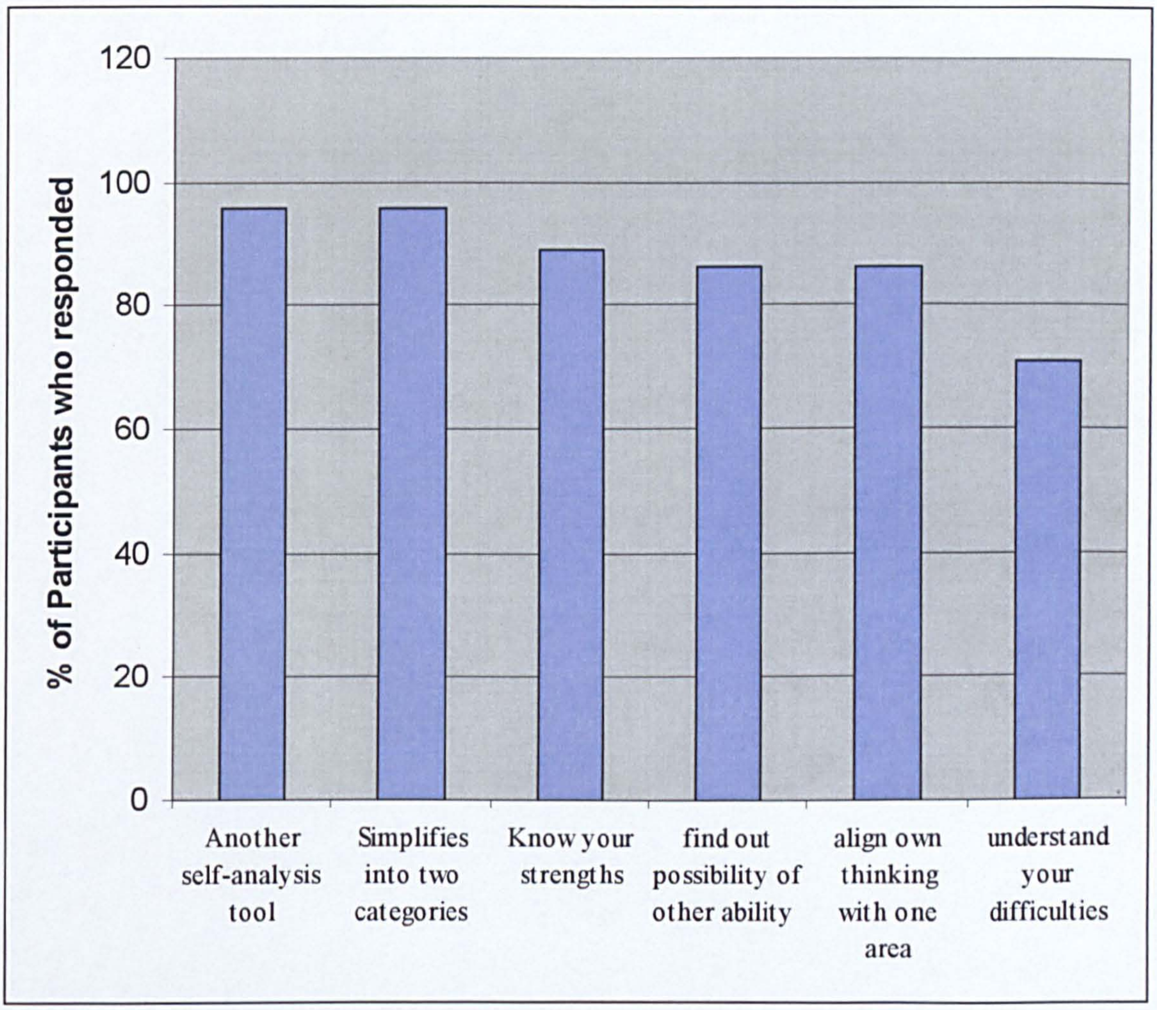


Figure 1.1: How the Concept helps in Understanding Differences in Thinking

Q How well do you think the concept has been researched and is therefore reliable?

Well researched - there are loads of books on it - 86% (24)

It's used in management development workshops so must be – 79% (22)

It's a big thing in school education now so it must be ok - 50% (14)

Yes there's medical research saying which bit of the brain does what – 43% (12)

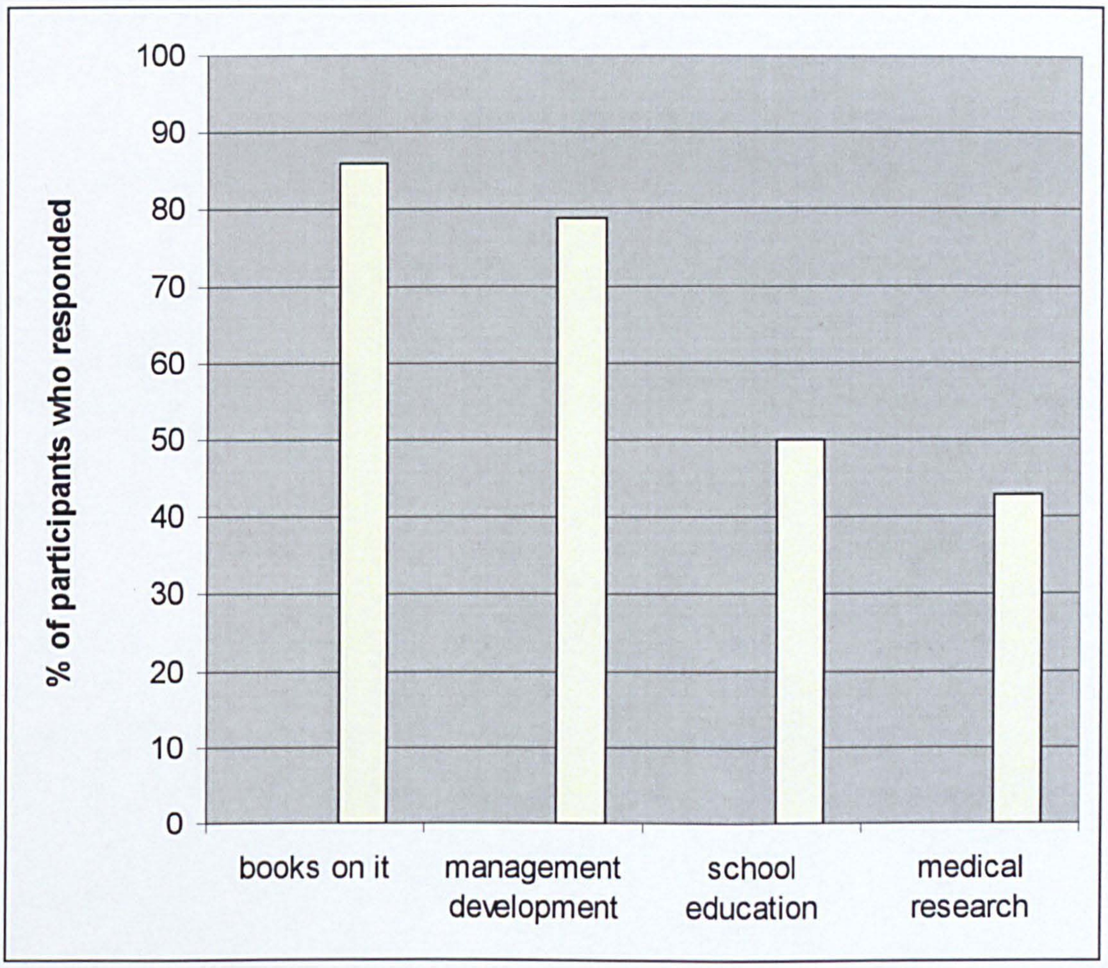


Figure 1.2: How Well the Concept Has Been Researched

Q Do you think being 'right brained' is related to being left handed?

Probably not – 36% (10)

Yes, it's the same thing eg left handed people are creative, play music, paint etc – 32% (9)

Don't know – 18% (5)

Probably yes because there are links with left handedness and dyslexia etc – 14% (4)

Q Have you ever done a psychometric/personality/management/ test or questionnaire?

Yes - 100% (28)

Q If so, has the test asked whether you were right-handed or left-handed?

Yes 61% (17) (Myers Briggs 54% (15) Herrmann Dominance 7% (2))
Fairly sure it didn't, no 21% (6)
Can't remember 18% (5)

This informal survey illustrated how common the concept of 'right brain/left brain' was for a group of managers. It also shows that those questioned believed it was a well researched topic. People were less sure about the connection between handedness and right brain or left brain thinking but there was a general acceptance of the notion of two groupings of thinking most commonly referred to as 'logical' versus 'creative'.

1.3.3 Lefthandedness

Since so many people are right handed it is worth considering why the other 10% are left handed. Two main reasons are given. One is due to family genes, namely 'familial left-handedness'. The other is due to something happening in the uterus, perhaps an imbalance in the hormone testosterone or other chemicals secreted by the kidney which has changed the 'normal' left hemisphere dominance for fine motor skills into a right hemisphere dominance. This is labelled 'pathological left-handedness'. Of course, there are also people who are right-handed who would consider themselves 'truly' left-handed ie they have been 'forced' to become right-handed due to social acceptance or the education system. Even today when ambiguity is shown in small children as they begin to learn writing the teacher will assume a right-handed dominance since there is 90% chance this is correct. Injury to the naturally dominant hand may also temporarily or permanently alter a person's handededness. So then, a person's natural handededness usually states which hemisphere is dominant as far as fine motor control is concerned. Whether other thinking abilities are affected by a left-hand dominance is still a major area of debate.

1.4 Hemispheric Asymmetry

1.4.1 Split-brain patients and the findings

Much of the information concerning hemispheric asymmetry has come from the studies in split brain patients (Sperry 1974) who have had their corpus callosum severed to treat epilepsy. The corpus callosum consists of 200-250 million nerve fibres and it joins the two hemispheres and by cutting it a seizure on one side of the brain cannot travel to the other side of the brain. The procedure of cutting the corpus callosum is called commissurotomy.

Sophisticated experiments have been carried out on these patients (Sperry 1974, Springer & Deutsch 1998) and interesting discoveries have been made in the way the two hemispheres of the brain deal with stimuli differently.

Research into split-brain patients shows that the right hemisphere and the left hemisphere have different preferences as far as some thinking patterns are concerned. Speech is usually located in the left hemisphere and face recognition in the right hemisphere. However, a 'normal' brain which has not had any brain damage or interference has the two hemispheres joined in the middle so that each side can communicate. This means that an individual uses both hemispheres at the same time. The reason researchers know that each hemisphere has different preferences is because they have observed patients who have had a commissurotomy. Studies have been done (Gott 1973) to identify which abilities are lost or weakened in these conditions.

Some experiments used Tachistoscopic presentation to one visual field to show only one hemisphere a particular image. For example, when experimenters flashed an image to the right hemisphere of a patient the patient reported they saw nothing, yet with their left hand could pick out the identical item to the one they were shown. It appeared that the left hemisphere was not aware of what the right hemisphere had seen and what the left hand was picking out. (Sperry 1968, 1974)

Some interesting observations have been made of commissurotomy patients for a short while after their surgery. Some of the more unusual observations have involved the right hemisphere and the left hemisphere appearing to have different intentions.

In one experiment Gazzaniga (1978, p 70-72) describes how a particular patient who had some language ability in the right hemisphere was asked questions and was able to spell out the answers in words on scrabble letters. In this way the two hemispheres were interviewed separately and the answers compared. The answers the patient gave for a question asking what he wanted to be when he grew up were different for each hemisphere, the right hemisphere reporting he wanted to be a racing driver and the left hemisphere saying he wanted to be a draughtsman. In another experiment the patient was asked questions about how he felt about certain people including himself and his mother. The ratings for each hemisphere were sometimes different and when they were at their most diverse the patient was more emotionally irritable.

Ferguson et al (1985) describes a female patient whose left hemisphere and right hemisphere were not in agreement concerning which dress she should take out of the wardrobe to wear. When she reached out to take out the dress of her choice with her right hand, her left hand took hold of a different dress and would not let it go. Sperry (1974) tells of a patient trying to pull on his trousers with his right hand and his left hand would be trying to pull them down on that side. When putting on a dressing gown belt the left hand would assist the right hand in putting it on but would then proceed to attempt to untie the knot with the right hand trying to stop it. Similarly, Joseph (1990) reports a patient whose right hemisphere would not let him smoke so that every time he lit a cigarette his left hand would take hold of the cigarette and put it out.

There is also some evidence to show that one hemisphere finds ways of helping the other hemisphere to complete an exercise when it is not able to do so in the normal way. For instance in experiments done by Bogen (1990) the patients showed evidence of cross-cuing from the right hemisphere to the left hemisphere. One experiment involved identifying whether a 'sphere', a 'cube' or a 'pyramid' were being placed, unseen, in the left hand. The stimuli would give the information to the right hemisphere only and it was not expected that the left hemisphere would be able to name the item. However the patient could name the item correctly. The experimenters realised that the patient's right hemisphere was telling the left hemisphere what the answer was by looking at the clock when the answer was the 'sphere', by looking at the door when the answer was the 'cube' and by looking at the ceiling when the answer was the 'pyramid'. Once the patient was blindfolded he was completely unable to name the objects. The right hemisphere was autonomously intelligently working out how to solve the problem.

It was also found in studies done by Hillier (1954), by Gott (1973), and by Smith (1966) that patients who had the whole of their left hemisphere removed by surgery showed fairly well developed cognitive abilities for the remaining right hemisphere as if it had compensated for the loss of the left. Also that the personalities of the patients had not appeared to have changed significantly, though, of course, it is important to remember that the patients' brains cannot be classified as 'normal' before surgery.

The cognitive abilities of the right hemisphere has come under a lot of debate from Gazzaniga (1983) saying that 90% of split brain patients have right hemispheres which are "extremely passive mental systems capable of performing at best, simple match-to-sample nonverbal perceptual tasks" to Levy (1983) saying that most split brain patients have a high degree of cognitive function in the right hemisphere. The broad scope of literature including post-commissurotomy syndrome, left hemispherectomy patients and Wada studies (Wada 1960) (discussed further in the following section) suggest that the isolated right hemisphere generally functions at a sophisticated level (Schiffer F, 1996). The fact that these findings have been from patients who have had brain surgery and therefore complications from the type of brain disorders they already had, means they cannot be automatically applied to 'normal brains'.

1.4.2 Normal 'Intact' Brains

To what degree can information gained from studies on split-brains be applied to normal in-tact brains where the corpus callosum is intact and providing communication across the two hemispheres?

Blakeslee (1980) says "all of the left-right differences we saw in the split-brain patients can be demonstrated, although less dramatically, in normal people" (page 168)

Bogen (1990) has reviewed the literature and made some conclusions on this point. He argues that in normal individuals there is a 'duality of mind' attributable to a partial hemispheric independence. He gives evidence for the inability of the corpus callosum to offer a complete transfer of information from one hemisphere to the other. He reviewed experiments in which human intact brains could be taught something to one hemisphere which is not transferred to the other hemisphere. In line with this (Ringo et al, 1994) suggests that hemispheric specialisation comes about because of the significant interhemispheric conduction delays.

Another way of studying the hemispheres separately, apart from separating them surgically by cutting the corpus callosum, is to perform the Wada Test (Wada 1960) named after its inventor Juhn Wada. This procedure is used before patients have neurosurgery to determine which hemisphere supports the individual's language and memory abilities. One hemisphere of the patient's brain is anesthetized by injecting a fast acting anaesthetic, sodium amobarbital, into the carotid arteries, on the side of the neck directly affecting that hemisphere. The participant lies down with both arms raised in the air and counts repeatedly from 1 to 20. When the arm opposite the side of the injection falls limp this tells the surgeon that the drug has taken effect as expected. When one side is anesthetized in this way the other side can be tested for language and memory abilities. This is discussed further in section 5.2. Risse and Gazzaniga (1978) carried out experiments on 8 patients using this method. They anesthetized the left hemispheres of their patients with sodium amobarbital to carry out the Wada test. An item, such as a ball, was then placed into each patient's left hand and then taken away. When each patient's left hemisphere was awakened the patient would be asked what had been put into their left hand. They could not remember. However, when they were asked to point to a picture of the item put in their hand, from a choice of a number of items, they could pick out the right one. Therefore, in much the same way as the split-brain patients, it was the right hemisphere which remembered the item whilst the left hemisphere did not know anything about it. The left hemisphere therefore could not articulate the answer but the right hemisphere could select the correct picture. So the two hemispheres in normal intact brains do work autonomously when one of them is anaesthetized so that it is 'out of action'. However, in normal everyday life, people do not have one hemisphere anesthetised, both are fully awake. However, this does highlight the fact that the brain can use specialisation of some cognitive functioning, when required, and that it does not have to transfer information across the corpus callosum to function independently.

1.5 Assumptions Concerning Hemispheric Functions

The subject of neurolinguistic programming (NLP), developed by John Grinder and Richard Bandler, has brought about some interesting ideas about how the left hemisphere and right hemisphere are used. NLP attempts to introduce practices which help an individual to use one or other hemisphere more effectively in their interpersonal relations. It also offers methods of deducing whether an individual is using their right or left hemisphere to process particular activities. One such method is the observation of eye movement. The 'standard' eye movement directions as mapped out by Grinder and Bandler in their book Frogs into Princes (1979), are illustrated below. They illustrate someone's eyes looking out from the page. When a person's eyes move in a particular direction, it is said he or she is thinking in one of three possible ways: visual; auditory or kinaesthetic. If the eyes move up to the right, it means the individual is remembering something and visualizing it, called 'visual remembered'. If the eyes move up to the left, it means the individual is seeing an image of something not seen before ie fantasy. If the eyes move to the left, it means they are constructing a sound not heard before and if the eyes move to the right it means they are remembering sounds. If the eyes move downwards to the left it means the person is feeling emotions through sense of touch or muscle movement. If the eyes move downwards to the right it means the person is talking to himself or herself. Grinder and Bandler add a qualitative note that these usually apply in the case of normally mentally organised right-handed people but do not offer how to find this out.

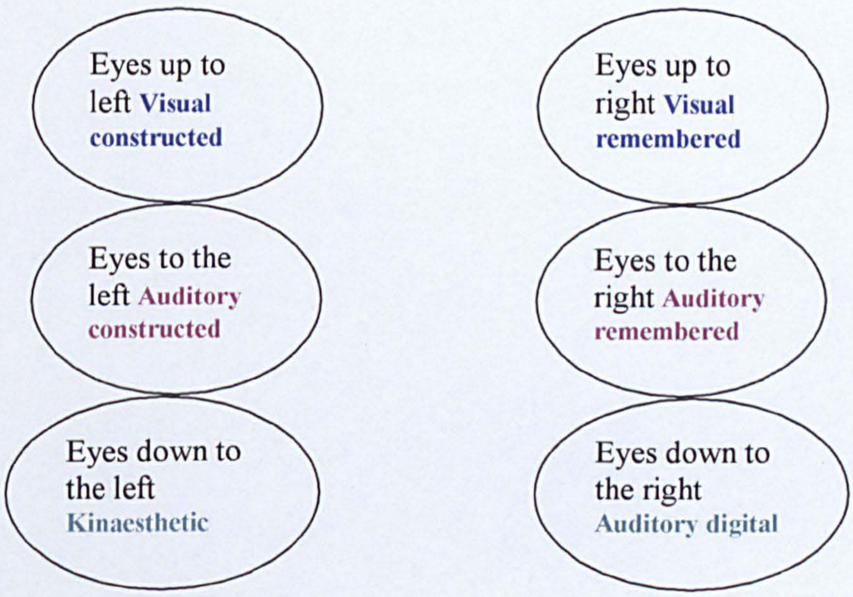


Figure 1.3: Illustration of Eye Movement and their Associated Thinking from NLP

Hogan (1996) an NLP Practitioner, researcher and author of 'The Psychology of Persuasion: How to Persuade Others to Your Way of Thinking' undertook research to test the NLP theory of eye positioning. In the Journal of Hypnotism (on line) he writes the following *"Six months ago, at a hypnotherapy certification training here in Minnesota we started researching eye accessing cues. After my initial research, I became frustrated because what I had written in The Psychology of Persuasion, about eye accessing cues was completely wrong. It was the only section in the book I personally didn't research. This research aimed to determine whether or not there was adequate support for the eye movement hypothesis in NLP. As our results show and other studies relating to this hypothesis have shown, there is not the support available to uphold the theory."*

This present research is concerned with the use of such practices in learning and development where information is portrayed as having been validated by research when, in fact, it may not have been. For the NLP example there is some research to support its claims. Kinsbourne (1972) carried out research on the link between direction of eye gaze and the different types of thinking called 'spatial' and 'verbal'. He suggests that the eye direction is a useful index of cerebral lateralization of cognitive function. He also found that if subjects were made aware of their gaze or were interrupted or were not pressed to the limits of their mental capacity then the phenomenon disappears. The difficulty comes with using such research to create general rules for understanding people and ignoring the conditions under which the findings are true.

1.6 Research Questions

Detail of the research methodology is covered in Chapter 4. In short the main theoretical perspective of this research is positivist using observation and experimentation with the researcher being independent of the research.

The research question is concerned with finding differences and therefore all experiments are making a comparison between left hemisphere and right hemisphere. In the main these experiments are testing whether the use of a fine motor control task (handwriting, tracing, manipulation) stimulate hemispheric arousal and affect a cognitive task. One experiment uses didactic hearing as an attempt to establish hemispheric differences in perception of emotional cues in voice tone.

This research addresses the following questions:

General Question:

- Can we use fine motor control of the hands to help individuals to stimulate different kinds of thinking?

Specific Questions:

- Can a person's verbal recall ability be affected by using one hand or the other?

- Can a person's ability to recognise an unfamiliar face be affected by using one hand or the other?

- Do people perceive orally expressed emotions differently depending on which hemisphere hears them?

- Can a person's idea generation ability be affected by using the one hand or the other?

- Can a person's problem solving ability be affected by using one hand or the other?

- Does a person experience reduced stress by using one hand or the other?

1.7 Outline of The Thesis

Given below is an outline of the thesis giving the reasoning, aims and hypotheses of each experiment. More details concerning the research methodology used and methods used for each experiment are given in Chapter 4.

An assumption, based on published research (Goldstein 1974, Peters & Pang 1992), is that the use of non-automatic fine motor skills arouses the contralateral hemisphere. In one of the experiments it is oral stimulus which is used to arouse the contralateral hemisphere.

This research is trying to establish the possibility of further application of this contralateral relationship, in particular whether it is possible for this contralateral relationship to enable other thinking skills, commonly associated with that aroused hemisphere, to also be aroused.

If one single factor is used to determine handedness, handwriting is the most accurate. However, it is important for this research to know whether participants are strongly right handed or mixed or left handed. A questionnaire which has been especially designed for this research is given in Section 5.3.1.

The Thesis is organised in the following way:

Chapter 1 gives a broad outline of the research area with the research questions

Chapter 2 gives a review of the findings concerning fine motor control and the use of the contralateral hemisphere for these

Chapter 3 gives a review of literature and evidence concerning the degree to which thinking skills can be attributed to a particular hemisphere

Chapter 4 gives details of the methodological approach to the research

Chapter 5 is the first experiment. The literature search shows (Loring et al 1990) that verbal tasks are generally accepted as left hemisphere dominant. This experiment tests for any difference in the execution of the verbal task when a different hand is used for the manipulation task.

The hypothesis is that those using their right hand for the manipulation task would improve in verbal repetition ability.

Chapter 6 is the second experiment. The literature shows (Young et al 1993) that recognising unfamiliar faces is generally accepted as a right hemisphere task. This experiment tests for any difference in the ability to recognise unfamiliar faces when a different hand is used for the tracing task.

The hypothesis is that those who traced with their left hand would be able to remember more faces that those using their right hand.

Chapter 7 is the third experiment. In contrast to the first two experiments where research was clearly in favour of a dominant task for one particular hemisphere the area of perceived emotions is one of current debate and ambiguity. Most research states that emotional perception is more strongly rooted in the right hemisphere (Springer & Deutsch 1998 p233, Davidson 1993) but some research (Hellige 1993) distinguishes between negative emotions and positive emotions saying the right hemisphere is dominant for perception of negative emotions and the left hemisphere is dominant for the perception of positive emotions.

This experiment aims to test the newest opinion that whilst the right hemisphere is dominant overall for emotional perception that the left hemisphere is dominant for positive emotions.

The hypothesis is that individuals who listened to the sentences through their right ear would perceive the emotions as more positive.

Chapter 8 is the fourth experiment which is part of a group of experiments linked to a longitudinal study in which participants carried out a handwriting task repeatedly with their non-preferred hand for 6 months. The literature suggests that the individual ability to generate ideas is a right hemisphere task and is the first step in the creative thinking process. This experiment aims to find out if there are differences in the ability to generate ideas before and after repeated handwriting for 6 months with the non-preferred hand.

The hypothesis was that those who use their left hand for repeated handwriting would improve in their idea generation ability.

Chapter 9 is the fifth experiment. Problem solving is a complex task. The ability to think creatively enhances the effectiveness of problem solving. Creative thinking uses an optimum balance of convergent and divergent thinking which are loosely linked to the left and right hemisphere respectively. The aim of this experiment is to find out if repeated use of handwriting with the non-preferred hand has any effect on the type of thinking used in problem solving.

The hypothesis is that writing with the non-preferred hand will alter the balance of types of thinking used for problem solving.

Chapter 10 has the sixth and seventh experiments. The sixth experiment aims to establish whether using the fine motor control task, of handwriting with the non-preferred hand, can interrupt thinking in the contralateral hemisphere and thereby bringing stress relief or relaxation.

In order to minimise any anxiety caused by the task itself participants were asked questions concerning the experience after they had been regularly doing the task for at least 5 months and had become well practised and comfortable with it. They were specifically asked to give data concerning how they felt whilst actually doing the task, as compared to when they were not.

The hypothesis is that using the non-preferred hand would decrease the feeling of stress and increase the feeling of relaxation in all participants due to causing an interruption in normal thinking patterns.

The seventh experiment is similar to the previous one except participants were asked to select particularly stressful situations and to carry out the handwriting task at these times and then report on their experience of whether this reduced the stress. This task was done in the 6th month of the repeated handwriting.

The hypothesis is that using the non-preferred hand would decrease the feeling of stress in that stressful situation for all participants.

Chapter 11 is a summary of the research and its findings and conclusions

2 Fine Motor Control

2.1 Introduction

The purpose of this chapter is to establish what is already known about fine motor control. Two approaches are discussed here, firstly, the neurological approach based on the biology of the brain and secondly, the psychological approach based on experimentation.

2.2 Neurological Structures and Systems

There are three motor structures in the brain which are involved in the fine motor control of hands and fingers (Bullock et al 1992, Peters 1995 and Abernethy et al 1997). These are the motor cortices via the pyramidal tract, the cerebellum and the basal ganglia.

2.2.1 The Motor Cortex

The cerebral cortex is the outermost layer of the cerebrum of the brain and it contains half of the total neurons in the human nervous system. The cerebral cortex is divided into two halves, which appear essentially symmetrical although they are somewhat different in function. These are the left and right cerebral hemispheres, which join at the midline through a thick sheet of interconnecting nerve fibres called the corpus callosum. Each cerebral hemisphere contains a motor cortex, a pre-motor cortex and a supplementary motor area. Each of these structures, located within the frontal lobe of the cerebrum, is intimately involved in the production and control of skilled movement. Experiments using weak electrical pulses have been used to determine which parts of the brain control which muscles.

The way muscles are represented in the motor cortex depends on the amount of *precision* needed by those muscles represented. Therefore the size of the muscles is not reflected in the amount of brain allocated to their control. The muscles of the hands and mouth occupy nearly two-thirds of the total area of the motor cortex. Electrical stimulation shows that the pre-motor cortex is concerned with gross movements rather than fine movements. Finger movements are not based here. The supplementary motor area appears to control bimanual co-ordination as damage here disrupts the performance of tasks that require those skills. (Abernethy et al, 1997)

The motor cortex instructs the muscles in two ways. "*The most direct route is via the pyramidal tract (or cortico-spinal tract), which allows neurons from the motor cortex to synapse directly in some cases (and through a minimum of interneurons in most cases) with the alpha motor neurons at the spinal level. This tract carries impulses that are primarily excitatory in nature. Alternative routes, known collectively as the extrapyramidal tract, allow nerve impulses from the motor cortex to reach the spinal level through a range of pathways via the cerebellum, basal ganglia, thalamus and brain stem. Outputs from these pathways are primarily inhibitory in nature. Damage to the motor cortex results in a loss of fine movement control, especially in the fingers and toes.*" (Abernethy et al 1997)

The pyramidal tract, the pathway running directly from the motor cortex down the spinal cord, crosses over so that "each of the motor cortices controls muscles on the *contralateral* (opposite) side of the body" (Abernethy et al 1997). This pyramidal tract is involved in the fine control of the hand and fingers (Bullock et al). Therefore when the motor cortex controls the hands directly via the pyramidal tract and not through the extrapyramidal tract it does so contralaterally. The left hand is controlled by the right hemisphere and the right hand by the left hemisphere.

Movement that would be controlled contralaterally by pyramidal tract neurons is those actions that need to be controlled quickly and which require manual dexterity such as grasping a pen. The cortical cells used are called Betz cells. There are more Betz cells in humans than other primates, which is thought to be the reason why humans have better dexterity and are able to control each finger separately. As the primates have evolved, so the number of Betz cells have increased. (Bullock et al, 1992)

However when the motor cortex sends messages via the extrapyramidal tract, which goes through the cerebellum and the basal ganglia, the result is not only contralateral control but also involves ipsilateral control. In order to explore this further and give an illustration Figure 2.1 has been adapted from Melbourne University teaching notes.

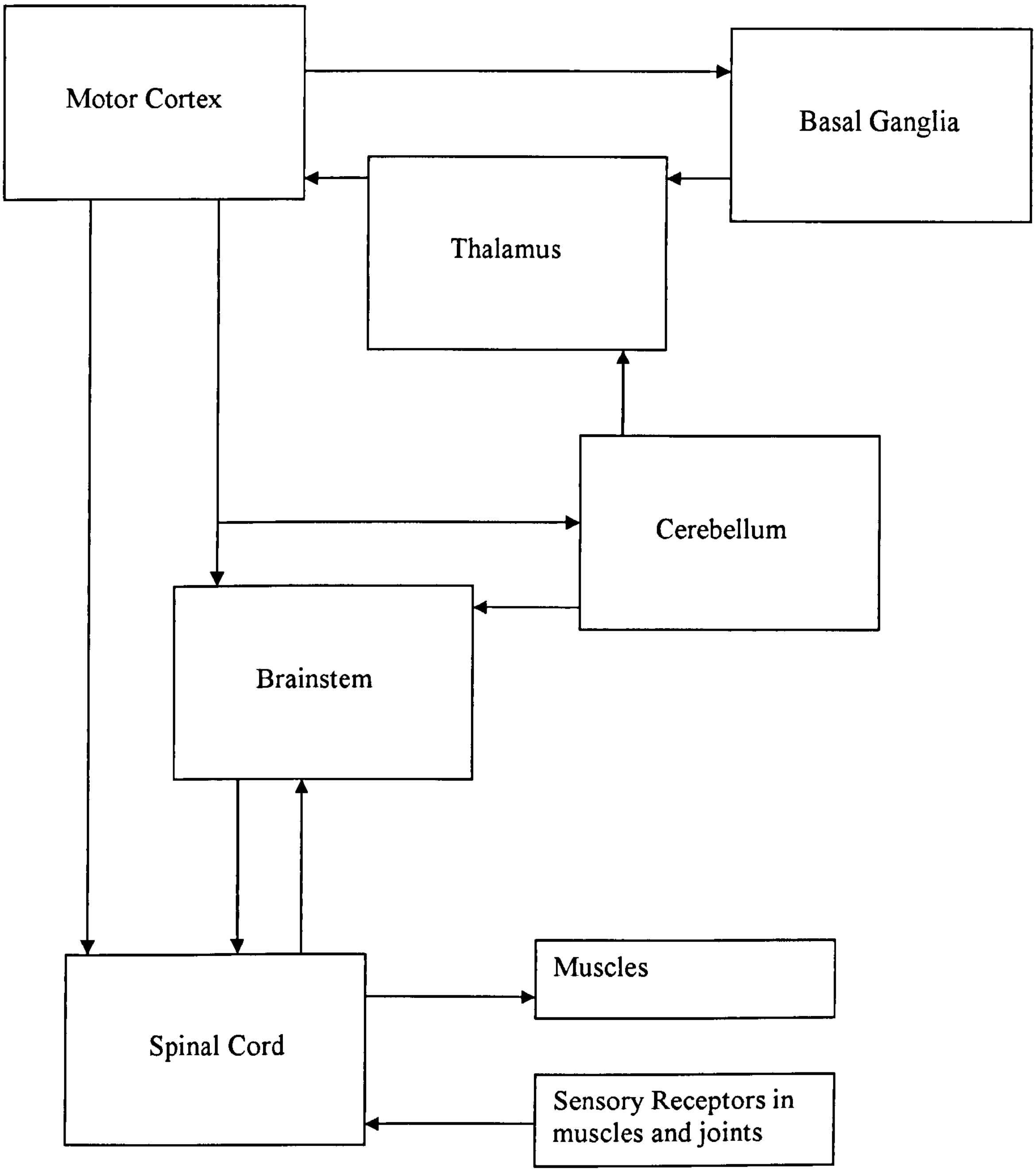


Figure 2.1: The Motor System

2.2.2 The Cerebellum

"The cerebellum attaches to the brain stem and is located behind and below the cerebral hemispheres. Like the cerebrum, the cerebellum has an outer cortex, divided into two distinct but interconnected hemispheres. Beneath the cortex are four deep-cerebellar nuclei. The cerebellum receives input information from a vast array of areas in the cerebral cortex (including the motor areas), from various areas in the brainstem, from the vestibular apparatus and, via the spinal cord, from the kinesthetic receptors located on the same (ipsilateral) side of the body". (Abernethy et al 1997, p 292).

Peters (1995) is of the opinion that although the cerebellum is not often brought into discussions on handedness that it does have significance. He states that the lateral portions of the cerebellar hemispheres are implicated in movement of the digits by a number of indicators when relating to 'practised' movements termed skilled movements. Also that *"(a) the lateral neocerebellum is likely to play a very important role in skilled movements of the hands and (b) the role played in skilled movement of the hands is likely to be at the level of organization, planning and learning as well as execution of skilled motor patterns".* (Peters 1995, p 194)

He illustrates the importance of the role of the cerebellum by giving descriptions of patients with brain damage. These descriptions include: slowness, awkwardness and irregularity of finger movements; difficulty in moving fingers separately; problems with using simple and familiar tools and obvious disturbances in writing. He also states that *"The cerebellar hemispheres exert their influence on the ipsilateral musculature of the body. That is, the outflow from the left cerebral hemisphere reaches the right neocerebellar hemisphere and, conversely, a complex system of double crossovers from the neocerebellum to the red nucleus ensures that the ascending and descending communications of the cerebellum meet up with the motor control processes of the contralateral cerebral hemisphere."* (Peters 1995, p 196)

"A number of major motor control functions have been attributed to the cerebellum, all broadly related to the translation of abstract movement plans into specific spatial and temporal patterns that can be relayed to the muscles via the motor cortex. Principal cerebellar functions appear to be the regulation of muscles tones, the co-ordinate 'smoothing' of movement, timing and learning. Patients with cerebellar damage demonstrated one or more of the symptoms of low muscles tone, incoordination (especially in standing , walking, speaking or performing precise aiming movements), poor temporal control of muscle recruitment, and difficulty in learning new movements or adapting old ones. Fast, ballistic types of movement appear to be particularly affected." (Abernethy et al 1997, p 292).

One of the outputs from the cerebellum goes to the brain stem. In the brain stem, the cerebellum's major output structure is the 'red nucleus', which is one of four brain stem nuclei. A lesion in the red nucleus has little effect on general motor control but impairs the ability of a monkey to use its hand and fingers (Shepherd 1988, p 444). Damage to the cerebellum can result in poor co-ordination and lack of precision in movement. A patient with damage to the right lobe of the cerebellum reports problems with movement of the right arm. "The cerebellum, unlike the motor cortex, influences the muscles on the *ipsilateral* (same) side of the body." (Bullock et al 1992, p 244)

The cerebellum produces 'ballistic' responses. These are learned sequences of behaviour that are carried out too fast for the brain to use sensory feedback to develop them. In this way the cerebellum has been implicated in 'motor learning' which is learning sequences of motor behaviour so that they become automatic. When someone plays a piece of music 'by heart' then this would involve the cerebellum and would avoid the central nervous system having to compute the muscular movements each time. Tennis players and cricketers practice so much that their responses become 'instinctive' (Bullock et al, p 244). Also it is possible that some aspects of handwriting, for example, signatures, could be considered to be a ballistic response. When someone writes the muscular behaviour of the fingers, wrist and arm could be partly 'automatic'. The brain is involved in organising the activity in both the pyramidal and brain stem pathways through its anatomical connections with these systems.

2.2.3 The Basal Ganglia

"The basal ganglia comprise a group of interconnected nuclei located deep within each of the cerebral hemispheres and close to the thalamus. The basal ganglia receive input from two major sources, from the motor areas of the cerebral cortex and from the brainstem, and, similarly, send their output to two different locations, the thalamus and the brainstem. Therefore, like the cerebellum, the basal ganglia, while not synapsing directly with spinal neurons, are able to influence alpha motor neuron activity through both the pyramidal tract and the rubrospinal tract. The basal ganglia work together as a loosely connected unit, although each of the component nuclei are quite different and generally connected in an inhibitory fashion with each other. (Abernethy et al, 1997, p 289)

Acquired knowledge about the function of the basal ganglia in motor control is mainly based on studies of patients suffering from two identifiable diseases of the basal ganglia. These two diseases are Parkinson's disease and Huntington's disease. However, despite knowledge of the obvious movement problems, the precise function of the basal ganglia in movement control remains elusive. *"Some favoured suggestions include the control of slow movements, the retrieval and initiation of movement plans, and the scaling of movement amplitudes, as required in daily tasks such as handwriting."* (Abernethy et al, 1997 p 291)

Bullock et al (1992) state that the basal ganglia play a key role in 'planning action'. To illustrate this by using the task of drinking a cup of coffee, the role of the basal ganglia in the task would be to access pre-stored information learned from repetition concerning the vision and touch including the weight of the cup to enable the planning of the task. Bullock suggests that similar skills are used in the tasks of writing and drawing and that therefore these tasks would also require the use of the basal ganglia. The basal ganglia would pass on the general specifications of the movements to the cerebellum, leaving it to organise the detail of the necessary muscles movements

Like the motor cortex and the cerebellum the basal ganglia are bilaterally symmetrical, ie there is one in each hemisphere. They are made up of three structures: the caudate nucleus, putamen and the globus pallidus. There are extensive interconnections between the basal ganglia and other parts of the brain. They have a unique interactive role.

There are distinct differences in function between the cerebellum and the basal ganglia.

"The two central motor structures, the cerebellum and the basal ganglia, play different roles in the organisation of behaviour. The cerebellum acts within its cortical loop organisation and has access to information about the muscles and joints from ascending spinal cord pathways and from vestibular, visual and auditory systems. It is involved in programming behaviour by generating the sequencing or patterning of muscle contractions and in their integration within the general control of the disposition of the body. Damage to the cerebellum can result in loss of co-ordination, with individual movements losing their 'flow', as the movements have to be constructed laboriously by other motor system structures. (Bullock et al, 1992, p 248)

Evidence from disorders such as Parkinson's disease suggest that, in contrast to the cerebellum, the basal ganglia play a 'higher', more executive role in the control of behaviour. One symptom of Parkinson's disease is that the victim has difficulty in 'initiating' behaviour, as if the plans for the action become inaccessible. Here the absence of any direct connection with either the motor cortex or the brain stem motor systems, and the presence of connections with the cortical areas involved in sensory processing and with the pre-motor cortical areas suggest such an executive role. (Bullock et al 1992, p 249)

What the cerebellum and the basal ganglia do have in common is that they can both influence muscle sequencing on the ipsilateral side of the body.

2.2.4 Discussion

The most important thing to note from this information which affects the present research is the difference in the way the cortex, the cerebellum and the basal ganglia influence the control of hands and fingers. Although finer details of some of the movements are still not understood it can be seen that the motor cortex has contralateral control whilst the cerebellum and basal ganglia have bilateral control.

The extent to which each part of the brain is being used may depend on the exact fine motor skill that is being tested. Often in experiments it is the speed, strength and dexterity that is being tested. However, these use the contralateral control to a different degree. The present thesis is interested in manipulative fine motor skills of which there are several different types, for example: power grip (pulling on a rope); precision grip (holding a pen); power hook grip (lifting a briefcase); power pinch grip (lifting without a handle); combined power and precision grip (removing a pen lid whilst grasping the pen); complex posture and manipulation (string games). This research focuses on the skill which is most likely to ensure contralateral control and which has the most practical application which is 'precision grip' used in 'pincing', 'tracing' and 'handwriting'. The opinion of Goldstein (1974, p 97) is that "many motor functions are subject to the principle of contralateral control and those of the hand particularly so".

However, it is important not only to consider the neurological approach but also to consider the psychological approach: *"neurophysiologists interested in motor control are still many years away from a complete integrative model of brain mechanisms for motor control. One approach that may hasten understanding may be to look alternatively or, better still, simultaneously at motor control from a* *conceptual (psychological) perspective in addition to a neurophysiological one.*" (Abernethy et al, 1997, p 292).

2.3 Psychological Findings

Psychological literature is reviewed in order to add to the information gathered from the neurobiological findings. The question to be asked is "does any of the psychology research on the control of fine motor skills give findings to support contralateral control, ipsilateral control or a mixture of the two?"

Much of the research has assumed contralateral control for fine motor skills and this is still the main accepted view (Peters 1995, Hellige 1993, Abernethy et al 1997). However, when differences in findings occur this leads to discussion around the possible different types of fine motor control that exist. Therefore, subclassifications of fine motor control skills have been made and then tested to see whether some of them may not be so clearly contralaterally controlled as others. Also, that it may depend on whether a person is right handed or left handed.

Another important aspect is to what extent ipsilateral control is used and does this depend on whether someone is left handed or right handed. One detailed case study of a subject was used to explore the extent of ipsilateral motor control in a pathological left hander (Triggs et al, 1998). A pathological left hander is someone who is left handed due to an abnormality or random condition which has adversely affected the left hemisphere rather than due to genetics. The hypothesis was that the "ipsilateral motor cortex contributes to functional recovery of the right arm in patients with pathological lefthandedness".

It is suggested that in a pathological left hander the unaffected right hemisphere may have made up for the damaged left hemisphere by using the ipsilateral motor pathways to recover the right arm as shown in Figure 2.2 below. The contralateral connection between the left hemisphere and the right hand is broken (illustrated by the scribbled over line) and the ipsilateral pathway (illustrated by the dashed line) is used instead giving some movement to the arm. In normal subjects the distal extremities (hand muscles) would be controlled primarily by the contralateral hemisphere and the proximal portions of the arm are controlled both contralaterally and ipsilaterally so this ipsilateral control would enable use of the arm but not hand.

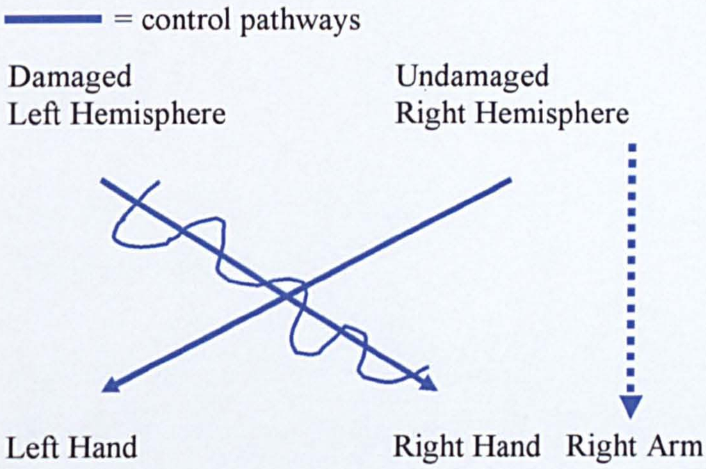


Figure 2.2: Illustration of Contralateral Motor Control for Pathological Lefthander

In the testing, stimulation of the hand area of the undamaged right motor cortex elicited motor evoked potentials in the left hand muscles and caused electromyographic inhibition in right hand muscles. Stimulation of the hand area of the left damaged motor cortex elicited motor evoked potentials in the right hand muscles, but failed to produce expected electromyographic inhibition in left hand muscles as illustrated in Figure 2.3 below.

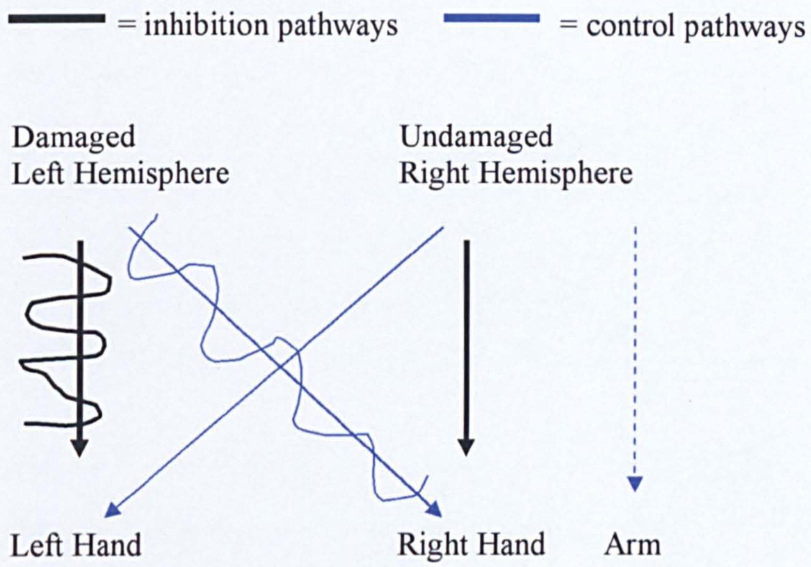


Figure 2.3: Illustration of Ipsilateral Motor Inhibition (and Contralateral Control) for Pathological Lefthander

In five normal subjects, (these are not specified but assumed to be familial lefthanders) there were ipsilateral 'silent periods' in both the left and right hands rather than just the left hand as in the case above. Therefore, there is a difference between the familial left hander and the pathological left hander as concerns the ipsilateral control of inhibition. Triggs et al, propose that absence of the ipsilateral 'silent period' in their patients' left hand reflects cerebral reorganisation associated with switching control of the preferred hand from the left to the right hemisphere. They also admit that the significance of the ipsilateral 'silent period' is unknown. The finding could indicate decreased ipsilateral control by the injured left hemisphere or increased ipsilateral control by the right hemisphere. As far as this thesis is concerned it gives some indication that pathological lefthanders may have different brain organisation from non-pathological left handers and also highlights that along with the contralateral control for fine motor skills to one hand the same hemisphere sends ipsilateral inhibition messages to the other hand.

Trying to separate the 'normal' lefthander from the 'pathological' lefthander is difficult. Often the only way a left hander is classified as being 'normal' is when he/she is termed 'familial' having one or more fairly close relatives as left handers.

This indicates that their lefthandedness is hereditary and not due to brain damage. Research varies in how close the relationships have to be. However, as discussed by Peters (1990) there are many pitfalls to this approach. One is the size of families. If you have a history of large family units you are more likely to find relatives who are, or were, left handed. Also, the author questions whether something that is hereditary should be assumed to be 'normal' since 'dyslexia' is hereditary and yet is also classified medically as being 'brain damage'. (Peters 1990).

Left handers do only make up a small proportion of the population (approx 10%) (Springer & Deutsch 1998, Hellige 1993 p221) but there is a great deal of lefthandedness amongst right handers so to some degree some of the observations of left handers may apply to certain right handers. This is why many research projects have used classification systems to screen out anyone who is not a right hander (eg Ernest 1998 using Annett's questionnaire, Mohr et al, 2002 using the Edinburgh inventory and Moscovitch et al 1976 using the Crovitz & Zener inventory). This has left us with a substantial amount of research on right handers only and some of this research has not been split into gender, which reduces the usefulness of the findings across all people.

Another group of people who have been tested for motor control lateralisation differences are 'right-armed' lefthanders. These are people who write with their left hand but would throw a ball with their right arm. These inconsistent left handers make up nearly 50% of lefthanders, about 5% of the population. Although inconsistent right handers who write with the right hand but throw with the left hand exist, these only make up fewer than 2% of right handers. Peters and Pang (1992) were trying to ascertain whether fine manual dexterity skills such as writing and precision tracing have a different lateral advantage from coarse hand skills such as strength and throwing. Their expectations, based on Geschwind and Galaburda's (1987) model that inconsistent lefthanders show opposite asymmetry patterns in finger and arm tapping performance were not met. They concluded that inconsistent left handers are an idiosyncratic group with a relatively unique pattern of lateral specialisation. (Peters and Pang 1992). It was also concluded that the 'type' of movement, rather than musculature (distal versus proximal), was the crucial variable in lateral specialisation. (Peters 1995, p 194). Type of movement is, therefore, crucial to this present research.

The most common 'type' of movement that has been used by researcher is that of tapping speed. One piece of research, Podbros and Wyke (1988) suggests that the left hemisphere predominates in rapid movement and in sequencing aspects of hand motor skills but that with regard to factors other than speed the left and right hemispheres are equal. The main difficulty with this research is that all the subjects were right handed so the conclusions are limited to right handed people. It is assumed that the left hand is being contralaterally controlled for the tapping activity which may not have precision or control requirements. Also, that being right handed has no effect on the ability to tap more easily. It would be interesting to carry out the same experiments on left handers and compare results.

There is an indication from these experiments that 'type' of fine motor skill is an important issue in determining the controlling neurosystems. The manual dexterity and precision skills involving control such as writing, drawing and tracing rather than the tapping, speed and strength skills are those that the author wishes to concentrate on. Concerning writing there is the issue of writing position to consider.

There is some debate as to whether hand position while writing, inverted and non-inverted, indicates differences in neuromotor organisation. Levy and Reid (1978) conducted testing on subjects having subclassified them according to their hand position while writing. They suggest that in some individuals, and specifically in lefthanded inverters and righthanded inverters, there may be ipsilateral hand control (p 139). They postulate that inverted writers, whether they be right handed or left handed, use the uncrossed pyramidal tract for writing. Writing movements, except possibly in cases of unusual pathology, always derive from motor programs originating in the verbally specialized hemisphere. Approximately 7% of the population have language hemispheres ipsilateral to the writing hand. They do not agree with Geschwind (1975) that all instances of ipsilateral control involve only the proximal muscles and quotes 2 cases of split brain patients where the left brain controlled writing movements of the left hand. There are other studies that show a positive relationship between handwriting position and cerebral lateralisation.

Parlow (1978) carried out research to clarify this but instead of firm conclusions could only speculate that "the right hand of left-inverters may be ipsilaterally controlled and that of non-inverters contralaterally", (p 611). Peters (1995) suggests that this may be due to the way visual half-fields relate to fine motor control in guiding the movements. He concludes that there is not sufficient evidence to show a link between handwriting position and lateral organisation.

Writing is a skill that has some ballistic element to it as once learned it becomes automatic. It is less ballistic if it is not a repeated task such as a signature. Drawing and tracing, although controlled skills, are not so ballistic. Therefore because of this, and the resulting extent to which the cerebellum is being used, there may be differences even within these three particular skills.

Above it was noted that Levy and Reid (1978) state that most people's writing movements derive from programs in the verbally specialised hemisphere ie the left hemisphere. Blakeslee (1980) agrees with this stating *"Motor skills for detailed movement of each hand reside in the hemisphere of the opposite side of the body. These detailed movements can be programmed by either hemisphere. Writing with either hand is programmed by the left brain while drawing is programmed by the right brain."* When a normal person writes with either hand, the high-level commands come from the left hemisphere. When a person draws with either hand the commands come from the right hemisphere. The motor skill stays the same for each hand no matter which hemisphere does the programming. Spatial concepts and drawing are better performed by the right hemisphere. *"When a normal person does a nonverbal task like the block design test, he clearly does it with his right brain. When he does a verbal task such as writing a sentence, control comes from the left brain."* This contralateral arrangement of the motor skill with the specialisation of the skill of drawing and writing is illustrated in Blakeslee's diagram below. (Blakeslee 1980 p 147).

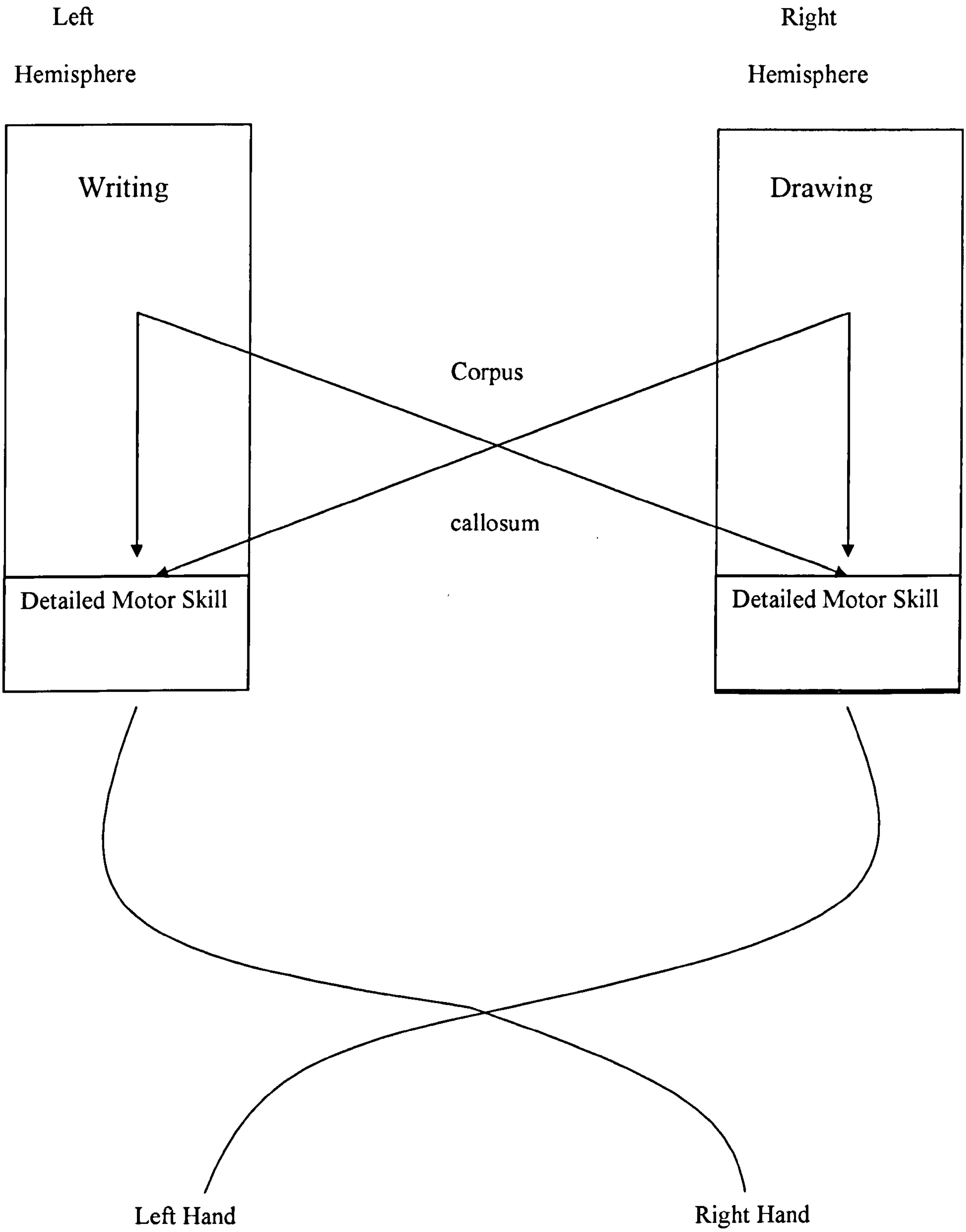


Figure 2.4: Illustration of Contralateral Control of Hands
Sources from Blakeslee (1980) page 147

This is an interesting argument because it is separating the higher level programming of the writing and drawing from the fine motor control of the actual task. How can one tell if the impairment is due to the programming (the right hemisphere for drawing and left for writing) or in the motor skill (contralateral to the hand being used). Also, in linking spatial concepts and drawing together there may be assumptions made here which cannot be clearly evidenced. Evidence to support a right hemisphere dominance in 'drawing' output, that is, carrying out the motor task, includes (Gardner 1982 and Grossman 1988) who show that even in right handers copying and drawing are less impaired after left hemisphere lesions than right hemisphere lesions. Grossman (1988) determines different attributes of drawing. He carried out a study to examine errors in brain-damaged patients in attempting to produce freehand drawings. The findings showed that right hemisphere brain-damaged impaired the patients ability to draw more than left hemisphere damage. However, there were different types of impairment according to the location of the insult. Different impairments included the attributes of shape, colour and relative size and also the ability to generate mental images to serve as a basis for the pictures. Therefore, although in general the right hemisphere has dominance for drawing the task is a complex one and is located in different areas of the right hemisphere. Gazzaniga et al (1965) also suggests that a split-brain patient draws better with his left hand than his right hand showing the right hemisphere's dominance for the task. This would therefore suggest that the fine motor control is also better.

Some artists eg Escher, Klee and Wain have been reported to have written with their right hands and drawn with their left but it is not clear from literature review as to whether they were true left handers only writing with their right hand due to social pressures.

Also, although there is a link between spatial ability and drawing, and although there is evidence that both of these have a right hemisphere dominance, there are also many different attributes to spatial ability to consider and even its definition is not clear. As Berenbaum and Harshman (1980) state " *'spatial' ability itself is a rather amorphous, 'catchall' term used by neuropsychologists and psychometricians to* *refer to a number of different functions. In the psychometric realm, it includes at least spatial orientation, spatial visualization, speed of closure, flexibility of closure, spatial scanning, and figural fluency. In the neuropsychological literature, it includes direction sense, form and pattern recognition, facial recognition, colour recognition, stereopsis, visuoconstructional abilities, and visual haze learning to mention just a few areas that have been investigated.* (Herenbaum and Harshman 1980).

A good deal of research has been carried out in an attempt to determine what are the specialities of each hemisphere. Many of these experiments have involved the use of hands as a determining factor ie if the hand cannot function then it is the contralateral side of the brain that cannot carry out the task. However, this appears to be a circular argument as it is always assumed that it is the brain which decides whether the hand can be used and not the hand being used that determines what side of the brain is being accessed. The current research attempts to consider both aspects.

Concerning 'tracing', this is a fine motor control task that has been used in many recorded experiments particularly in conjunction with mirror imaging. In one such experiment (Moir and Moir 2000) two tasks had to be done simultaneously: mental imagery and fine motor control. The participants, looking into a mirror only, had to reverse the mirror image they saw in order to move their hand to trace it out on paper in front of them. They could only view what they were doing through the mirror. Women were better than men at this task. The tests were done to demonstrate that the male brain is more focused and compartmentalised whilst the female brain is more integrated. The male has spatial awareness in the right brain. When he traces with the left hand he has no problems because the right brain controls the left hand and the right brain also has spatial awareness to reverse the image. However, when he tries to draw with the right hand, which is controlled by the left brain, he freezes because the left brain cannot also reverse the image. In women, whose brains are more integrated than males, having spatial awareness on both sides, the exercise is completed well with either hand. (Moir and Moir 2000). Although these tests were done to illustrate the differences between male and female brains there are observations which are relevant to the present research. The use of the right hand forces the use of the left brain and the use of the left hand forces the use of the right brain. The explanation of the result was that the male brain could not reverse the image, which is the thinking task, and therefore the hand could not trace. However, it is difficult to ascertain which task was disabled, the mental task of imagery or the physical motor task of moving the hand. This is an example of the circular argument often used.

Some research has claimed that the left hemisphere controls fine movement sequencing in both left and right hands for both left and right handers. (Wolff et al, 1977). The left handers in these particular experiments were not subclassified so may have included pathological and familial left handers and inverted and non-inverted writers. The authors' findings were that for difficult rhythmical sequencing left and right handed adults tapped more precisely with their right hand. This finding supports the findings of Leipmann proposing that the left hemisphere is dominant for the control of 'learned' motor tasks performed by each hand.

In conclusion it is the generally accepted view that fine motor skills are contralaterally controlled. However, this cannot be assumed for every person and for every type of fine motor control. There are two main issues to be considered. Firstly, that not all classifications of subjects can be assumed to have the same cerebral organisation for fine motor control. Particular areas of difference appear to be where there is a degree of lefthandedness; in right handers as well as lefthanders, and whether this is familial or pathological; in ambidexterity and/or in inverted writing style. Secondly, within the category of fine motor skills there are many different types of skill and different levels of processing required for each. This means that to some extent there may be some ipsilateral control and that the higher level tasks are more likely to have some aspect of ipsilateral control within them. The precision motor control of novel handwriting, drawing and tracing involve mainly the contralateral hemisphere but where there is programming and repetition this may include the cerebellum and basal ganglia to provide bilateral control.

Therefore this establishes that fine motor control is mainly contralateral but may also have an element of ipsilateral control and that this ipsilateral control depends on subclassification of participants as to their handedness and level of novelty to the writing and drawing undertaken.

3 Hemispheric Asymmetry

This section will review the evidence for a difference in processing abilities of the left and right hemisphere and in particular how these relate to the contralateral control of fine motor skills related to handedness.

3.1 Evidence of Left Hemisphere Processing Abilities

3.1.1 Learned, Skilled and Purposeful Action (Motor Skills)

The left hemisphere dominates for learned, skilled and purposeful action. Studies have been done on people who have an impairment of learned, skilled or purposeful action and yet there is no problem with the actual limb movements. The problem is in the left hemisphere. It holds the motor representations for these fine movements. It was Liepmann and Maas in 1907 who first suggested that this was the case and Liepmann in 1920 called these "movement formulaes" – time-space-form picture of the movement. (Poizner et al. 1998)

Apraxia (ie movement errors) occurs either when there is destruction of the representations of learned movement stored in the left parietal cortex or when there is separation of these from translatory areas in the left premotor or motor cortices.

The research carried out by Poizner et al (1998) was to ascertain whether the right hemisphere also had some effect on learned, skilled or purposeful actions. The results showed that the left hemisphere lesioned participants had problems with joint coordination, arm angle variation and apportionment of arm angles whereas the right hemisphere lesioned participants did not – they gave the same results as the control group. All participants were male and right handed. In one test the right hemisphere lesioned participants did show disturbances and this was in the plane of motion. The difference was not as marked as for the left hemisphere participants but more than occurred in the control group. On further discussion of these cases there seemed to be other explanations for this and therefore the research concluded by confirming the findings that the left hemisphere was the one which controlled learned, skilled and purposeful action.

3.1.2 Language

In 1864 Broca speculated that the right hemisphere did not have any language skills. Whilst it is indisputable that the left hemisphere is dominant for language overall (Ivry and Robertson 1998) the emphasis of this dominance appears to be more on the oral output skills of language. Research has shown that the right hemisphere can understand a researchers instructions when the left hemisphere has been anesthetised (Sperry 1968). Also, in patients who have had their left hemisphere removed it usually takes about six months for their right hemisphere to learn to use language so it obviously has this potential (Healy, 2000). Ahern et al (1993) studied two patients using the Wada test and both of these had limited speech in the right hemisphere and Lutsep's (1995) left-handed patient had language dominance in the right hemisphere (as well as expected right dominance tasks such as face recognition). Certainly there is evidence to show that left-handers have less asymmetry in the hemispheres (Bryden 1965).

3.1.3 Speech

Speech, although related to language, is only the vocal articulation of it. Intracarotoid sodium amytal tests indicate that in over 95% of right handers the left hemisphere is dominant for speech. Similarly, in over 70% of left handers, speech is lateralised to the left hemisphere. (Loring et al 1990). In the remaining 30%, about half have bilateral speech representation, and half have a right-sided localization. (Rasmussen T et al 1977). This is further evidence in Section 3.4.1 and Section 5.1 as it pertains to the first experiment.

From published materials it is generally accepted that most language skills reside in the left hemisphere but of course language is a complex set of tasks and each can be split down into individual parts. The purpose of this section is to highlight the *main* components of language and whether they can be attributed to one or the other of the hemispheres.

3.1.4 Sequencing

This is a skill attributed to the left hemisphere. Damage to the left hemisphere impairs sequencing and performance of learned movements made by the contralateral and ipsilateral limbs. (Rushworth et al 1998)

3.2 Evidence of Right Hemisphere Processing Abilities

3.2.1 Spatial Processing Abilities

Much research suggests that the right hemisphere is specialised for spatial ability. However, this again is a very complex task and Willis et al (1979) suggest that although it is presumed to be right hemisphere that this may not necessarily be the case. Spatial reasoning and spatial perception are viewed differently. In reviewing the research Willis et al say "*it is suggested that, in most people, the left hemisphere treats stimuli serially, operating in a logical, analytic fashion, abstracting out relevant details and attaching verbal labels. The right hemisphere processes stimuli many at a time and is primarily a synthesis, more concerned with the overall stimulus configuration, organizing and processing information in wholes or gestalts.*" The inference from such characterizations has been that the kind of non-verbal reasoning that typifies spatial ability is essentially a function of the right hemisphere. However, there is as yet little direct evidence supporting this hypothesis. Willis et al carried out a study to determine whether spatial reasoning as opposed to spatial perception was a cognitive function of the right hemisphere. Their results showed that spatial reasoning did not require more right hemisphere processing as compared to left hemisphere processing.

Berenbaum and Harshman (1980) also discuss spatial abilities and citing Ekstrom et al (1976) they describe the different abilities as; 'spatial orientation', 'spatial visualization', 'speed of closure', 'flexibility of closure', 'spatial scanning' and 'figure fluency'. Citing Blakemore et al (1972) spatial abilities include, amongst other things, 'direction sense', 'form and pattern recognition', 'facial recognition', 'colour recognition', 'stereopsis', 'visuoconstructional abilities' and 'visual maze learning'. Indeed authors cannot even agree on what does constitute spatial ability. (Berenbaum and Harshman 1980)

On a mental rotation task, a common task used in spatial processing experiments, right-handed, right-eyed males scored high in spatial abilities whilst left-handed, left-eyed females scored low (Freedman and Rovegno 1981). A relationship between eye dominance and spatial ability was previously shown in women but not in men (Freedman et al 1979) and this study showed the eye dominance contributed to the lower spatial scores of women

3.2.2 Shape Recognition

To identify hemispheric lateralization of haptic perception, participants are typically asked to identify shapes with either hand. There are conflicting results as to which hemisphere recognises the shapes more effectively. Lacreuse (1996) who did not classify individuals according to handedness, compared male and female participants. In the first experiment participants were asked to feel an object and then identify a drawing of it from a page of drawings. The hand contact was recorded in terms of shape, location and duration. No hand differences were shown in terms of scores but in men the left hand touched the stimulus more globally than the right. In the second experiment participants used both hands at once on a shape each ie a dichhaptic task and then identified them amongst others as before. The left hand outperformed the right hand in recognition of shape. The left hand continued to touch the shape more globally than the right and only 20% of the exploration time was used simultaneously. Two further experiments were involved and the overall result of the research was that for dichhaptic recognition the left hand was better than the right but not for haptic recognition where this was the same in result although more holistic in process. The conclusion was that the research demonstrated that, for men, there are hand/hemispheric differences in processing haptic information. They also suggest that information presented to the left hand would be more easily processed if it were displayed globally whereas information to the right hand would be processed more easily if displayed sequentially and that men show a limited capacity to process two distinct sources of haptic information at once.

3.2.3 Emotional Processing

A very simple experiment was developed by Jaynes (1976) where a smiling face and a non smiling face are cut in half and the halves matched against the other face so that one side appeared smiling and the other not. A mirror image was then made of this chimeric face producing the stimuli of two faces. Jaynes showed these two faces to 1,000 people, asking them to look at the nose as a central point and say which of the two faces seemed happier. 80% of participants gave the face with the smiling side on the left (which would be seen by the right hemisphere through the left visual field).

Much research (eg Davidson 1993) has suggested that the right hemisphere is dominant for emotions whatever the valence but some newer studies (Hellige 1993) suggest that the right hemisphere is better at perceiving and/or experiencing negative emotions and the left hemisphere the more positive emotions. However, this debate still continues. In studies done by Dimond et al (1976), films were shown to each hemisphere respectively of healthy in-tact brained individuals. Negative films viewed by the right hemisphere evoked a significantly greater emotional response than when viewed by the left hemisphere. This showed that the two hemispheres experience emotions but the right hemisphere perceived more strongly the negative emotions. This is discussed in more detail in section 7.2 prior to the experiment on perception of emotional intonation in speech.

3.3 Comparison of the Two Hemispheres

Edwards (1993) in her book 'Drawing on the right side of the brain' gives a generalised breakdown of the characteristics of thinking in the left mode and right mode based on her review of the literature and discussions with Professor Roger W Sperry. Taking into account that these are generalisations they serve a useful illustrative purpose and they have at least originated from studies in the scientific literature. However, although popular literature treats these as 'fact' there is still scientific debate about many of them.

Left Mode Characteristics		Right Mode Characteristics	
Verbal:	Using words to name, describe, define	Nonverbal:	Awareness of things, but minimal connection with words
Analytic:	Figuring things out step-by-step and part-by-part	Synthetic:	Putting things together to form wholes.
Symbolic:	Using a symbol to *stand for* something. For example, the sign + stands for the process of addition. Road signs?	Concrete:	Relating to things as they are, at the present time.
Abstract:	Taking out a small bit of information and using it to represent the whole thing.	Analogic:	Seeing likenesses between things; understanding metaphoric relationships.
Temporal:	Keeping track of time, sequencing one thing after another. Doing first things first, second things second etc	Nontemporal:	Without a sense of time.
Rational:	Drawing conclusions based on reason and facts.	Nonrational:	Not requiring a basis of reason or facts; willingness to suspend judgement.
Digital:	Using numbers as in counting	Spatial:	Seeing where things are in relation to other things, and how parts go together to form a whole.
Logical:	Drawing conclusions based on logic: one thing following another in logical order - for example, a mathematical theorem or a well-stated argument.	Intuitive:	Making leaps of insight, often based on incomplete patterns, hunches, feelings, or visual images.
Linear:	Thinking in terms of linked ideas, one thought directly following another, often leading to a convergent conclusion.	Holistic:	Seeing whole things all at once; perceiving the overall patterns and structures, often leading to divergent conclusions.

Table 3.1 Left Mode and Right Mode Characteristics.
Source: Drawing on the Right Side of the Brain, Edwards (1993)

It is interesting to see that emotional processing does not appear in these lists.

3.3.1 Visual Field Studies

Schiffer (1996) talks about dual-brain psychology, uses the visual field to arouse each hemisphere and then claims to be able to talk to each hemisphere independently of the other.

Experiments have been done to see whether lateral attention could be induced by voluntary lateral eye movements which in turn would induce relative heightened arousal of the contralateral cerebral hemisphere. Some have concluded that hemispheric activity can be affected by voluntary lateral gaze. (Gross et al 1978, Gurr & Gur 1977). Kinsbourne (1972, 1974) states that it is the cognitive task that determines where the eyes moves to and that the eyes move to the right during a verbal mental task (left hemisphere task) and to the left during a spatial task (right hemisphere task). This was discussed in relation to neurolinguistic programming in Section 1.5.

3.3.2 Interhemispheric Processing

According to Benoit-Dubrocard (1997), left handers have better interhemispheric transfer and/or bilateralization than right handers which helps them in simultaneous tasks. The one they used in the experiment was a dual cognitive task of matching letters by their physical shape and matching the letters by meaning. It is a task which necessitates cooperation between the hemispheres. Left-handers were better at identifying and naming the letter shapes by touch, using forefinger and being blindfolded, and only needed to feel part of the letter therefore using Interhemispheric transfer more easily than the right-handers.

3.3.3 Writing and Drawing

In Section 2.3 it was noted that Blakeslee (1980) states that motor skills for detailed movement of each hand reside in the contralateral hemisphere and that writing, with either hand, is programmed by the left hemisphere and drawing is programmed by the right hemisphere.

It has been ascertained in the literature so far discussed that fine motor skills, which are those required for drawing and in particular for writing, are controlled by the contralateral hemisphere. It is therefore useful to discuss these activities further. In normal brains spatial concepts and drawing are 'performed better' by the right hemisphere. In experiments where participants are asked to draw with their right and left hands, though right-hand muscle control is better so the left handed drawings are more shaky, it is clear that the relationships between the features are incorrect and show the left brain's ineptness with spatial concepts. Blakeslee says "When a normal person does a nonverbal task like the block design test, he clearly does it with his right brain. When he does a verbal task such as writing a sentence, control comes from the left brain". Galin confirmed this by measuring the EEG in each half of the brain while doing a task. Whilst doing a block design test the right hemisphere is more active (less alpha) and whilst doing a writing task the left hemisphere is more active – this is presumed to be because of the word and logic processing required for the writing. (Galin and Ellis1975)

Experiments on split-brain patients have been highly useful in indicating what skills a hemisphere cannot carry out well because it has been surgically separated from the other hemisphere. This has given us the basis for the hemispheric specialism models. It is therefore very clear that having cut the corpus callosum certain thinking patterns are completely disrupted. Also, the use of the Wada test in anaesthetising one hemisphere to dissempower the contralateral side of the body is evidence that the biological link is firmly established.

It is also ascertained that although the contralateral hemisphere controls the 'fine motor skills' for a task such as writing and drawing, which by definition are precise and controlled, that these particular 'types of thinking' are associated with the left (handwriting) and right (drawing) hemisphere respectively.

Of further interest is the work that Edwards has developed for a method of helping people to draw successfully by getting them to draw in ways which the left-hemisphere does not like therefore allowing the right hemisphere to have dominance. It is difficult to ascertain what effect the fine motor control of the contralateral hand has on the hemisphere's ability to perform writing (as in the case of the left hemisphere) and drawing (in the case of the right hemisphere). It is the purpose of this research to find out whether there is a link and whether it is possible to use the fine motor control link to the contralateral hemisphere as a means of arousing other thinking processes in that hemisphere. If possible this would be helpful in aiding people to arouse thinking processes which may not be their normal preference.

In this current research this is the hypothesis that is being tested concerning verbal skills, face recognition, problem solving, creativity, stress management and emotional perception. The first two being chosen because they are the skills most well documented as having the strongest alignment with one particular hemisphere. The others being chosen because they are particularly helpful in leadership development today. It is important first to test out whether the use of a different hand will make a difference to a skill which is generally accepted as being the strength of one particular hemisphere more than the other. Then a longer test to show whether use of the non-preferred hand over time makes any difference to thinking.

In the literature, no experiments were found where participants changed hands in the middle of a test. This would be interesting if clear EEG readings were made to see if any changes occurred in the brain in areas other than those relating to fine motor skills.

3.3.4 Handedness and Brain Biology

The term 'hemispheric dominance' is used in different ways in the literature but usually refers to language dominance. The Wada test (1960) shows that nearly all right handers and most left handers have 'dominance for language' in their left hemisphere. However, in this research the term 'dominance' will always be qualified. This is necessary because this study concerns fine motor skills and these are dominant in whichever hemisphere is contralateral to the preferred hand.

There is not sufficient evidence to show that there are biological differences in the brains of right handed, left handed and ambidextrous people. However, there is evidence that the brains of left handers are less strongly lateralized than those of right handers. It is for this reason that most left handers are excluded from experiments in the literature because they skew that data. There is very little research done purely on left handers. This is partly because of the practicality of finding them but also the fact that left handedness occurs for different reasons, for example, pathological problems in the womb, hereditary reasons and compliance to cultural norms.

3.3.5 Degrees of Handedness

Not everyone who is said to be right handed is strongly right-handed. There are those who are weakly right-handed. Both would write with their right hand and therefore be identified as right-handers but some would do other tasks with their left-hand or not show a preference for some tasks – that is, swap hands randomly when doing a task or even during the task. It is difficult to ascertain whether such individuals would have the same hemisphere preferences.

To find out whether strong right-handers and weak right-handers would have the same hemispheric preferences a study was carried out by Papanicolaou and Molfese (1978). Papanicolaou and Molfese were trying to find out which specific aspects of language information were processed in the hemispheres eg syntax, semantics, phonology. The aim of the research was to be able to identify the specific cognitive and linguistic processes ocurring in each hemisphere and to provide some information concerning the interactions between the processes. They used the Edinburgh Inventory (Oldfield 1971) to classify participants by handedness. (This tool is further described in section 5.3.1.) Those who strongly preferred to use only their right hand on all items on the scale were classed as high handedness and the others as low handedness. The first group had 5 males and 5 females , the second having 4 males and 6 females. The gender mix was obviously not considered important enough to balance out in this experiment.

In the experiment one group of participants (made up of 5 high handedness and 5 low handedness) was asked individually to respond to hearing the words 'two' and 'four' with a particular key press and to hearing the words 'three' and 'five' with a different key press. The key presses involved pressing a left key for one set and a right key for the other set. The individuals in the other group were to respond differentially to numbers 'two' and 'five' versus 'three' and 'four'. This group's keys to press were the opposite way round. The results showed that although all participants responded correctly to the stimuli that there were differences in the timings dependent on the classification of handedness. This was considered by the researchers as indicating that there are functional differences in brain activity for highly right handed versus mildly right handed people. (Papanicolaou & Molfese 1978). Therefore, classification of handedness should not just be limited to left and right but to degrees of handedness.

3.3.6 Cognitive Differences in Men and Women

The present research is not centrally concerned with cognitive differences in men and women but it is important to be aware of these differences because they may account for some of the differences that occur in the results. Gender differences in cognition has been heavily researched and there is much support for some differences. The main differences reported are than women's brains are less lateralised (Davidson, Schwartz, Pugash & Bromfield 1976), and that there are definite differences in spatial awareness and rotating mental models (Freedman and Rovegno 1981). Therefore where possible and appropriate this research considers gender in the data analysis to see if any additional information can be found.

3.3.7 Inverted Hand Posture

Inverted hand posture was touched on in Section 2.3. Here it is explored further. It has been suggested that inverted hand posture may be because the hand is being ipsilaterally controlled by the left hemisphere, which is dominant for language, rather than contralaterally controlled as would be normally expected. However, this has never really been proved.

One explanation is that it may be a way of adapting behaviour to be able to write from the left to the right which is not natural for the left hand. It appears it develops during ontogeny (maturation as well as writing practice). To classify inverters and non-inverters one cannot ask the participant which they are; the person has to be observed writing. There have been attempts to classify individuals using criteria such as direction of the pencil, that is whether it is pointing to the *top* or *bottom* of the page; by wrist crook, that is, whether a crook position is *present* or *not*, and by hand position, that is, whether the hand is *above* or *below* the line of writing. (Levy and Reid 1978) (McKeever 1979).

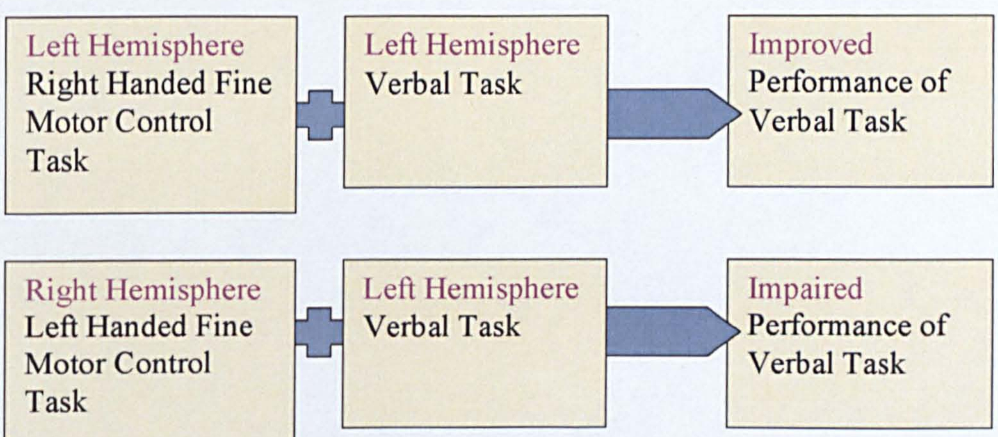
However, further research gives clearer indicators for classifying inverters and non-inverters (Guiard and Millerat 1984). The rotation of the paper is a useful guide and shows that inverters slant the page, on average, 15° to the left and non-inverters 32° to the right. A second variable is the relative slant of the writing forearm. When the slant of the line from the elbow to the pencil tip is measured, for the inverters the slant is an average of 83° to the right and for the non-inverters 12° to the right.

3.4 Combination of Two Hemispheres

3.4.1 Priming a Hemisphere with a Motor Task

Most experiments in this current research combine a neural task (linguistic, face recognition, generating ideas, or problem solving) with a fine motor control task (pincing, tracing or handwriting) and in doing this there is the assumption made that the fine motor control task arouses the contralateral hemisphere.

However, it is acknowledged that with a combination of two tasks (one neural and one fine motor) there is a possibility of competition for limited neural resources within one hemisphere. There is also an acknowledgement that a dual task is more demanding than a single task. The hypotheses expect an improvement in the mental task when the same hemisphere is being used for the fine motor control task as illustrated by:



In the experiments here it is assumed that a hemisphere has sufficient processing abilities to accommodate both tasks at once and that the priming of one hemisphere by activating it with a fine motor control task using the contralateral hand will improve performance on the mental task.

Priming a hemisphere was carried out by Macrae and Lewis (2002) where they gave some participants a verbal task of reading aloud, (left hemisphere), and others a holistic visual task, (right hemisphere), as primer tasks before asking them to identify faces which they had seen earlier on a video tape. Those completing the visual task before identification of the faces were more accurate than those having completed the verbal task giving evidence that overloading one hemisphere was not a problem.

3.5 Classification of Handedness

Most people are said to be right-handed. However, it can be argued that handedness is a continuum (Annett 1967) where an attempt at identifying gradients is made for ease of selection for testing. It is important to understand these gradients. For instance, one person who carries out every task with their right hand would be considered strongly right handed but another who writes with their right hand but does all other activities with the left would be considered mixed handed. It is also important to consider that classification of handedness alone does not guarantee screening out the differences which handedness brings. As discussed in Section 2.3 it is not possible to classify all left handers together as there are at least four different reasons for the occurrence of left-handedness and these reasons give rise to additional differences.

Ambidextrous people can be put into two categories as some may be naturally ambidextrous and some may be so by the 'forcing' element mentioned earlier or through an accident making the preferred hand out of action for a while.

Since this research is concerned with testing the link between handedness and laterality, classification of handedness is an important issue for the selection of participants for the experiments. For this research a questionnaire was designed to classify individuals. The design took into account the following:

- The questionnaires already used in the field
- The particular objectives of this piece of research

There are many measures of handedness. A useful comparison of different measures is given by Chapman and Chapman (1987), Johnstone et al (1979), Bishop (1990, ch 5) and Peters (1990 and 1995). These were reviewed. The two questionnaires which appeared to be most well respected were the Edinburgh Handedness Inventory (1971) and the Annett Questionnaire (1967 and 1970). They both emphasise the fine motor control skills of the hands which is appropriate for this research and it was decided to use these as a basis for designing one which concentrated on the fine motor control of the fingers and which would also collect extra information.

Another important issue is on what skill the classification is made and this is where the individual questions are important. Handwriting is considered by most classification systems to be the most reliable indicator of handedness and this relates to the literature on fine motor skills for precision and control. However, if someone writes with their right hand but plays sports with their left hand then this brings in a mixed factor as 'strength' is obviously in the left hand. Careful consideration had to be given to each task to ascertain exactly what it was testing.

The Edinburgh Handedness Inventory (1971)

This 10 item inventory was created using the results of an original 20 item inventory (which was adapted from Humphrey 1951) concerning 1,100 undergraduates at the University of Edinburgh. The Inventory asks participants to indicate their preferred hand for the following activities by placing a + in the appropriate column. Where the preference is so strong they would never use their other hand they are asked to place ++ in the column, and where they are indifferent to put a + in both columns, only leaving a blank for no experience at all. The questionnaire yields a laterality quotient (LQ) that ranges from –100 for extreme left-handedness, through 0 for equal use of the two hands, to +100 for extreme right-handedness. To calculate the score of the LQ all the + scores are added for each hand. The sum for the left hand is subtracted from the sum of the right hand. This figure is then divided by the sum of both hands and this resultant figure is multiplied by 100.

		LEFT	RIGHT
1	Writing		
2	Drawing		
3	Throwing		
4	Scissors		
5	Toothbrush		
6	Knife (without fork)		
7	Spoon		
8	Broom (upper hand)		
9	Striking Match (match)		
10	Opening box (lid)		
I	Which foot do you prefer to kick with?		
Ii	Which eye do you use when only using one?		

	LQ		Leave these spaces blank	DECILE	

Figure 3.1: Edinburgh Handedness Inventory (Oldfield 1971)

The Annett Inventory

This was designed by Marion Annett of the University of Hull. Annett (1967) published an 8 item inventory in 1967 and then later a 12 item inventory in 1979, (Annett 1970). The 8 item inventory comprised: sweeping, shovelling, striking a match, using scissors, threading a needle, writing, drawing and throwing and the 12 item inventory comprised: dealing cards, unscrewing a jar, shovelling, sweeping, threading a needle, striking a match, using scissors, hammering, using a racket, writing, throwing, and using a toothbrush. It is important to note that there are quite different tasks here. Some emphasise strength, some are bimanual tasks, some involve the whole hand and some emphasise finger control.

1967	1970
Sweeping	Sweeping
Shovelling	Shovelling
Striking a match	Striking a match
Using scissors	Using scissors
Threading a needle	Threading a needle
Writing	Writing
Drawing	
Throwing	Throwing
	Dealing cards
	Unscrewing a jar
	Using a racket
	Using a toothbrush

Figure 3.2: Annett Inventory Items 1967 and 1970

Questionnaire for this Research

The questionnaire designed for the present research incorporated a self-reporting questionnaire including most of the features of the Edinburgh Inventory (1971) and the Annett Inventory (1976) with some additional items to cover earedness, eyedness and footedness. Participants were not tested on their performance of these activities. A score was then developed to classify all those who were 'strongly right handed' and 'strongly left handed'. Anyone not falling into these categories was screened out of the research. For this research the fine motor skill of precision control was the most important aspect and not strength or other factors. The items covering this type of skill were 'writing', 'drawing', 'using scissors' and 'threading a needle'. The item 'using a spoon' and 'spreading butter' were considered to be open to having been forced through culture eg a left handed child would be taught to eat soup with the right hand. Therefore these items had less weighting.

Participants were scored as 'Strongly Right Handed' if they indicated they were right handed for 'writing', 'drawing' 'using scissors' and 'threading a needle' and if they also ticked 9 out of the remaining 13. Items 18 to 21 were not scored but were for data collection purposes. In the Edinburgh Inventory all 10 items carried the same weighting for handedness. However, as this research intends to use precise controlled fine motor skills in order to ensure the most contralateral effect then these items are given more importance in the selection of participants for the tests.
For a score of 'Strongly Left Handed' the same applied if the participants indicated left handed for the items.

Name ______________________________

Please put an 'R' for right hand and an 'L' for left hand.

With which hand do you:

1 Write? ___

2 Draw? ___

3 Use a bottle opener? ___

4 Throw a snowball to hit a tree? ___

5 Use a hammer? ___

6 Use a toothbrush? ___

7 Use a screwdriver? ___

8 Use an eraser on paper? ___

9 Use a tennis racket? ___

10 Use scissors? ___

11 Hold a match when striking it? ___

12 Stir a can of paint? ___

13 Thread a needle? ___

14 Pick up a heavy suitcase? ___

15 Spread butter on bread? ___

16 Use a comb? ___

17 Use a spoon? ___

18 With which foot do you kick a football? ___

19 To which ear do you normally hold a phone? ___

20 When you are thinking about something in which direction do your eyes normally go? ___

21 Please state any activities which you have noticed you do with your non-preferred hand ie your left hand if you are right-handed and your right hand if you are left-handed.

Figure 3.3: The Classification Questionnaire Designed for this Research

It should be noted that this questionnaire is not used to measure handedness but to select participants for, or eliminate participants from, the experiments. Therefore it has been designed with slightly different objectives from Oldfield and Annett. For comparison, the following Figure 3.4 shows how this questionnaire differs from the other two questionnaires.

This Research	Oldfield	Annett 1967	Annett 1970
1 Write..................................	✓	✓	✓
2 Draw..................................	✓	✓	
3 Use a bottle opener..................			
4 Throwing................................	✓	✓	✓
5 Use a hammer...........................			✓
6 Use a toothbrush........................	✓		✓
7 Use a screwdriver......................			
8 Use an eraser on paper..................			
9 Use a tennis racket......................			✓
10 Use scissors.............................	✓	✓	✓
11 Hold a match when striking it.........	✓	✓	✓
12 Stir a can of paint.....................			
13 Thread a needle.......................		✓	✓
14 Pick up a heavy suitcase............			
15 Spread butter on bread..............	✓		
16 Use a comb...........................			
17 Use a spoon..........................	✓		
18 With which foot do you kick a football?	✓		
19 To which ear do you normally hold a phone?			
20 When you are thinking about something in which direction do your eyes normally go?			
21 Please state any activities which you have noticed you do with your non-preferred hand ie your left hand if you are right-handed and your right hand if you are left-handed.			

Figure 3.4: Comparison of Inventories

The three items that were not used from the Edinburgh Inventory (Oldfield 1971) were items 'which eye do you use when only using one', 'holding a broom' and 'opening a box', and from Annett's Inventory (1970) 'dealing cards', 'sweeping' and 'shovelling' . The reason for omitting these is that the eye is not related to skills of the hand and the others rely on skills of strength and extend to the use of the arm which encounters more likelihood of ipsilateral control. For this research it is the precise control skill of the fingers which are the most important as this ensure contralateral control. Once the hand and other parts of the arm are used bilateral control become more active. Some items are similar but not identical to the Edinburgh Inventory, e.g. spread butter on bread instead of use knife without fork – this was just in order to clarify the action.

As mentioned previously questions 18 and 21 were not for classification purposes. They do not appear in the Edinburgh or Annett inventory and have been added here as an opportunity to collect extra data for possible further exploration concerning some of the widely promulgated ideas in the field of management and neurolinguistic programming as discussed in Section 1.5.

The questionnaire was used to select participants for each experiment according to the requirements of the experiment. For most experiments strong right handers were selected because of the difficulties with the heterogeneity of left handers. However, in the later experiments comparisons are made between right handers and left handers.

4. Research Methodology

4.1 Theoretical Approach

This research is scientific using a positivist approach. Robson (1993) lists five sequential stages for this type of research which have been followed for this project, namely:

1. deducing a *hypothesis* – a testable proposition about the relationship between two or more events or concepts) from the theory

2. Expressing the hypothesis in operational terms (ie ones indicating exactly how the variables are to be measured) which propose a relationship between the two specific variables

3. Testing this operational hypothesis, involving an experiment or some other form of empirical enquiry

4. Examining the specific outcome of the enquiry. It will tend to confirm the theory or indicate the needs for its modification

5. If necessary modifying the theory in the light of the findings. An attempt is then made to verify the proposed theory by going back to the first step and repeating the whole cycle.

Therefore, this research has a number of distinguishing features:

- It is deduction – theory tested by observation

- It is seeking to explain a causal relationship between variables

- It is using quantitative data – but, perhaps not so common, some qualitative as well

- It employs controls to allow the testing of the hypothesis

- It uses a highly structured methodology to facilitate replication

Easterby-Smith (1991) lists eight features of positivism and these have been taken into account in this research project:

- Independence: the researcher is independent of what is being observed
- Value-freedom: values are not driving the research but objective criteria
- Causality: the aim is to identify causal explanations and fundamental laws that explain the relationship between variables
- Hypothetico-deductive: it is a process of hypothesising the relationship and then deducing what kinds of observations will demonstrate the truth or falsity of these hypotheses
- Operationalisation: concepts need to be operationalised in a way which enables facts to be measured quantitatively
- Reductionism: problems as a whole are better understood if they are reduced to the simplest possible elements
- Generalisation: in order to generalise about the regularities in people it is necessary to select appropriate samples
- Cross-sectional analysis: regularities can be most easily identified by making comparisons across samples

Easterby-Smith (2002) illustrates the methodological implications for different epistemologies in the table below and positivism is being used in this current research:

	Positivism	Relativism	Social Constructionism
Elements of Methods			
Aims	Discovery	Exposure	Invention
Starting Points	Hypotheses	Suppositions	Meanings
Designs	Experiment	Triangulation	Reflexivity
Techniques	Measurement	Survey	Conversation
Analysis/interpretation	Verification/Falsification	Probability	Sense-making
Outcomes	Causality	Correlation	Understanding

Figure 4.1: Social Science Epistemologies

The epistemology is therefore objectivism, the theoretical perspective is positivism, the methodology is experimental and the methods are sampling, observation, measurement, statistical analysis and content analysis.

There are advantages and disadvantages of the positivism approach. The main advantages are that there is clear theoretical focus at the outset with greater opportunity for the researcher to keep control of the research process and that the data are easily comparable. The disadvantages are that it is an inflexible approach where the direction often cannot be changed once data collection has started. It also is weak at understanding social processes and unearthing the meanings people attach to social phenomena. (Saunders et al, 1997). In order to add value to the research reported here there is a thread of qualitative enquiry and the last experiment in particular does use a more qualitative approach of collecting and analysing data in order to further explore what the experimental research has or has not found. This therefore removes part of the disadvantage with the positivist approach where meanings are not explored.

Most of the collection and analysis of data in this project was done using a strategy of experimentation and therefore follows the process given by Saunders (Saunders et al, 1997):

- The definition of a theoretical hypothesis

- The selection of samples of individuals from known populations

- Allocation of samples to different experimental conditions

- Introduction of planned change to one or more of the variables

- Measurement on a small number of variables

- Control of other variables

4.2 Experimental design

The experiments were undertaken and sought to provide the empirical evidence to compare with other experiments that were informing the literature and conclusions around at the time.

Experiments 1 and 2 are aimed at testing tasks which from the literature have evidence of being associated more strongly with one particular hemisphere. Experiment 1 uses a so-called left hemisphere task and Experiment 2 a right hemisphere task. Each is tested to see if the task is improved or impaired by a fine motor control task (see below for rationale).

Experiment 3 does not involve fine motor control. It is testing whether there is a specialisation difference in the hemispheres concerning oral emotional perception.

Experiment 4 and 5 are aimed at testing whether hemispheric asymmetry can be used for practical applications in the area of business and management. They involve idea generation and problem solving.

In Experiment 6 and 7 the data from participants is collected and analysed in a more qualitative fashion in order to establish 'rich' data.

Experiment 1 – Left Hemisphere Task

This experiment sought to establish whether a left hemisphere thinking task (verbal repetition) is improved or impaired by a right hemisphere fine motor task (bead manipulation)

The experimental design is a one factor between-participant and one factor within-participant. The between independent variable is the manipulation with the right hand or left hand. The within independent variable is the stage of experiment. The dependent variable is the ability to verbally repeat words that have been heard. Three scores were used to assess ability.

The participants for this experiment were all right handed females. Right hand only participants were chosen as verbal repetition is a left hemisphere task and may not be in the favour of left handers. All left handers would not be possible because of the practical difficulty in finding them but also the fact that they can be left handed for different reasons, each reason bringing its own associated consequences. Females only were used as they have different verbal ability to males and such an advantage might skew the data.

In order to test for a difference between those using their right hand and those using their left hand, at a statistically significant level, the t-test was used.

Experiment 2 – Right Hemisphere Task

This experiment sought to establish whether the right hemisphere thinking task (face recognition) is improved or impaired by a left hemisphere fine motor task (tracing)

The experimental design is a two factor between-participants with one independent variable being tracing with the left hand or the right hand, and the other being male or female. The dependent variable is the ability to recognise unfamiliar faces. Males and females were used in the study as there was not sufficient evidence to suggest there are gender differences in the ability to recognise unfamiliar faces. Only right handed participants were tested as the right hemisphere dominance for face recognition could favour left handed participants and, as before, because left handers form a heterogeneous group.

The statistical test for the difference between the groups at a statistically significant level was a 2 way ANOVA (2 independent variables each with 2 conditions).

Experiment 3 – Both Hemisphere Task

This experiment sought to establish whether there are differences in oral emotional perception abilities of the right hemisphere and left hemisphere. It tests whether the use of the left hemisphere improves the likelihood of perceiving emotions in a more positive manner.

The experimental design is one factor between-participants with one independent variable being the use of the left ear (and left hand) or the use of the right ear (and right hand). The dependent variable is the ability to hear positive emotions.

All the participants were right handed so that the possibility of more ability from one or other hemisphere did not confuse the data. Females only were used as there is evidence that they have a different ability to perceive emotions.

As there is only one dependent variable in this experiment, the test for a difference between the groups at a statistically significant level, was the t-test.

Experiment 4 – Right Hemisphere – Idea Generation

This experiment sought to establish whether the right hemisphere thinking task (idea generation) is affected by the repeated use of a left or right hemisphere fine motor task.

The experimental design is a two factor between-participants and 1 factor within-participant design. The between independent variables are the use of the non-preferred hand for handwriting and handedness. The within independent variable is the 'before' and the 'after 6 months' of the repeated handwriting task. The dependent variable is the ability to generate ideas.

Participants were right and left handed and male and female. There is not sufficient evidence to suggest that any groupings should be removed from this particular study. It was also of interest to see whether the left handed participants showed different results to the right handed participants.

The test for a difference between the groups at a statistically significant level was a 3 way ANOVA (3 independent variables each with 2 conditions).

Experiment 5 – Both Hemispheres – Problem Solving Strategy

This was a scientific experiment to establish whether the problem solving strategy of an individual changed due to the repeated use of their non-preferred hand.

The experimental design is a two factor between-participants and a one factor within-participant. The two between-participant independent variables are repeated writing with the non-preferred hand or not, and left handed or right handed. The within-participant independent variable is the 'before' and 'after 6 months' of the repeated handwriting. The dependent variable is whether the approach to problem solving changed measured by five criteria. The five criteria were established through reviewing the literature Participants were right handed and left handed and also male and female.

In experiment 5 the data was content analysed into categories in order to break down the complex task of problem solving. To do this all the data was recorded as text and the text was analysed using the standard processes of content analysis, which is, coding, categorizing, classifying, comparing and concluding. The coding involved analyzing the type of thinking illustrated in the phrases and sentences used. The categories were then quantified and compared. It is important to note that whilst content analysis is considered a non-reactive instrument it is possible that the researcher's interpretation of the text and categorization will be influenced by his/her values, attitudes and opinions. (Merten 1996). However, as Berg (2001) argues, it is the way the data is managed which is important. In this research the contextual aspect of the data and the way in which was collected was fairly controlled so it did take a positivist approach.

The important factor was to establish any 'difference' in the problem solving approach so as long as the same criteria was used to measure both groups it added more value to establish the criteria from data itself. This criteria can then be used in further experiments.

The test for a between the groups at a statistically significant level was a 3 way ANOVA (3 independent variables each with 2 conditions, writing/not, LH/RH, 0/6 months)

Experiment 6 – Stress Experience

This was an experiment to establish whether writing with the non-preferred hand would reduce the experience of stress.

Experimental design is one factor between-participant and one factor within participant. The between-participant independent variable is handedness and the within-participant independent variable is whilst handwriting or not handwriting. The dependent variable whether the participant felt a decrease in stress. The data was collected via questionnaires. The participants were right and left handed and male and female.

The test for a difference between the groups at a statistically significant level was a 2 way ANOVA (two independent variables each with 2 conditions, left handed or right handed, whilst writing or not writing).

Experiment 7 – Stress Reduction

This experiment aimed to establish whether writing with the non-preferred hand under a stressful condition relieved the stress.

The experimental design was one factor between-participant and one factor within-participant. The between-participant independent variable was handedness with the

within-participant independent variable was handwriting with the non-preferred hand. Participants were right and left handed and male and female.

The test for a difference between groups at a statistically significant level was a 2 way ANOVA (two independent variables each with 2 conditions, left handed or right handed, whilst writing or not writing).

All experiments had only one dependent variable and a differing number of independent variables from one to three. Statistical tests were chosen for their appropriateness with and were discussed with more experienced researchers. Tables such as the one below from Dancy and Reidy (2002) were referred to.

4.3 Data Collection

Data collection for Experiments 1 (verbal repetition), 2 (face recognition) and 3 (oral emotional perception) was very similar. Literature search was conducted to aid the bespoke design of each experiment. Data were collected under experimental conditions and analysed statistically. Because the purpose of all three experiments was to find differences, the analysis of variance was used to analyse the data.

Data for Experiments 4 (Idea Generation) 5 (Problem Solving) 6 (stress experience) and 7 (stress reduction) were collected in a less controlled format as participants sent in their responses by email. Time limits were given for the exercises but this cannot guarantee adherence. Data was collected periodically over a six month period and was reliant on the goodwill of the participants to comply.

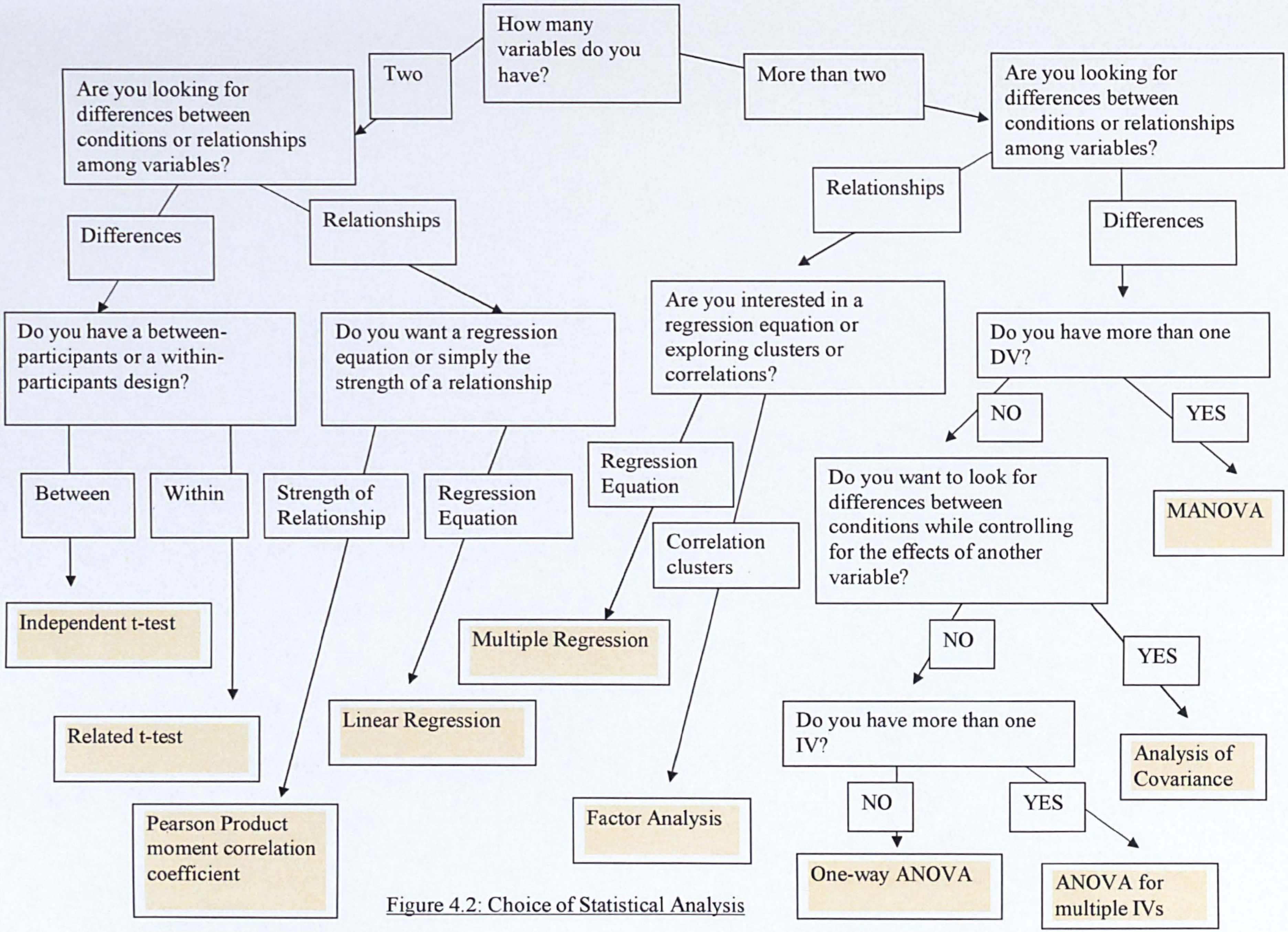


Figure 4.2: Choice of Statistical Analysis

5 Experiment 1: Verbal Repetition – Left Hemisphere Superiority

5.1 Introduction

It was shown in Chapter 2 that it is generally accepted in the neuroscience literature that the left hemisphere controls the fine motor control skills of the right hand and the right hemisphere controls the fine motor control skills of the left hand. The more a task requires the use of the fingers, as opposed to the wrist, the more the contralateral hemisphere is in control because the proportion of control by the contralateral hemisphere increases in relation to how distally located that part of the body is from the trunk. Contralateral control also increases with the 'precision' and 'dexterity' (controlled action) of the use of the fingers in a task so that tasks such as 'tapping' are not as contralaterally controlled as manipulation of a pen or picking up something fiddly between the fingers as these latter tasks involve small controlled and restrained movements. Many different precise tasks which were easy to perform were considered for this experiment including: pincing as if pulling petals from a flower, directional moving such as moving the hands on a clock face, grasping tightly with the fingers such as winding up something, tapping with the fingers, squeezing a ball in the hand and picking up fiddly beads. An important factor was that the fingers rather than the hand be used so this eliminated the directional moving and the ball squeezing. Tapping was eliminated because although the most popular test for fine motor control it was considered to be learned one so using bilateral control. Winding something gave the preciseness but could cause strain on the participant. Pincing and picking up were in essence the same action and this seemed the most appropriate. It was more practical to provide apparatus of a bowl of tiny beads than numerous flowers. Therefore the former was chosen.

Speech and language have been associated with the left hemisphere. However, it is clear that there is a difference between these skills. The former being the process of translating thought into motor specifications for speech production (Peters 1990) with the latter being far more complex. It was, therefore, important for this current research to use the skill of speech rather than language. The cognitive task which has been shown by Wada testing, explained in Section 1.4.2., to be the most clearly left hemisphere dominant is that of spoken language. If the patient cannot count after being injected this shows the surgeon that speech is in the hemisphere that has been injected. If speech continues and is unaffected by the drug then it can be assumed that speech ability resides is the non-injected hemisphere. Originally this method gave results of 95% of right handers having speech in their left hemisphere, the remainder having it in the right hemisphere. Also, 70% of left handers were found to have speech in the left hemisphere with 15% having it in the right hemisphere and 15% in both hemispheres. (Rasmussen and Milner 1977). Some more recent studies suggest that the incidence of right hemisphere speech is even lower as further testing showed this to be bilateral speech. (Loring et al 1990 cited in Springer & Deutsch 1998). Also, speech can have different levels of memory requirement and memory is an extremely complex area of neuroscience. Therefore, considerations for this research are to use the skill of speech with a minimal reliance on memory. Reading was considered but thought to bring other factors into the experiment so, vocal recall of something immediately heard was thought to be the most appropriate skill to use to ensure left hemisphere control.

5.2 Experiment 1

Hypothesis

That those using their right hand for a fine motor control task would be arousing the left hemisphere strength for verbal tasks and would increase the accuracy of their score.

That those using their left hands for a fine motor control task would be arousing the right hemisphere which would interrupt the task resulting in a lower accuracy score.

5.3 Method

The experimental design is a two factor mixed ANOVA. Factor 1 is a between-participant of hand used with two levels – right hand or left hand. Factor 2 is a within-participant factor of stage of testing with 3 levels. The dependent variable is the ability to speakout sentences that have just been heard. Three measures are used; two to test for the number of errors in the verbal recall namely, 'missed words' and 'added words', and one to test for the manipulation skills, namely 'bead count'.

5.3.1 Participants

The participants were an opportunity sample of 24 right-handed females with an age range of 30 – 60 with a mean age of 47. Selection of candidates was made on the basis of a handedness questionnaire which was a combined and extended version of the Edinburgh Handedness Inventory (1971) and Annett's Handedness Questionnaire (1967 and 1970). Only those candidates who were strongly right-handed (as defined in Section 3.5) were selected. All participants had English as their first language. All reported they had normal or corrected-to-normal visual acuity and normal hearing ability. The participants were each paid £5.00 for their time. The participants completed the experiments in one session, which lasted approximately 30 minutes.

5.3.2 Materials

The materials used for the manipulation task were tiny 'fiddly' plastic beads which were purchased from the toy section at IKEA. These were chosen because they required precision and control to be manipulated. They were made of rigid plastic, were cylinder shaped and hollow inside like slices of a pipe, measuring 5mm by 4mm. They are for children to create designs. They are 'ironed with a household iron so that they partially melt and stick together to make the design permanent.

To carry out the task, hundreds of the beads were placed in a bowl shaped metal container 15cm in diameter and 11cm high so that it was half full. They were picked up one at a time and placed in a glass circular receptacle 20cm wide. The bowl and the receptacle were both placed on a large flat tray 45cm wide, 30cm deep and 4cm high which could collect any beads which missed the receptacle. This is illustrated in Figure 5.1

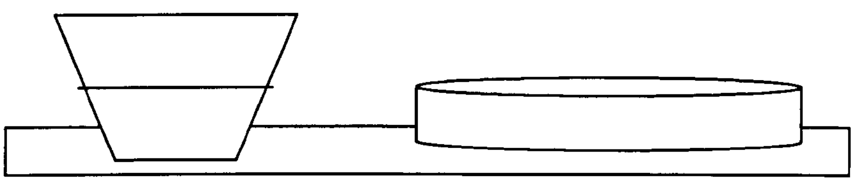


Figure 5.1: Illustration of Materials Used for Experiment 1

Manipulation was to be done by only one hand. Group A used their left hand and Group B their right. Originally the design included an additional stage where the participant used manipulation of both hands simultaneously but it was felt this was overcomplicated and unnecessary because the other stages of the test could be used for any required comparison of the two groups.

The materials for the verbal repetition tests were 4 sets of 10 sentences. The 4 sets being different but similar in design, see Appendices 1 and 2, for the actual sets of sentences and breakdown of sentence length designed specifically to ensure conformity. The design of the sentences took into account *vocabulary, length of sentence, structure of sentence* and *topic.* In terms of *vocabulary*, this had to be everyday terms with no specialist language or high level vocabulary. On average females score higher than males on vocabulary tests Hellige (1993) so the experiment was restricted to females. To cover differing educational levels which might be present the task was designed to include words which were relatively short and common in everyday language. The *length of the sentence* was designed to be just long enough to make it difficult to remember it all exactly. If the sentences had been too short then the experiment would not have been measuring anything; if too long then they would have been too difficult and would have de-motivated the participant. The *structure of the sentence* was designed so that each sentence did not depend on the former or next sentence to make sense. A storyline could not be used as this may have led to more attention being paid to listening to what was going to happen next than to the repetition of the words. It may have also led the participant to speculate on the content of the next sentence. As concerns the *topic*, this had to be of general interest across ages and gender and attempted to avoid any particular sport or hobby in case a participant was involved in that. It also had to contain non-specialist vocabulary which.

The draft design of the sentences was piloted on 4 volunteers and minor amendments were made to the originals. These amendments were that the length of each sentence was increased slightly to make the task more difficult and that the number of sentences per section was reduced from 12 to 10 because the test was too long. Also the range of scoring was increased. Originally it scored 3 when a complete sentence was omitted/added – this was not found to be high enough so was changed to a 6. As well as testing the design of the materials the pilot was useful for noticing the participants responses to the experiment. It was noticeable that some participants closed their eyes whilst listening to the audio tape in order to aid their concentration. This was therefore offered as an acceptable practice in the experiment. Also, the practice of the manipulation task was shown to be an important factor in dissipating any embarrassment for the participant at the awkwardness of using their left hand.

The final design involved 3 sections of 10 sentences. Each sentence length was an average of 5 seconds and involved around 20 syllables. The topic used was 'decorating' and the sentences talked about choosing colours and the use of light. This was viewed as appropriate as it needed no specialist vocabulary. The text could also be split up into short sentences and words removed and added to fit the experiment criteria. The text for the experiments was adapted from phrases and sentences taken from the text entitled Colour by Linda Barker (1999). It was chosen because it was a recent publication in this topic, it was written in conversational style with low level vocabulary, the book was aimed at a mixed age and gender audience and the text could easily be manipulated and edited for the experiment.

Two cassette tape recorders were used, one for playing the pre-recorded tapes of sentences and one with a microphone for recording the participants responses (and the pre-recorded sentences as they played on the other tape). There were 4 pre-recorded cassette tapes, one practice and 3 testing, and blank tapes for recording participants' responses.

During the analysis of the participants' recordings, a stopwatch was used to time their responses.

5.3.3 Procedure

The participants were seated comfortably and shown the apparatus. They were informed that their responses would be recorded for analysis later. They were given a circular container of plastic beads and asked to familiarise themselves with the feel of the beads. They listened to a few seconds of a practice tape to ensure the volume was comfortable and that they could hear the words clearly. They were asked to speak into the microphone to check for comfort and recording level. After they were familiarised with the equipment there was a practice session of the verbal repetition task and the manipulation task. Participants were informed that they could close their eyes whilst listening to the tape if they wished, that if any beads fell out of the receptacle that they should ignore them and not pick them up, and that if they made an error in speaking that they should just carry on.

Verbal Repetition Task.

For this task there were 4 tape cassettes each with 10 sentences on it. One was a practice tape and the other three were used in rotation throughout the test. Each tape of 10 sentences lasted exactly the same amount of time. The participant listened to a sentence on the tape, which was then paused by the experimenter, and the participant attempted to repeat the sentence word for word. When they had finished their attempt at repeating the sentence the pause button was released and the next sentence played – this was repeated for the 10 sentences of the tape. The whole process was taped onto a blank tape with a separate tape recorder so that errors in the participants' responses could be accurately recorded and the seconds they took to repeat each sentence could also be timed. If a participant could not remember any of the sentence, or paused for more than 2 seconds, the researcher played the next sentence. A table top microphone was used for the participant to speak into to ensure a clear recording of the words they spoke. The participant controlled the speed of the exercise in that the next sentence was not played until they had finished repeating the last one.

Bead Manipulation Task

The container of beads was placed in front of the participant so that they could accommodate a comfortable position for removing the beads with the assigned hand (left hand or right hand), from the bowl into the receptacle. If a bead missed the receptacle it simply fell into the tray. The practice was timed for one minute and the participant was instructed to move the beads one at a time at a speed which was as fast as they could without dropping the beads. The picking of one bead at a time was the crucial factor, as this meant that precise control was being used therefore ensuring the use of the contralateral hemisphere.

The order in which the elements of the task were run was as follows:

1.Practice Verbal Repetition. The participant would listen to and repeat up to a maximum of ten practice sentences until they were comfortable with what was required.

2.Practice Manipulation. The participant practised moving the beads from the bowl to the receptacle at a fast speed without dropping them.

3.Baseline Manipulation. The participant carried out the task for one minute and the beads were counted.
(Time Pause – repeat of expectations and procedure given to fill in time)

4.Verbal Repetition. Sentences 1 to 10 were played and the participant repeated each one and all the responses were recorded.

5.Manipulation. The participant, using their right hand or left hand as requested, moved the beads one by one from the first container to the second as fast as they could. This was timed for one minute after which the beads were counted.

6.Verbal repetition. This was the same as task 3 but with a different set of 10 sentences.

7.Verbal Repetition with Manipulation. This was a combination task where the participant repeated the third set of 10 sentences whilst at the same time moving the beads from one container to the other at the pace already determined by the previous two runs. The verbal repetition was recorded and the beads were counted.

5.3.4 Measures

For this experiment there are three measures used to compare the groups: 'missed words', 'added words', and 'bead count'. The score for 'missed words' and 'added words' was the number of actual words 'missed' or 'added' in the verbal repetition up to a maximum of a score of 6 per sentence and with part words or nonwords eg 'er' not being scored. The score for 'bead count' is the number of beads manipulated into the receptacle. This rendered the scores described in Figure 5.2 overleaf.

Missed words....	*without* manipulation (benchmark) *after* manipulation (residual effect) *with* manipulation (combination effect)
Added words....	*without* manipulation (benchmark) *after* manipulation (residual effect) *with* manipulation (combination effect)
Bead count.....	*without* verbal repetition (benchmark) *after* verbal repetition (residual effect) *with* verbal repetition (combination effect)

Figure 5.2: Measures Used to Compare Groups

5.4 Scores on Handedness Test

Variable means of each group were compared at the three stages of the experiment. In the case of 'error' in the verbal repetition task, this would comprise the scores of missed words and added words.

5.4.1 Score of Missed Words

The mean score for the error 'missed words' at each stage is given in the Table 5.1 overleaf. Score are shown as negative to highlight that they are error scores indicating increased impairment.

Task	Mean Left Hand Group	Mean Right Hand Group	Difference In Means
Verbal Repetition without manipulation (no effect)	-16.75	-16	-0.75
Verbal Repetition after manipulation (residual effect)	-15.75	-15.33	-0.42
Verbal Repetition with manipulation (combined effect)	-19.5	-18.83	-0.67

Table 5.1: Comparison of Scores for Mean 'Missed Words' for Each Group in Experiment 1

The mean error score for 'missed words' for the left hand group was slightly higher than the right hand group in all three stages of the experiment, that is, 'before' manipulation, 'after' manipulation' and 'with' manipulation. This is illustrated in Figure 5.3 overleaf.

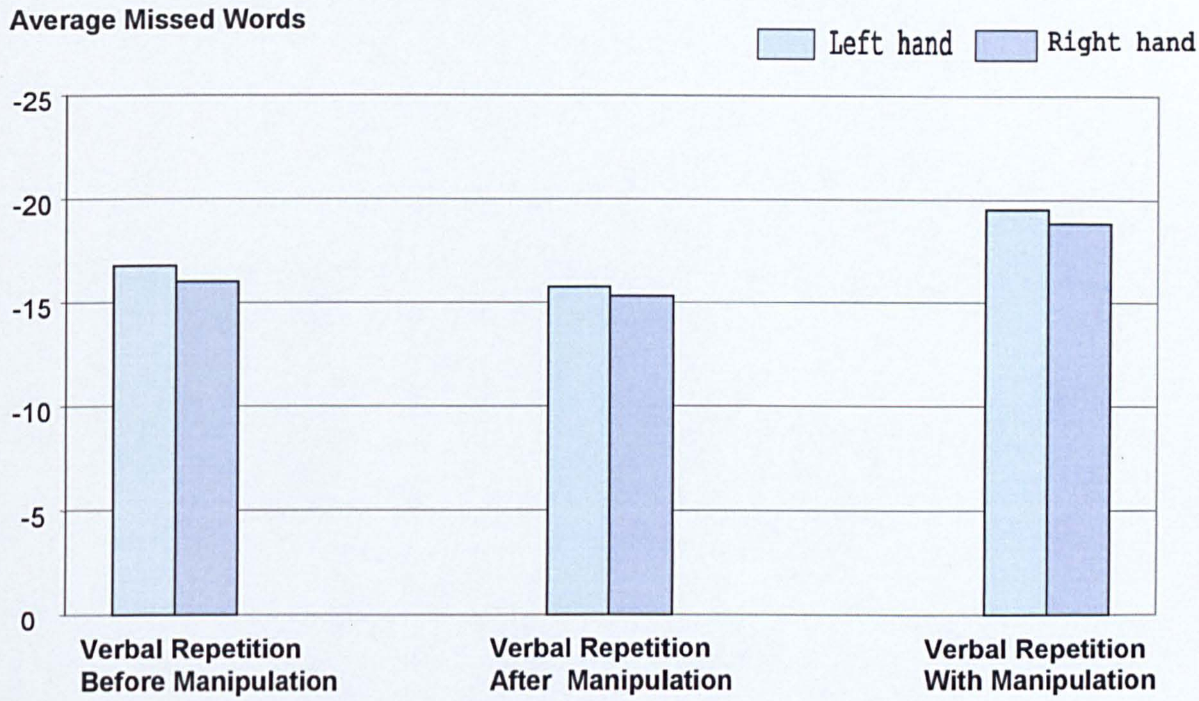


Figure 5.3: Mean Number of 'Missed Words' in Experiment 1

The boxplot over the page in Figure 5.4 shows the range and median error scores for each hand at each stage of the experiment.

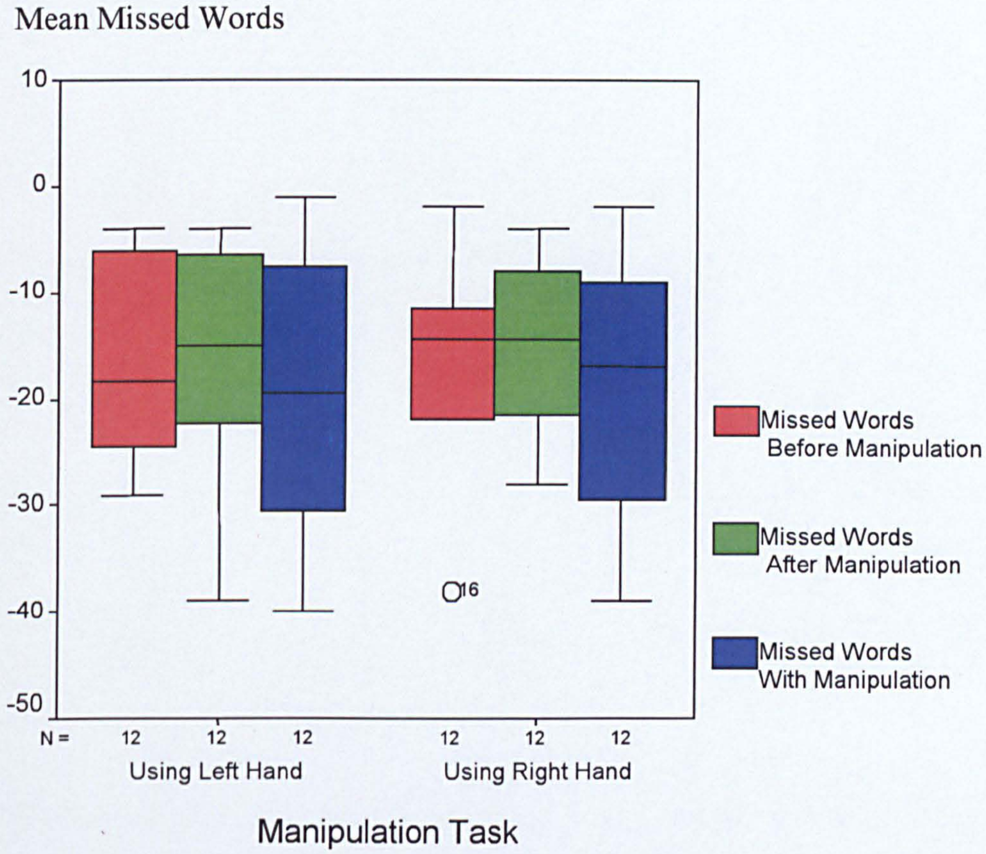


Figure 5.4: Boxplot for Both Groups Over all Stages of the Experiment for Score of 'Missed Words'

One set of data, the missed words 'before' manipulation for those using their right hand, is slightly skewed. There is also one outlier score in this data set.

All other data sets are normally distributed with no outliers. For the missed words 'after' manipulation and for the missed words 'with' manipulation both groups gave a similar distribution of data.

Figure 5.5, over the page, shows the profile plot for both groups (those using their right hand and those using their left hand) and it can be seen that there is no interaction between the groups.

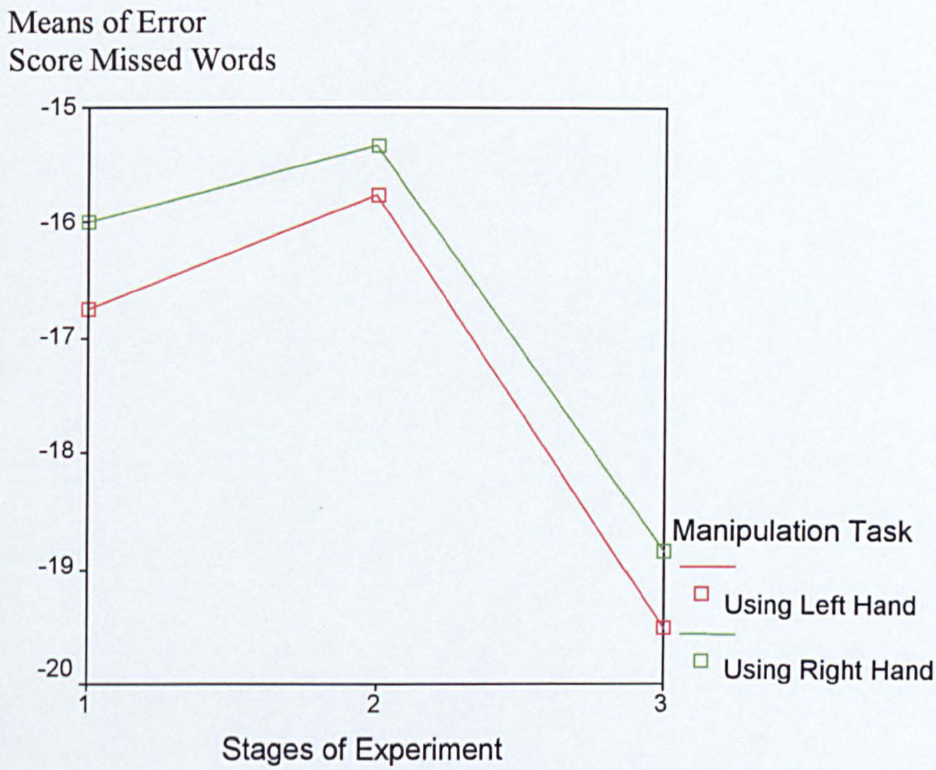


Figure 5.5: The Stage Performance Profile for each Hand for Missed Words

For the within-participant effect for the difference in performance between the stages of the experiment the error score of 'missed words' was not significant ($F(2,44) = 3.322$; $p > 0.05$).

There was also no significant interaction between the stages and the hand used ($F(2,44) = 0.007$; $p > 0.05$).

For the between-participant effect of the use of hand, the error score of 'missed words' was not significant at $F(1,22) = 0.023$; $p > 0.05$ showing no difference in performance.

5.4.2 Added Words

The mean for the score of the error of 'added words' at each stage is given in Table 5.2 below. Scores are shown as negative showing increased impairment.

Task	Left Hand Group	Right Hand Group	Difference
Verbal Repetition without manipulation (no effect)	-9.75	-5.92	-3.83
Verbal Repetition after manipulation (residual effect)	-7.83	-7.33	-0.50
Verbal Repetition with manipulation (combined effect)	-10.83	-9.83	-1.00

Table 5.2: Comparison of Scores for Mean 'Added Words' for Each Group in Experiment 1

The scores are also shown graphically in Figure 5.6 over the page.

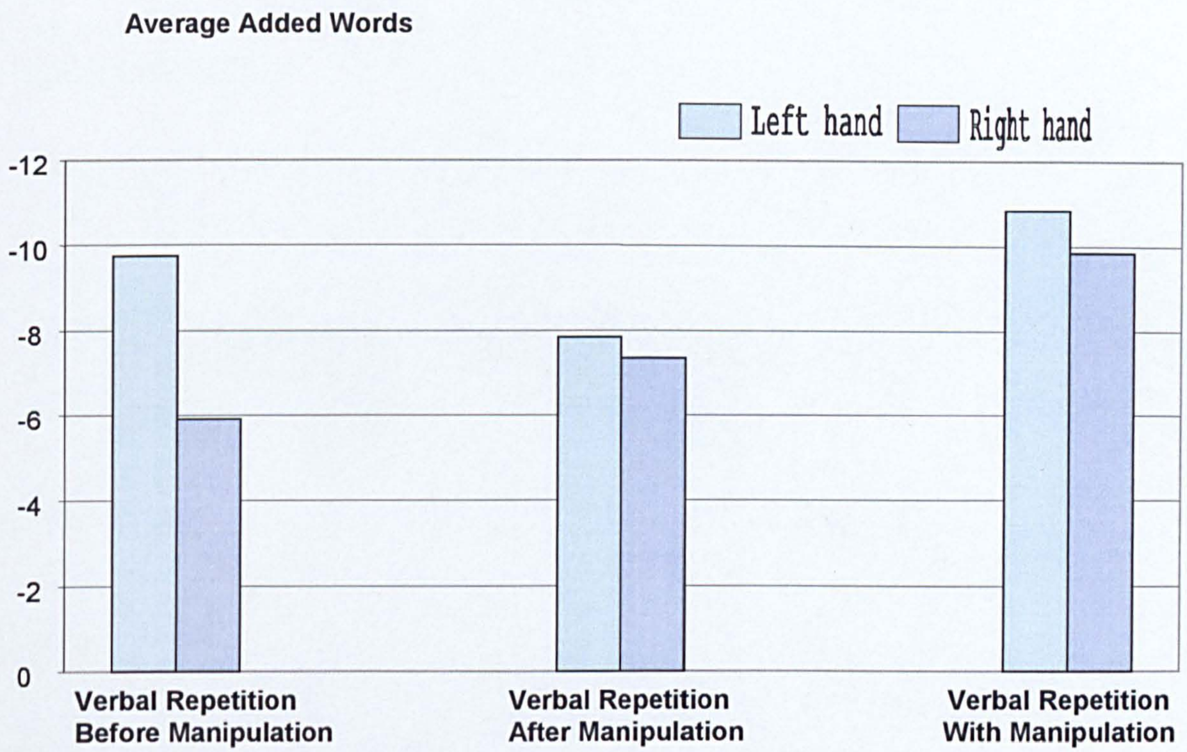


Figure 5.6: Mean Number of 'Added Words' in Experiment 1

As with the score of 'missed words', the left hand group had more errors of 'added words' than the right hand group. The biggest difference between the groups was at the 'before' manipulation stage and the largest amount of errors in the 'with' manipulation stage. At this 3rd stage the left hand group missed an average of 19 ½ words and added an average of nearly 11 words.

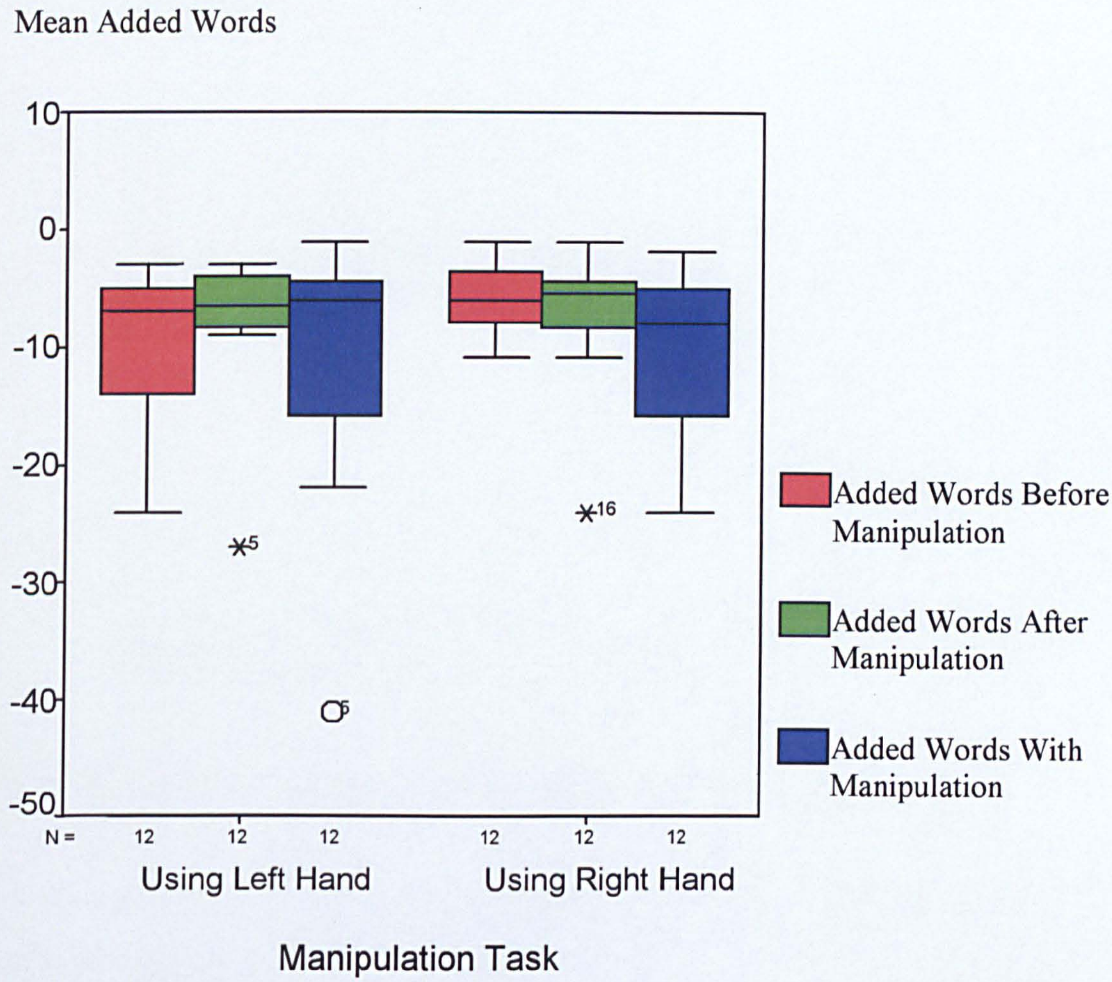


Figure 5.7: Boxplot for Both Groups Over all Stages of the Experiment for Score of 'Added Words'

Overall the data sets have normal distributions. In the 'added words' 'after' manipulation there are similar outliers in both the 'left hand' group and the 'right hand' group. There is also an outlier in the 'added words' 'with' manipulation data set for the 'left hand' group. It is interesting to note that the dispersions of data for both the left hand and right hand groups for the score 'added words' 'with' manipulation (blue box on the right of the graph) are wider than the other scores.

Figure 5.8 on the next page shows a profile plot for the data.

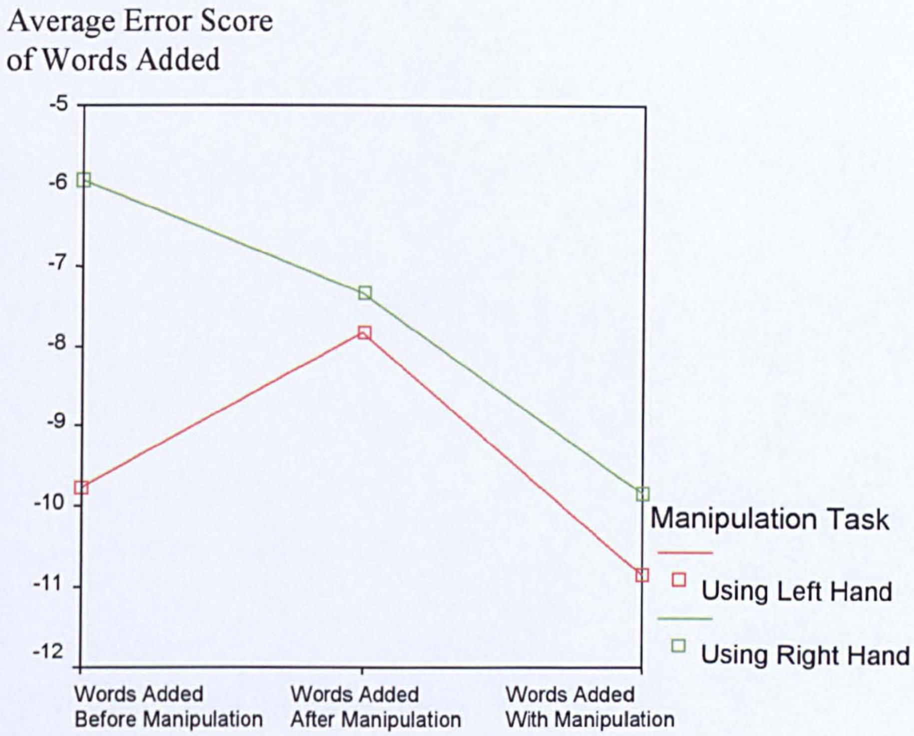


Figure 5.8: The Stage Performance Profile for each Hand for Added Words

In this profile plot there 'appears' to be a difference between the right hand and left hand participants for the score of 'added words before manipulation'. However, this graph gives a detailed scale and this difference may appear unduly large due to the scaling.

The ANOVA was applied to find if there is any difference at a statistically significant level. For the within-participant effect, the error score of 'added words' for the difference in performance between stages was not significant ($F (2,44) = 2.802$; $p >0.05$).

There was also no significant interaction between the stages and the hand used ($F (2,44) = 0.979$; $p>0.05$).

For the between-participant effect, use of hand, the error score of 'added words' was not significant at $F(1,22) = 0.490$; $p>0.05$ showing no difference in performance.

5.4.3 Bead Count

The average for the 'bead count' score at each stage is given in the Table 5.3.

Task	**Left Hand Group**	**Right Hand Group**	**Difference**
Bead Count without Verbal Repetition (no effect)	-48.00	-53.67	-5.67
Bead Count after Verbal Repetition (residual effect)	-48.25	-54.17	-5.92
Bead Count with Verbal Repetition (combined effect)	-41.75	-43.67	-1.92

Table 5.3: Comparison of Scores for Mean 'Bead Count' for Each Group in Experiment 1

The mean scores are shown graphically over the page in Figure 5.9. The bead count was used as an extra score although it was intended that this should be as consistent throughout the experiment as possible. Measuring 'bead count' was a means of monitoring this and also useful to see if, in the case of no difference in the verbal task, there was a difference in the manipulation task.

The means appear similar between the groups and in particular the combined task shows the smallest difference between groups. A significant difference is therefore unlikely.

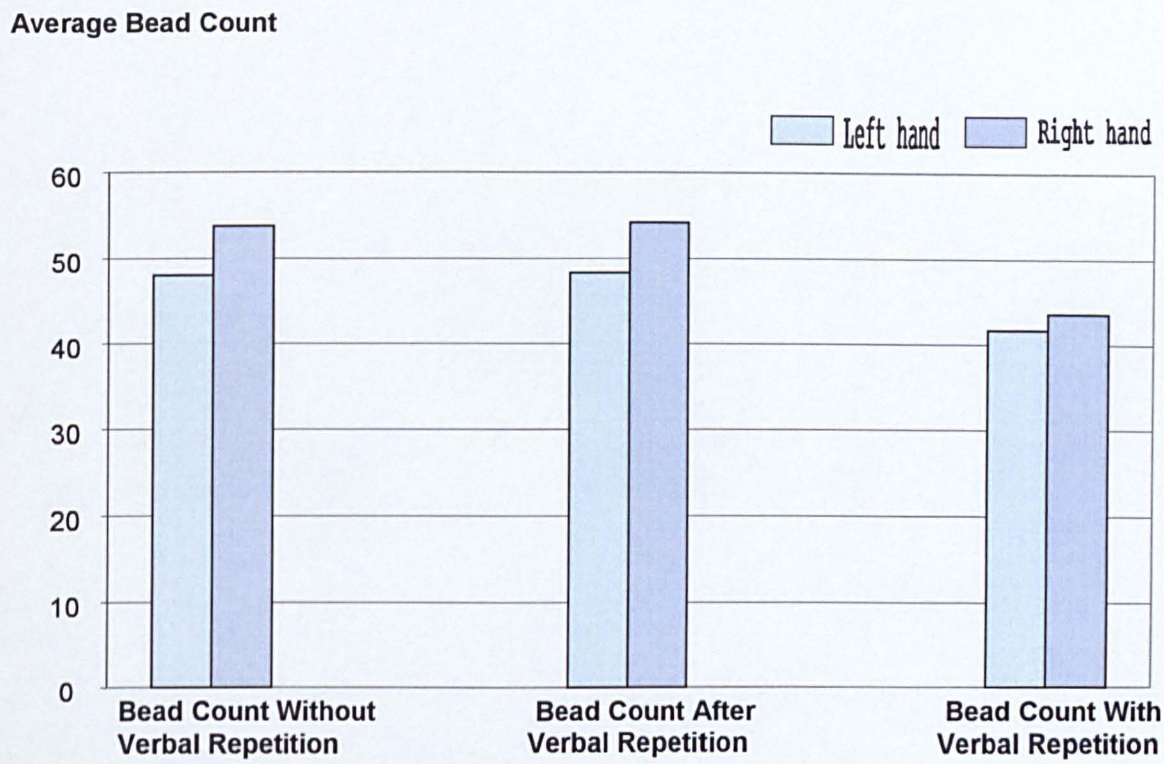


Figure 5.9: Mean Number of 'Bead Count' in Experiment 1

Both groups had a declining bead count on the combined task with the bead count on its own and the bead count after the verbal task showing a similar group difference.

The boxplot over the page gives more detail concerning the distribution of data.

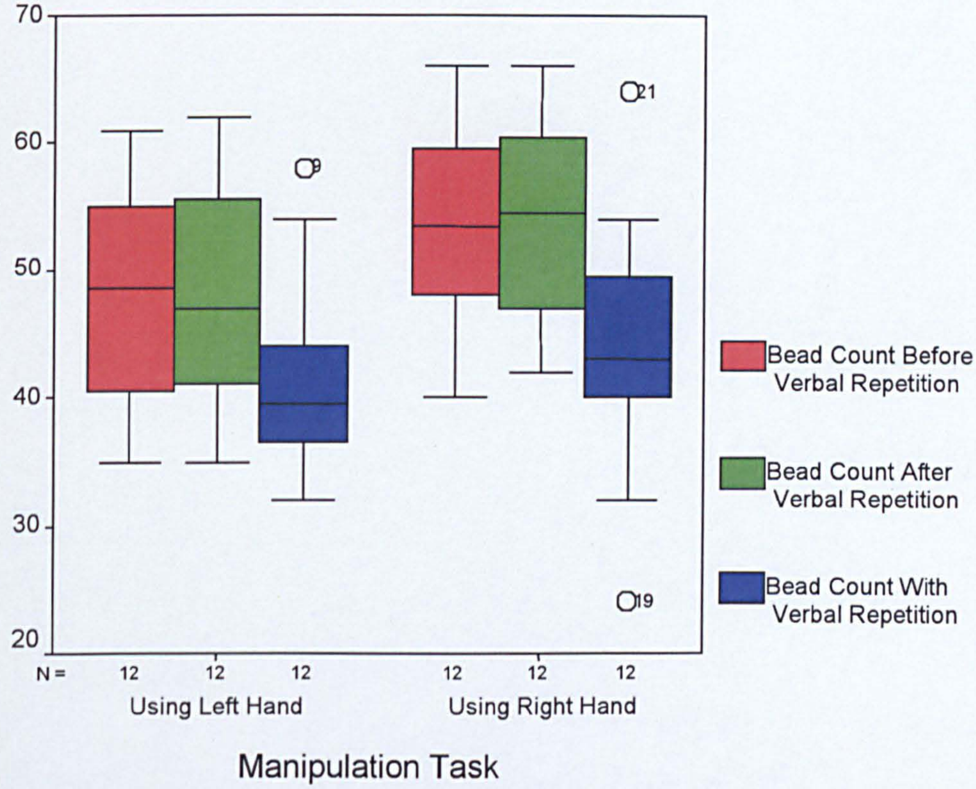


Figure 5.10: Boxplot for Both Groups Over all Stages of the Experiment For Score of 'Bead Count'

The distributions for the data sets were normal. There are outliers for the data sets for 'bead count with verbal repetition' (shown in blue) for both groups, and no outliers in the other data sets.

Figure 5.11 over the page is the interaction graph for the data sets.

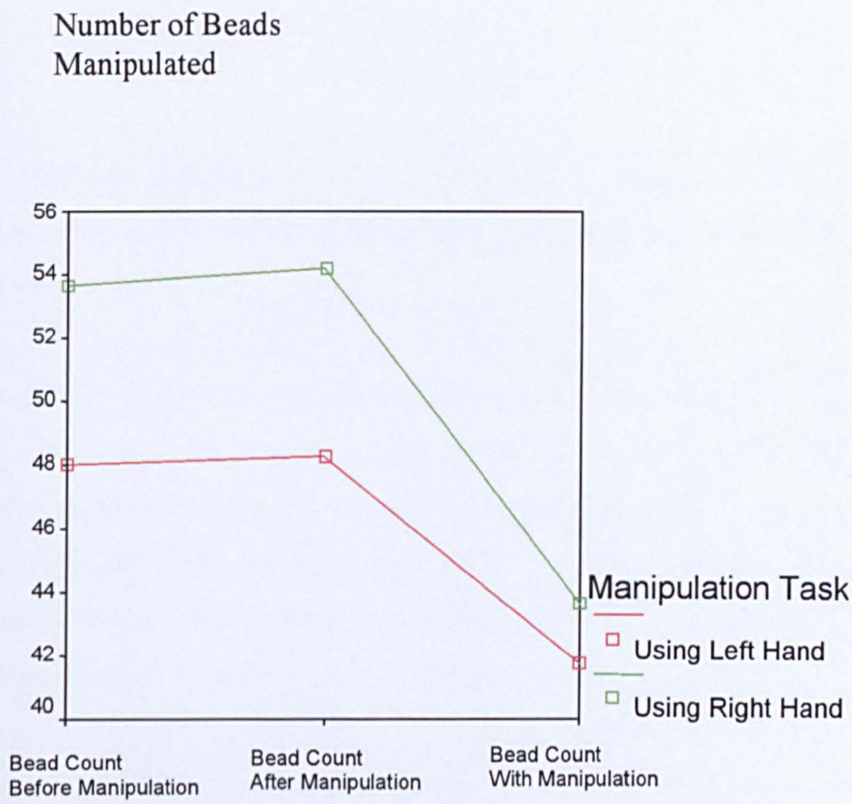


Figure 5.11: The Profile Plots for each Hand for 'Bead Count'

There 'appears' to be a difference in the groups with the difference becoming less for the combination task. The ANOVA was carried out to test for a difference as a statistically significant level.

Comparison of bead count between the stages of the experiment, that is, 'before verbal task', 'after verbal task' and 'with verbal task' showed a significant difference F (1.083,23.833) = 17.8; p < 0.01. It can be seen from the profile plot that the main point of difference is between stage two and stage three.

However, there was no significant interaction between the groups and the stages of the task F (1.083, 23.833) = 0.969; p>0.05.

For the between-subject effect, the score of 'bead count' was not significant at F(1,22) = 2.308; p>0.05 showing no difference in performance related to the use of hand.

5.5 Discussion

The hypothesis for this Experiment was that those using their right hand for a manipulation task would score better on a verbal task than those using their left hand for a manipulation task.

The tasks involved were a left hemisphere task of verbal repetition with a manipulation task which could invoke the left or right hemisphere. The purpose of the bead manipulation task was to cause arousal of the contralateral hemisphere through the use of one particular hand only. Each task (verbal or manipulation) was measured 'before' the other task was introduced, 'after' the other task had been completed and combined 'with' the other task.

The scores used for the experiment were:

- 'Missed Words' error and 'Added Words' error to measure impairment in the ability for the verbal repetition task
- 'Bead Count' to measure amount of manipulation.

The summary of the findings for Experiment 1 are as follows:

The Right Hand group's ability for verbal recall against the Left Hand group's ability, as measured by Missed Words, showed no difference.

The Right Hand group's ability for verbal recall against the Left Hand group's ability, as measured by Added Words, showed no difference.

The Bead Count score showed no difference between the Left Hand and the Right Hand group, giving the consistency required.

There was no difference in the ability of verbal recall due to different types of manipulation, that is, no manipulation, residual manipulation and combination manipulation as indicated by the error scores for Missed Words and Added Words.

The ability of manipulation between the stages of the experiment, showed a difference at stage 3 where bead manipulation was impaired due to the combination effect of the task. This was the only difference shown but it was not a difference between groups so does not add to the hypothesis.

There was no evidence, from any of the scores, of an interaction between the scores of the verbal task and the manipulation task at each stage of the experiment and with the hand used.

Therefore the hypothesis for this experiment has been disproved.

As mentioned above, the only result which gave a difference was the bead manipulation ability when combined with the verbal repetition task. However, since this difference was for both those using their left hand and those using their right hand, it purely relates to the difficulty or combination effect of the tasks. It is interesting though that the difference was in the manipulation task rather than in the verbal task, where such a difference was not shown. This would indicate that as the task became more difficult it was the manipulation task that was adversely affected rather than the verbal task when it was expected that the opposite would happen. In fact, there was an attempt to keep the manipulation task at a steady pace so that it was as constant as possible and that any interruption would be on the verbal task. Despite this, the manipulation task was affected showing a hemispheric preference for the verbal task over the fine motor control task. This is useful to consider if undertaking similar research.

Relating back to the literature for reflection on the experimental design it has been estimated that 95% of right handers have left hemisphere dominance for speech (Springer and Deutsch 1998, Loring et al 1990) therefore it is unlikely that this sample were different. However, the participants were not specifically tested for left hemispheric speech dominance. The verbal task was carefully selected to maximise left hemisphere processing. By providing the words for the participant to repeat there was no language generation required. Also, because it was an auditory task no visual spatial factors of words were involved. Also, there was a minimum of delay between hearing the sentence and repeating it so there was minimum requirement for use of memory. Therefore the task was the most appropriate possible for left hemisphere involvement.

In the experiments on split-brain patients there is clear indication that fine motor skills, particularly of the fingers and involving precise actions, are controlled contralaterally. Also the Wada Test and other experiments have shown that this is the case for most individuals. Therefore, it is unlikely that ipsilateral control was being used here.

Therefore, the experiment is robust in terms of choice of a left hemisphere cognitive task and a left and right hemispheric contralateral manipulation task. However, one is a higher order mental task, the other a motor task. The purpose of the experiment was to provide evidence for the existence of absence of a link, between these two, the fine motor skill and the higher level processing skill. This link has not been established by this experiment.

It was suggested in Section 2.3 that many experiments in this field can have circular arguments, that is, using ability of the hand to determine what is the ability of the hemisphere thereby assuming that the hemisphere affects the hand but that the hand does not affect the hemisphere. This experiment has shown that if there is competition between the mental task and the manipulation task that the mental task has less impairment and the manipulation task is the one adversely affected.

The conclusion is that the participants were able to carry out the verbal repetition task to the same degree whether they were using their right or left hand for the manipulation task. The manipulation task had no effect.

The fact that there was most impairment of the verbal recall and the manipulation skill when the two tasks were combined was to be expected as overall cognitive demands were higher at this stage of the experiment.

6 Experiment 2: Face Recognition – Right Hemisphere Superiority

6.1 Introduction

The main purpose of Experiment 2 was to find a task which was predominantly a right hemisphere task so that it could be used in conjunction with a fine motor control task to compare the effects of using the right hand against the left hand. Face recognition seemed to be a task which has been shown to use right hemisphere processing skills. There has been, and still is, much debate in this area and new research is showing that the left hemisphere does play a part in face recognition. The debates which reflect on this experiment are given below. The issue of face recognition is also important within the context of our everyday working lives. Because the aims of the present research include applications for business, then it is helpful to find a task that could have relevance to business situations. Although the experiments have to be carefully designed to maximise right hemisphere processing and minimise left hemisphere processing, the information gained can still have relevance in everyday situations. For example, there is the need to recognise faces of business associates in the house magazine or promotional literature, there may be the need to be able to remember a person's face after only a brief introduction. There are limitations to the application of the experiments in that only certain conditions prevail eg studying photographs not actual people, but nevertheless there is some relevance to business life. We look at people when we talk to them, we pass them in the office and any way to help this process of remembering and recognising faces would be helpful. We may need to recognise people quickly to avoid embarrassment and yet, often, people have difficulties identifying faces. Young et al (1985) asked participants to record difficulties they had in recognizing people over a seven-week period and they categorized these. The categories covered: failure to recognize a familiar person; mistaking one person for another; recognising someone but unable to bring to mind other information about them; difficulty in retrieving full details of the person; not being sure whether they had identified correctly the person they had encountered; thinking it wasn't the person it was and giving the wrong name to the person. In analysing these incidences it was shown that most categories involved using the faces as the primary source of information for recognition purposes so although other factors are included in the recognition of people such as gait, the face and the recognition of it, plays the dominant role.

6.2 Right Hemisphere Dominance for Face Recognition

From the 1960's there have been studies that have identified a significant connection between face recognition and the right hemisphere. Some of these studies relate to split-brained patients who have neurological disorders, usually epilepsy, and some relate to intact 'normal brained' individuals. The differences between the two are taken account of in the research – all the experiments have been done with intact 'normal brained' participants.

6.2.1 Prosopagnosia

The incidence of prosopagnosia, failing to recognise familiar faces, has given useful insights into face recognition theory. Classically, studies of prosopagnosic patients have found that the majority of them had right hemisphere lesions (Hecaen and Angelergues 1962). Right temporal lobectomy patients have been tested after operations and compared to left temporal lobectomy patients and the former were much poorer on face memory tasks (Milner 1968).

6.2.2 Chimaeric Faces

Chimaeric faces have been used in numerous studies and have shown, by normal participants predominantly picking out the left side of the faces when shown them tachistoscopically, that it is the right hemisphere which is perceiving the face more clearly than the left. (Levy et al 1972, Milner and Dunne 1977, Schwartz and Smith 1980).

6.2.3 Stimulus Features

Speed and accuracy superiority of the right hemisphere has been shown across various face processing experiments despite differences in the type of faces, length of exposure, lighting, distance etc. Sergent and Bindra (1981) give a useful review of such studies and conclude that in general a right hemisphere advantage is obtained when (a) stimulus information is degraded; (b) faces to be compared are highly discriminable; (c) a set of unfamiliar faces is used, and (d) task requirements allow a lax criterion of recognition. They assert that these conditions seem to make holistic processing adequate for the task. However, if analytic judgments are to be made then this may give a left hemisphere advantage.

In support of this Freeman (1980) suggests that the right hemisphere can recognise less detailed faces eg line drawings or photographs in a poor light better than the left hemisphere. They suggest this may be because the right hemisphere has a more holistic approach to receiving data which may be helpful in these situations. For some of the studies which did not give a clear advantage to the right hemisphere for recognising faces they have shown there is a speed advantage with the right hemisphere being quicker to recognise the image (Hay and Ellis 1981). The importance of task-relevant visual information has been stressed by Hellige et al (1984) and Sergent (1985). They discuss whether the two hemispheres are differentially efficient for processing global or local features and the fact that perceptual quality is more likely to interfere with the extraction of relatively specific local features. The naming of a face, a high resolution and the identification of local features, such as the eyes and the nose, were factors used for right visual field, that is, left hemisphere processing, whereas the left visual field, that is the right hemisphere, appeared to have a more holistic processing system where lower resolution and outer features, such as the shape of face and the chin line, are processed more accurately. Implications for the current research are that the faces used for the experiments need not be of a high resolution and that they should clearly show the jaw line and outer edges of the face.

In her experiments of face recognition of familiar and unfamiliar faces, Bruce (1982) photographed head and shoulders which allowed for more than just the face to be viewed and quite a number of the faces in the photographs had beards, moustaches and glasses. This may have provided extra cues for responding other than the face itself. To ensure the face itself was being remembered she changed the angle of the head and the expression of the face. However this would still include the extra information of the hair and shoulders. Also, in the experiments, there was quite an uneven split between male and female faces. The unfamiliar faces used were of staff from a different department but same university institution so may have given rise to the opportunity of having seen these faces around the campus or in publications etc. Her findings were that changing the view of the face between study and test made recognition more difficult. Familiar faces were recognised more quickly and more accurately than unfamiliar faces. Participants were told that half of the test photographs were the study photographs and used a 'yes', 'no' response when they were shown the photographs from which to select the ones they recognised. This method could have allowed for guessing, particularly towards the end of the test if the participant perceived they had not yet said 'yes' to the 50% proportion of the faces shown.

Both Hellige et al (1984) and Sergent (1985) used black and white photographs of faces for their experiments. Those by Hellige had no glasses, beards or other distinguishing features whilst this level of detail is not given in the Sergent experiments so is unknown. Most of the research reviewed excluded any features of this kind on the faces and this would seem appropriate for the proposed experiments in this current research. It is possible that such details may be more easily processed by the left hemisphere and therefore involve the left hemisphere which is not desirable. Sergent used photographs of faces through broad-pass filters to give a normal appearance and low-pass filters to give a blurred appearance. The results showed that there may be an intrinsic vulnerability of the left hemisphere to a degradation in the quality of the face detail which the right hemisphere does not suffer from.

Hochberg and Galper (1967) showed that recognition was slightly greater for upright faces than inverted faces suggesting that the faces are not simply recognised as patterns. This was for unfamiliar face recognition as compared to familiar face recognition which is an easier task and involves other data than just the face eg the reason the face is familiar. The inspection length did not affect the recognition accuracy of once-presented unfamiliar faces. The pictures shown in their experiments were of females only and only those pictures without glasses or distinctive clothing or backdrops were used. The participants viewed photographs one by one and responded at their own pace which was generally between 5 and 15 seconds. Participants viewed the photographs with both eyes enabling both hemispheres to process the faces in the normal way. Later Galper, who had previously discovered that faces shown in photographic negative were less easily remembered than photographic positive, tested for face recognition differences for different degrees of face expression on a continuum of natural/resting to smiling and including negative and positive images (Galper and Hochberg, 1971). Faces were exposed for 7 seconds with a 3 second interval and a 5 day gap between study and test. The experiment showed that recognition of the viewed faces was poorer when the expression had been changed between study and test and that therefore expressional variation alters aspects of the stimulus pattern which is used to remember faces. Therefore changing the expression makes the face more difficult to remember than keeping the photograph identical. Therefore for this current research the expression of the faces will be changed between study and test to make the task more difficult.

In the Benton Test of Facial Recognition (Benton et al 1983), test photos differed in lighting or orientation and participants had to find one face among five and then 3 out of 6. The different orientation meant that a pictorial match could not be used.

Therefore the faces shown at test should have a slightly different expression from the ones shown at study and have a slightly different orientation and a ratio of five novel faces to one target face.

It was common amongst the experiments viewed that the exposure time for viewing faces at study was about 5-10 seconds and in some studies, as already mentioned by Hochberg and Galper the participants proceeded at their own pace which was between 5 and 15 seconds. There is some evidence to show that the longer the view time the more the left hemisphere is involved in the processing. The right hemisphere taking in the initial holistic view and then the left hemisphere comparing more local details (Springer and Deutsch 1998). This indicates that viewing time should be restricted to a maximum of 10 seconds.

Face recognition is a complex task and involves several different processes which have been identified to some degree in the studies. Factors such as differentiating between male and female faces (McGlone 1980) and the briefness of the exposure which tailors more to the right hemisphere's holistic approach (Sergent and Bindra 1981) may be giving the right hemisphere advantage. Some studies have shown a right visual field (left hemisphere) superiority is some participants (Hilliard 1973) as have studies which have included other information such as names within the stimulus. It has even been stated that face recognition is possible without a right hemisphere (Teuber, 1978). The left hemisphere may be using a mental labelling, such as name or occupation, as a strategy to aid recall. This indicates that there should be no additional information attached to the stimulus of the face which could interfere with the right hemisphere processing.

Bruce and Young (1986) suggest three different neural pathways for face processing: recognition of familiar faces, recognition of unfamiliar faces and interpreting facial expressions. They suggest that these are dissociable face processing abilities which may require different levels of activity from the left hemisphere. In their further studies it was found that the participants who had problems with unfamiliar face matching had right hemisphere lesions and those who had problems with identifying facial expression had left hemisphere lesions. They suggest that they are not questioning the literature which gives a clear link between facial expression and the right hemisphere but there are indications that the left hemisphere can also be involved in the task. Young et al (1993) carried out experiments in unfamiliar face matching and facial expression analysis to find out whether the suggestion that different neural pathways were used for each task could be shown. Of the patients who had problems recognising the unfamiliar faces some of them had right hemisphere lesions and those who had problems with facial expression were all left hemisphere lesion patients. Therefore it was concluded that the left hemisphere does make a distinct contribution to the analysis of face expression. Indications for the proposed experiment then, is that it should not be concerned with the identification of the facial expression and that facial expressions should not be emphasised in any particular way or this would arouse the left hemisphere processing.

There are studies which show different face recognition accuracy depending on the colour of the skin and in general the results show that white skin and black skin participants performed better with own-race faces (Goldstein 1977). This indicates that if white students will be used as participants then the faces should be of white people and vice versa.

6.2.4 Processing of Unfamiliar versus Familiar Faces

It is suggested that familiar and unfamiliar faces are processed in different ways – that for familiar faces the centre of the face is more important and for unfamiliar the peripheral of the face (Ellis et al 1979). There is an important distinction to be made between faces. The research appears to cover three sets of faces: familiar, unfamiliar and novel. The 'familiar' would include such categories as self, famous person or colleague/friend. These faces usually have other associated information attached to them eg name, personality, voice. As concerns self-face recognition tasks, Keenan et al (1999) show that self-recognition may be correlated with neural activity in the right hemisphere. The 'unfamiliar' faces are usually those classified as faces which have been presented once only in the study stage of the experiment. In most face recognition experiments the faces are only seen for a limited amount of time, from milliseconds up to about 15 seconds. These will often have no other information associated with them unless specifically given as part of the experiment in which case the experiment is more complex. These faces are therefore 'target' faces to be shown later for recognition by the participants. The 'novel' faces are those that have never been seen before and are introduced into the experiment as alternative choices which are intended not to be recognised compared to the 'target' faces which have been seen at study stage.

Mohr et al (2002) conducted research which found that there was evidence for interhemispheric cooperation for familiar but not unfamiliar face processing. Because of the evidence that shows the left hemisphere is involved in some aspects of face recognition in general, they wanted to identify particular times when both hemispheres were involved. The study revealed that there was a bilateral advantage for familiar faces (they used famous people) and a lack of bilateral advantage for unfamiliar faces. There is an indication here for this proposed experiment that unfamiliar faces should be used. Unfamiliar faces were also processed more slowly than familiar ones and with more accuracy. Therefore the exposure time to the face will be acceptable at around the 10 second mark. The study involved 30 people including both sexes who were strongly right handed according to the Edinburgh handedness inventory and had no left-handed first degree relatives. The familiar faces were famous people and these were matched for hairstyles, glasses and age with the unfamiliar faces so although it was more than just the face itself showing, they were balanced across both groups.

Other experiments have also shown left hemisphere involvement in the recognition of familiar faces which relies more on the details of the inner features of the face than the holistic view of the face (Sergent and Bindra, 1981).

Katanoda et al (2000) conducted an experiment with 14 right handed men who were exposed to faces which they were then shown approximately 30 minutes later with no novel faces included. Whilst undertaking this face recognition memory the participants brains were fMRI scanned. A second experiment was given when the target (previously studied) faces were shown and with these were mixed novel faces. Again the brains were scanned during the response stage. The results showed that it was in experiment 2, where there was a mixture of previously shown photographs mixed with novel photographs, that the right hemisphere was more activated. Significant activation in the right inferior frontal gyrus and the right superior and inferior parietal lobules was clearly shown giving the right hemisphere emphasis for detection of novel faces or retrieval effort. Therefore an experiment finding target faces amongst novel ones clearly uses right hemisphere processes. This is an indication that the proposed experiment where once seen unfamiliar faces are to be identified from novel faces would arouse the right hemisphere processing abilities.

6.2.5 Other Abilities Affecting Face Recognition Ability

Ernest (1997) conducted experiments with right handed participants to find out whether a high spatial ability affected the accuracy and response time for recognising faces. The stimuli were black and white photographs of faces without any distinguishing features (beards, glasses etc). The results were consistent with other evidence which concludes that high spatial ability does not tend to be associated with enhanced right-hemisphere functioning. Individual differences in verbal fluency (not including vocabulary) significantly predicted response latencies by giving a faster response but this was for both visual fields not just one. There is no requirement to test people for spatial ability or verbal ability and the record of sex and handedness, which will be made, should give any additional information required.

6.2.6 Retention of Face in Memory

Moscovitch et al (1976) found that for strongly right-handed participants there was a right hemisphere advantage when faces had to be retained in memory for more than

100 msecs. From their research they suggest that both hemispheres use a holistic strategy in the first 50 msecs and then whilst the left hemisphere processes the face in a more localised way the right hemisphere continues in the more holistic way. Bahrick et al (1975) found that it is relatively easy to retain images of faces in memory for some time. They report that class-mates' faces were identified from novel faces after 15 years with a high success rate and after 50 years at three quarters success rate. Because these were actual individuals known to the participants there is obviously other meaningful information including relationship memories which would aid the recall of the face. Goldstein (1977) giving an overview of the literature states recognition success for faces shown immediately after study range from 89% to 54%. Most experiments are done with this immediate test after study although in the Galper and Hochberg (1971) experiments the participants had a 5 day interval between viewing the photographs and recalling them. There is also evidence to show that study to test time delay is a factor in the accuracy of face recognition. In the Shepherd and Ellis study the accuracy of performance deteriorates after 6 days to 80% and after 35 days to 71%, from the 87% accuracy after a few minutes. They also separated out the photographs of faces into three categories; high attractiveness, moderate attractiveness and low attractiveness, and the recall of those of high and low attractiveness faces did not diminish with time (Shepherd and Ellis 1973). Therefore for moderately attractive faces the longer the study-test delay interval the lower the recognition accuracy. For the purpose of experimental design for this current research this would suggest that the use of moderately attractive faces would increase task difficulty. The use of ordinary people, not models but the general public, who have been photographed in a magazine and therefore, have had some make-up applied, would be a helpful option. Also a recall time of 3 weeks would give the benefits of the study-test delay and would not be too long to be practical.

The research concerning the neural mechanisms underlying the way in which the hemispheres actually process the information of the faces ie serially or in parallel, is outside the confines of this research but as expected there is much debate on this matter too.

Taking all the details of this review into account and the way that experiments have been conducted and the findings from them this has led to the design of the proposed experiment to take into account the following:

- That unfamiliar faces should become target faces and then are to be identified amongst novel faces

- That participants to be asked to identify which faces they recognise from a set of faces, rather than give a 'yes', 'no' answer to every face shown – a forced-choice design

- Since the participants are from a predominantly 'white' population then the photographed faces should be 'white'

- There needs to be a long interval between study and test to make it harder to remember the faces – 3 weeks is appropriate and practical

- The ratio 1 target face to 5 distracter faces is optimum for selection

- The faces should have different expressions on study from on test and participants are not told that this is the case

- highly detailed pictures are not required

- that faces should be studied for a time interval less than 15 seconds and that a maximum time limit for retrieval should be set at 3 minutes

- unnecessary features of the face such as hair should be removed by cutting the photographs to show only the face giving a clear outline of the whole face, to enhance right hemisphere processing, but not giving peculiar details for the left hemisphere to process

- Give a mixture of male and female faces

- Sort participants into left-handed, right handed, male and female for analysis where possible

<u>Fine Motor Control Task</u>

To ensure the contralateral hemisphere was to be activated for the fine motor control task the task had to require precise action, controlled action and to specifically employ the fingers alone rather than involve the wrist. Three possibilities were considered namely tapping, writing and tracing. Tapping was very popular in experiments of this kind recorded in the literature but tapping does not give the precise control required. Also according to the neurological literature automatic actions can be controlled by the ipsilateral hemisphere and tapping could be argued to be an automatic action. Since many of the recorded experiments use this skill it makes the findings less useful.

Handwriting is a complex skill. It involves language, coding and shaping and some of these skills may be supported neurologically from the left hemisphere. Also, and more particularly, to carry out a handwriting task, in conjunction with studying the faces, would be very demanding for the participant. It was decided that tracing was a more appropriate fine motor control skill for use in this experiment. Tracing is a task which does not have ready formed standards applied to it such as writing so embarrassment at the results and awkwardness in carrying out the task were thought to be lessened. It would be better used in a longitudinal study.

6.3 Experiment 2

The aim of this experiment is to provide evidence of whether the arousing of each hemisphere, by carrying out the contralateral fine motor control task of tracing, will effect the right hemisphere's ability to carry out a face recognition task.

Hypothesis

That those using their left hand for tracing would show a better score for recognising unfamiliar faces than those using their right hand.

If this is shown to be the case then one explanation could be that the fine motor control skills of the left hand has aroused the right hemisphere and that arousal had assisted the right hemisphere's superiority in processing unfamiliar faces.

The experiment is testing for differences in the ability to recognise pre-shown unfamiliar faces whilst participants used their right hand or left hand for a simultaneous tracing task. Groups are compared within gender to allow for documented differences in gender ability of this task. (Rehnman & Herlitz 2006, Reichert & Kelly 2006, Connellan et al 2000, Lewin et al 2001, Lewin & Herlitz 2002). All the participants were right handed. The experimental design is between-subject (independent).

6.4 Method

The experimental design is a two factor between-participants with the independent variables being tracing with the left hand or right hand and being male or female. The dependent variable is the ability to recognise unfamiliar faces. The test for a difference between the groups at a statistically significant level is a 2 x 2 ANOVA (2 independent variables each with 2 conditions)

6.4.1 Participants

The participants were male and female undergraduate students from the University of Salford. They were all volunteers. They were all right-handed as declared by hand normally used for handwriting. For this experiment handwriting was chosen as the key determinator for handedness. They were split into groups by gender. They were then assigned to use either their left hand or their right hand so there were four groups in total: 32 males using their right hand, 39 males using their left hand, 24 females using their right hand and 40 females using their left hand.

6.4.2 Materials

The material for the fine motor control task of tracing was a pre-drawn and photocopied A4 size sheet of paper with a 'twisting path' running around it and a pen. This is illustrated below in Figure 6.1. The width of the 'path' was approximately 1cm which allowed a pen to be comfortably drawn within it. The 'path' deliberately curved to ensure pen control was being used.

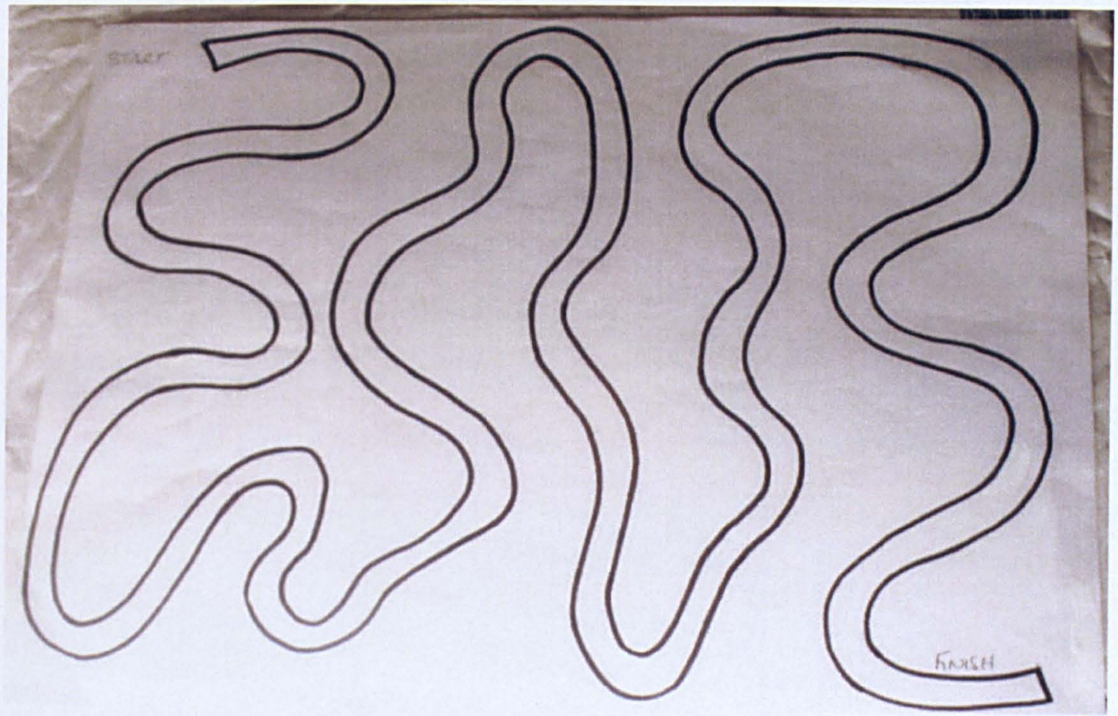


Figure 6.1: Paper with Tracing Design for Participants to Draw Between the Lines

The materials for the face recognition task were two sheets of A5 card with colour photographed faces on them, one with the 4 study faces and one with 15 test faces (the 4 study faces and 11 distracter faces). Figure 6.2 below shows the 4 faces which the participants were shown for 5 seconds. The size of the faces was approximately 2cm wide and 3cm high.

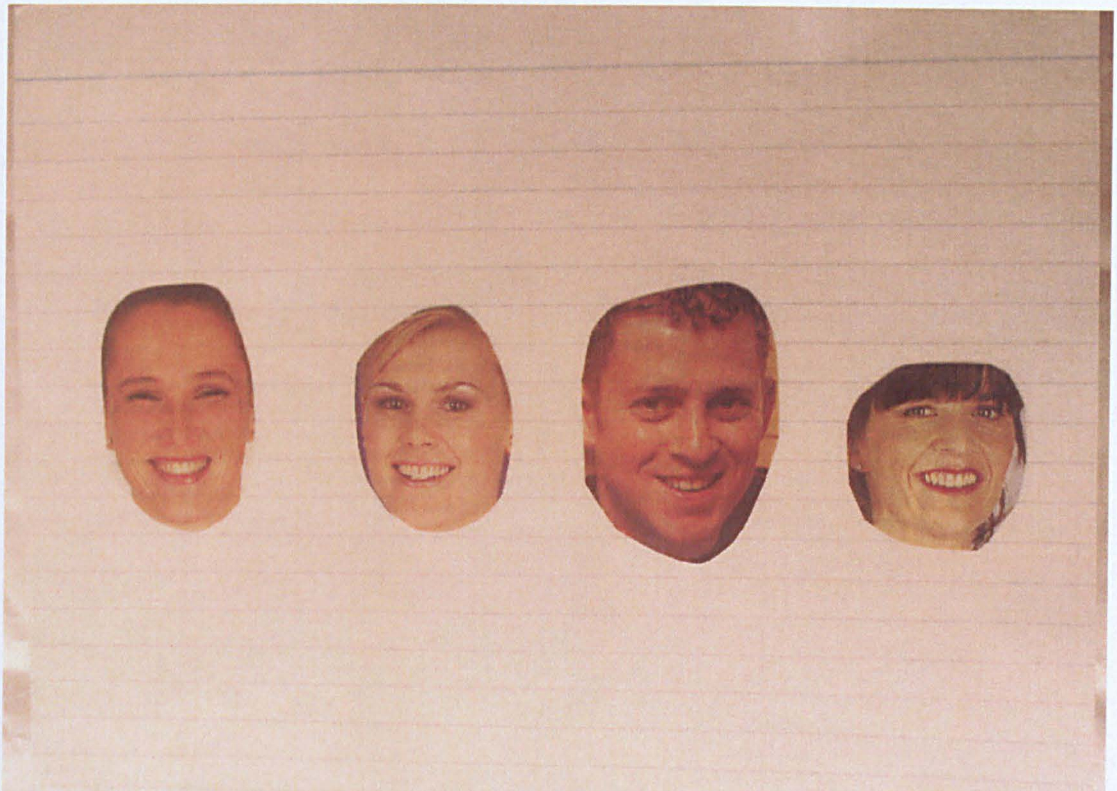


Figure 6.2: The Four Study Faces

In Figure 6.3 shown overleaf, is the card with the 15 faces from which each participant was asked to identify any they recognised as the faces they had been shown 3 weeks earlier.

Figure 6.3: The Fifteen Test Faces (Four Target and Eleven Distracter Faces)

The research into different materials used for this kind of experiment determined how this stimulus should be presented bearing in mind that the aim of the design of the experiment was to minimise activity of the left hemisphere and maximise activity of right hemisphere.

The right hemisphere is activated when the face is truly novel/unfamiliar, the outside of the face is visible but not the hair, and distinguishing features do not detract from the 'holistic' view which the right hemisphere prefers.

The left hemisphere becomes involved in face recognition processing if certain conditions are prevalent. These are when: exposure to the face is for more than 10 seconds; there are specific noticeable features eg beard or glasses; when familiar faces are used eg famous people or colleagues; when additional information is available for coding and labelling eg a name or a uniform; when local features are unusual or prominent eg nose or teeth and when distinctive facial expressions are used eg pouting or snarling.

The photographs were small to encourage holistic processing. They had no distinguishing features and the hair and shoulder were cut away. All faces were smiling but not in an exaggerated way. The angle of photograph was slightly different between study and test. The faces were all white as the participants were dominantly white. To ensure as much degree of unfamiliarity as possible it was decided that photographs of the general public, not famous people or models, pictured in slimming magazine would be used. Although it was possible that someone could have seen the particular magazine old issues were used to minimise any possible recent viewing. These photographs were therefore easy to access which was also a consideration and because there was more than one photo of the individual this gave the different poses required. Also because these individuals, though not models, had been made to look attractive for the magazine photographing session, they fitted into the 'moderately attractive' category which was the best option for the experiment. One male and three female faces were used.

Certain elements were introduced into the task to make it more difficult. These included: providing a short exposure time of 5 seconds to study the 4 faces; by having an long interval between study and test of 3 weeks; by using 'moderately attractive' faces (rather than 'very attractive' or 'not attractive'); by having slightly different angles for study and test; by keeping expressions of all faces similarly smiling and by asking participants to select 4 faces from 15 rather than using the 'yes' 'no' approach which can lend itself to guessing.

6.4.3 Procedure

The order in which the elements of the task were designed was as follows:

1. Tracing. On a signal the participant would start to trace a line on the pre-designed form using the *right* or *left* hand as instructed. They were told that they should continue tracing even if they finished the sheet – they should simply start the sheet again.

2. Studying the Target Photographs. When the participant reached halfway through the tracing sheet they were shown a card with 4 photographed faces on it. They were shown this for 5 seconds and were instructed to continue tracing.

3.Finishing Tracing. After the 5 seconds the card was removed and the participant continued tracing until the end of the sheet.

4. Recalling the Target Photographs. Three weeks later the participant was presented with the card with 15 photographed faces on it. This included the 4 target faces and 11 distracter faces mixed together. The participant was allowed a maximum of 3 minutes to select those faces they thought they recognised from the study stage.

6.4.4 Measures

The measure used was the number of target faces correctly identified from 0 to a maximum of 4.

6.5 Results

The results are illustrated below.

6.5.1 Means and Standard Deviations

The means and standard deviations for each of the handedness groups and then sub-divided into the gender groups within each of these, are given in Table 6.1 below.

Tracing Task	Gender	Number of Participants	Mean	Standard Deviation
Using Left Hand	Female	40	2.48	1.154
	Male	39	2.18	.885
	Total	79	2.33	1.034
Using Right Hand	Female	24	2.54	1.062
	Male	32	2.28	1.170
	Total	56	2.39	1.123
Total	Female	64	2.50	1.113
	Male	71	2.23	1.017
	Total	135	2.36	1.068

Table 6.1: Means and Standard Deviations of Faces Remembered

The average for those using their left hand was 2.33 compared to those using their right hand which was 2.39 slightly higher but an apparently very small difference.

Looking at gender as the additional factor, the means indicate that the females (2.50) may be slightly better at recognising faces than the males (2.23), with the females being better than the males with either hand, with a mean of 2.54 versus 2.28 for the right hand and a mean of 2.48 versus 2.18 with the left hand. Females using their right hand (2.54) scored the highest.

6.5.2 Interaction Graph

In order to explore any interaction which may be occurring between hand used and gender Figure 6.1 illustrates plots for each group.

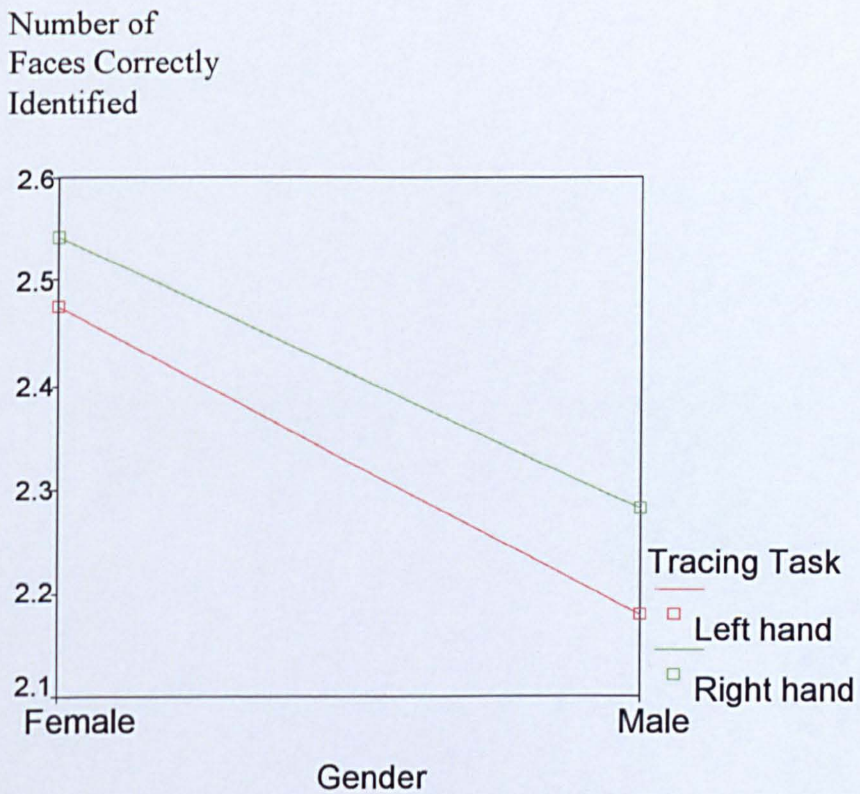


Figure 6.4: The Interaction Between Effect of Hand Used and Gender on the Ability to Recognise Faces

The interaction graph shows that the overall the females did slightly better at the task. It would appear the test may be showing sensitivity towards the female bias to recognising faces. The averages were well within the range of scores which is an indicator of the validity of the test. There is no interaction between right hand use and left hand use which goes against the hypothesis. For both male and female the use of the right hand gave better results. The diminished results from the left hand, brought the average score down by 0.06 for females and 0.10 for males so it 'appears' from the graph that the males suffered slightly more interruption by the left handed task.

6.5.3 Box Plots

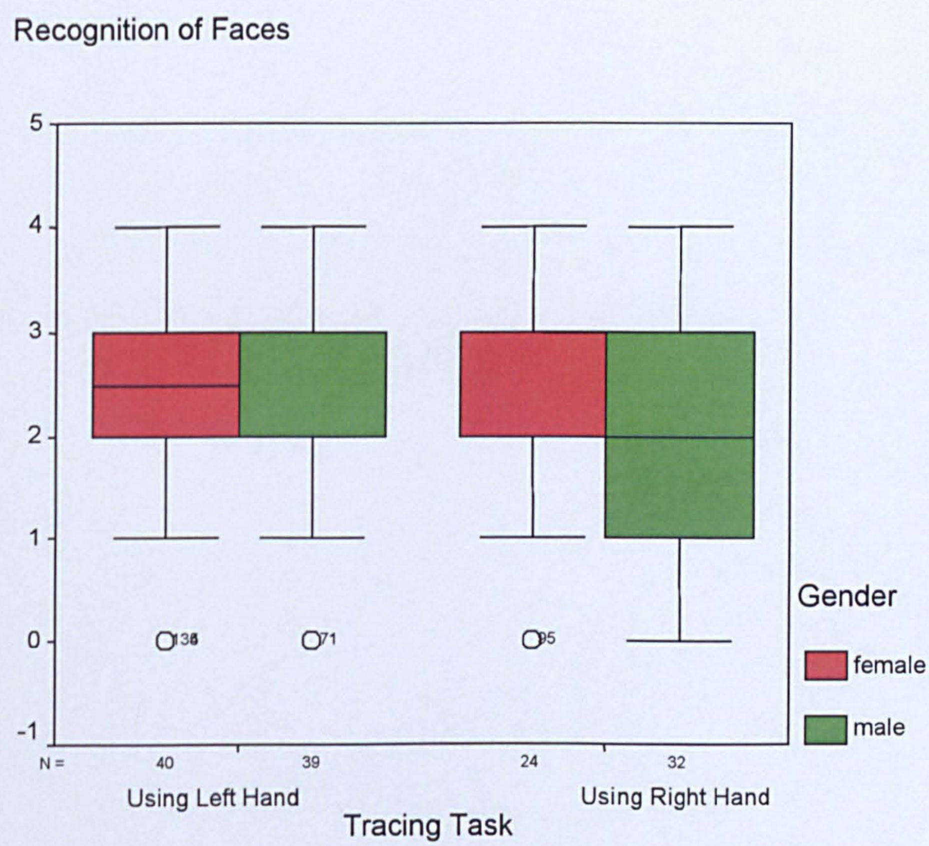


Figure 6.5: Box Plots of Faces Recognised According to Tracing Hand and Gender

The box plots show the data is normally distributed. All the extreme (outlier) scores are for the score of 0 faces recognised.

The median scores are, 2.5 left hand female, 2 left hand male, 3 right hand female and 2 right hand male. There is less difference between male and female in the left hand group than the right hand group. Females have the higher median score for both hands indicating female ability. There does not appear to be a significance difference in hand used. Concerning distribution of data, the 3 groups, females left hand, females right hand and males right hand, all have similar distributions. The distribution of the males right hand being wider.

6.5.4 Frequencies

To explore hand and gender comparison Figures 6.6 and 6.7 further illustrate the data showing which scores were most common. Figure 6.6 comparing use of left hand and right hand in males and Figure 6.7 comparing use of left hand and right hand in females.

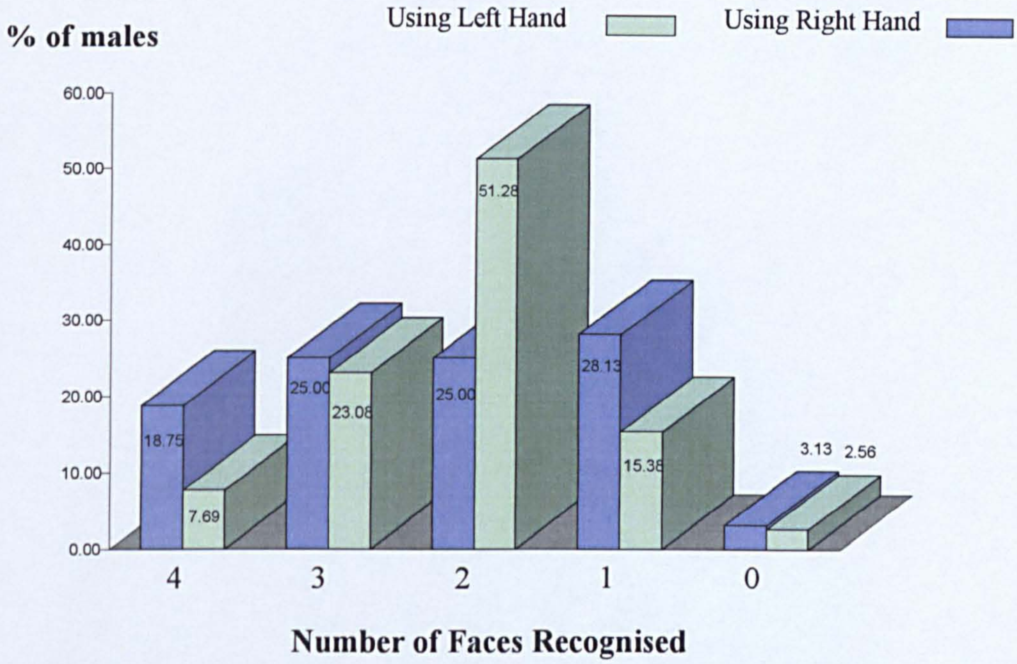


Figure 6.6: Frequency of Scores: Right Hand Versus Left Hand for Males

The highest frequency for the males was recalling 2 faces whilst tracing with their left hand (51%).

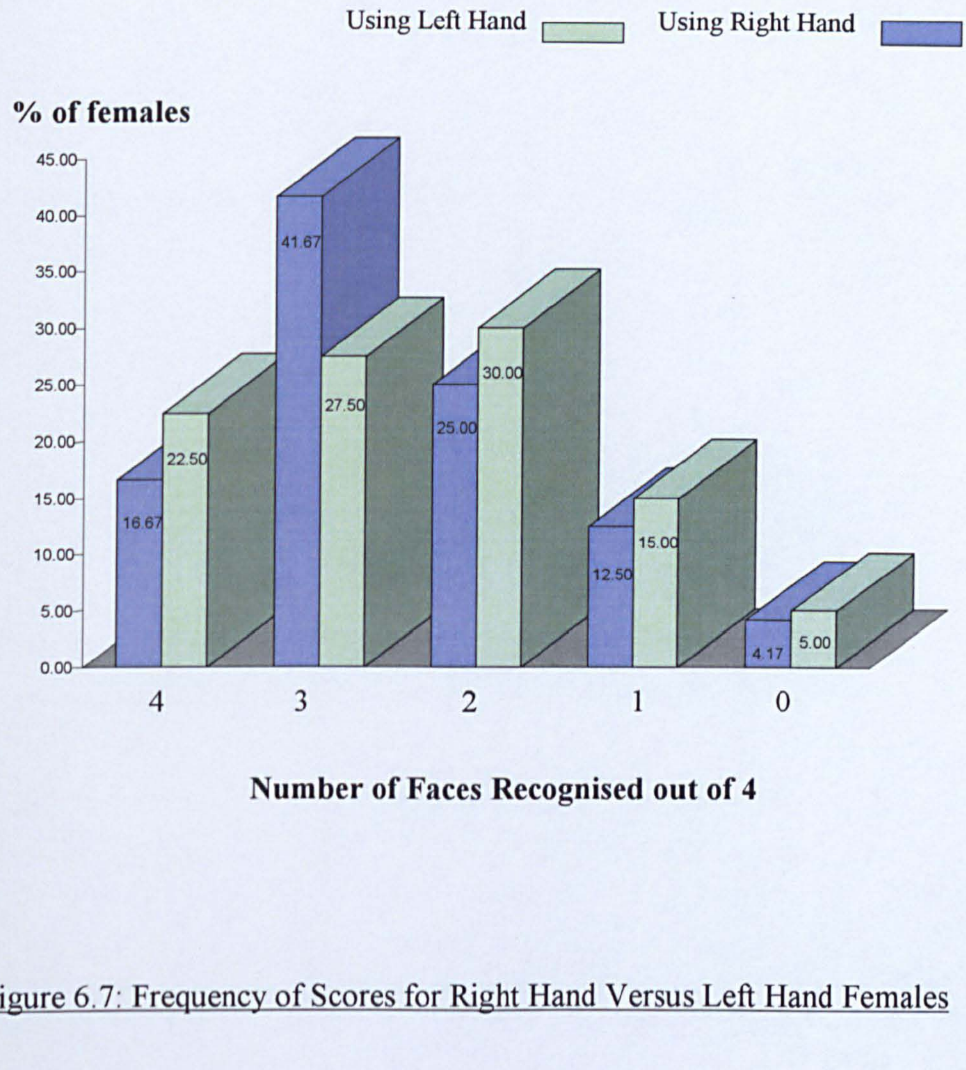


Figure 6.7: Frequency of Scores for Right Hand Versus Left Hand Females

The highest frequency for the females was with their right hand recalling 3 faces (42%).

Comparing differences

In order to visualise any potential differences between those using their left hand and those using their right hand and gender Figure 6.8 is shown overleaf. This Figure has been created by subtracting the right hand score from the left hand score for each frequency to highlight the hypothesis that the left hand/right hemisphere score should be higher thereby producing a positive score.

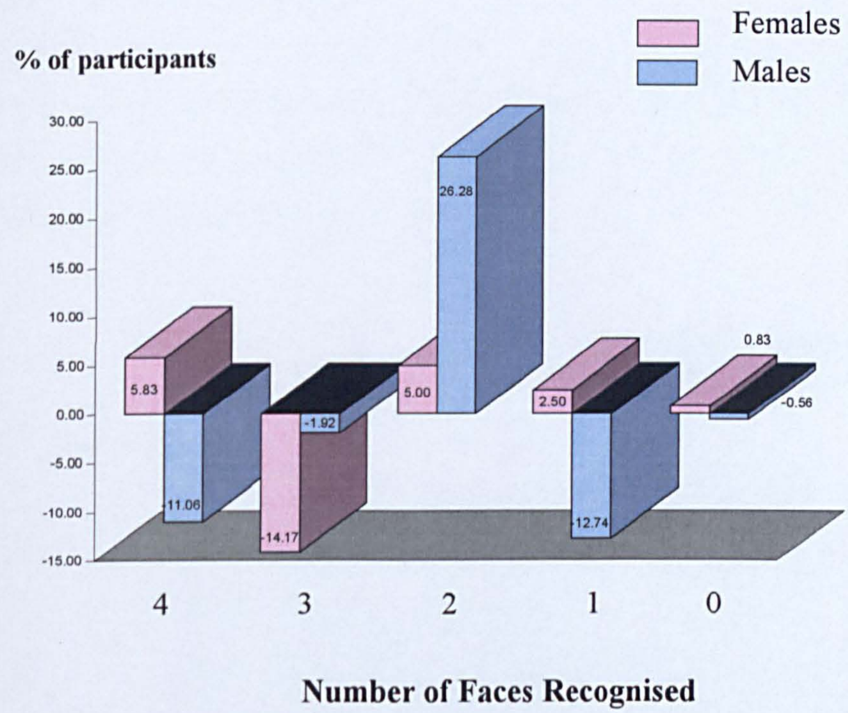


Figure 6.8: Comparison of Use of Hand and Gender (Left Hand Score Minus Right Hand Score)

The most interesting comparison is between the use of one hand over the other was for the males recognising 2 out of 4 faces.

Of those who remembered no faces the hand used did not appear to make much difference to males or females.

Cumulative accuracy ratings

The data has also been analysed cumulatively to illustrate at what point the apparent differences occur. These are graphically shown in Figure 6.9 for the males and Figure 6.10 for the females.

The frequency of remembering at least one face is extremely high for all groups. This indicates that test difficulty is about right, avoiding either floor or ceiling effects which would have hidden any effect.

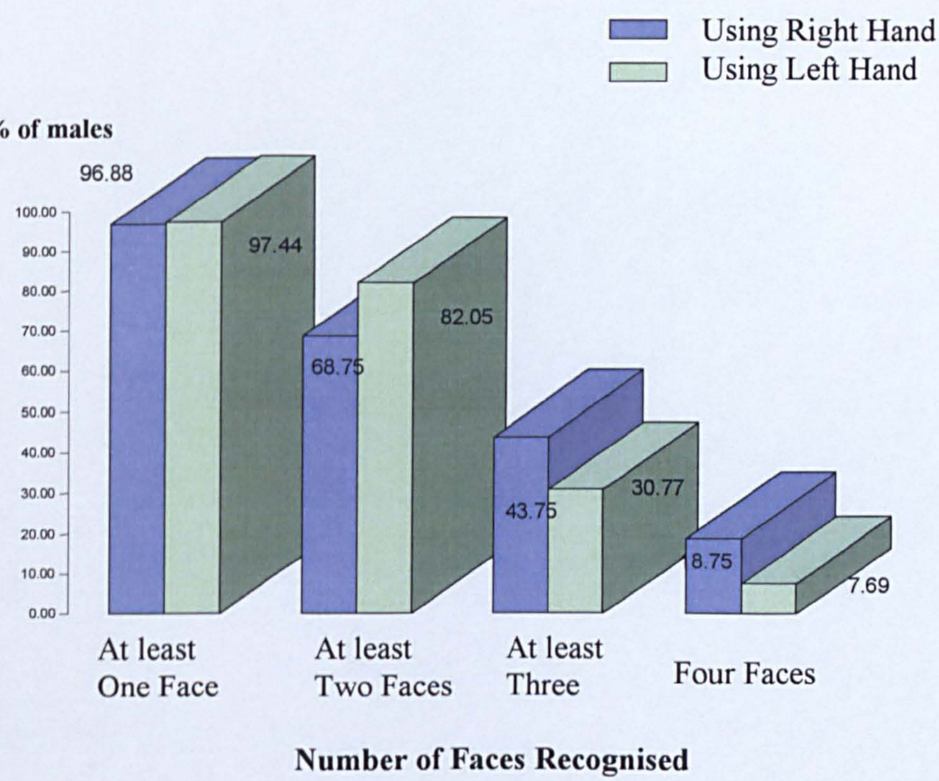


Figure 6.9: Cumulative Scores Comparing Hands – Males

At recalling at least 3 faces score, the right hand shows an apparent dominance for both males and females. The frequency for recalling at least 2 faces is the same for each hand in the female group and the same as the females in the male group but only for the left hand. The right hand shows a lower score for the males.

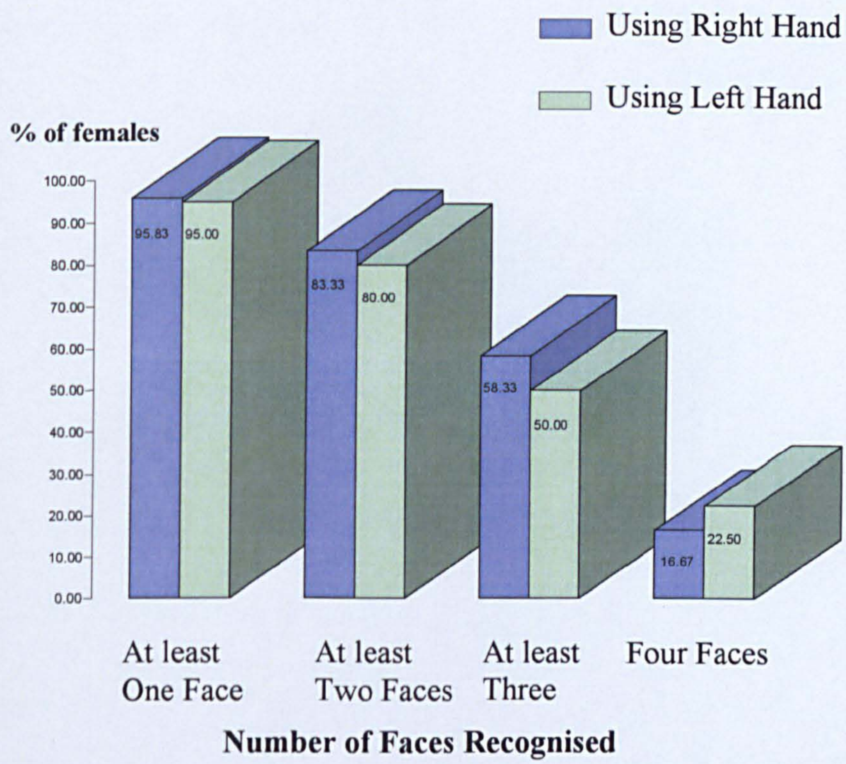


Figure 6.10: Cumulative Scores Comparing Hands – Females

Comparing differences

As before the right hand scores were subtracted from the left hand scores to illustrate where positive scores are shown, indicating left hand/right hemisphere superiority.

There were only 3 positive scores, two in the female group and one in the male group. The biggest of these was in the male group, recognising at least two faces (13%). Similar size differences were shown in the negative scores for the males indicating the hypothesis is not likely to be proven.

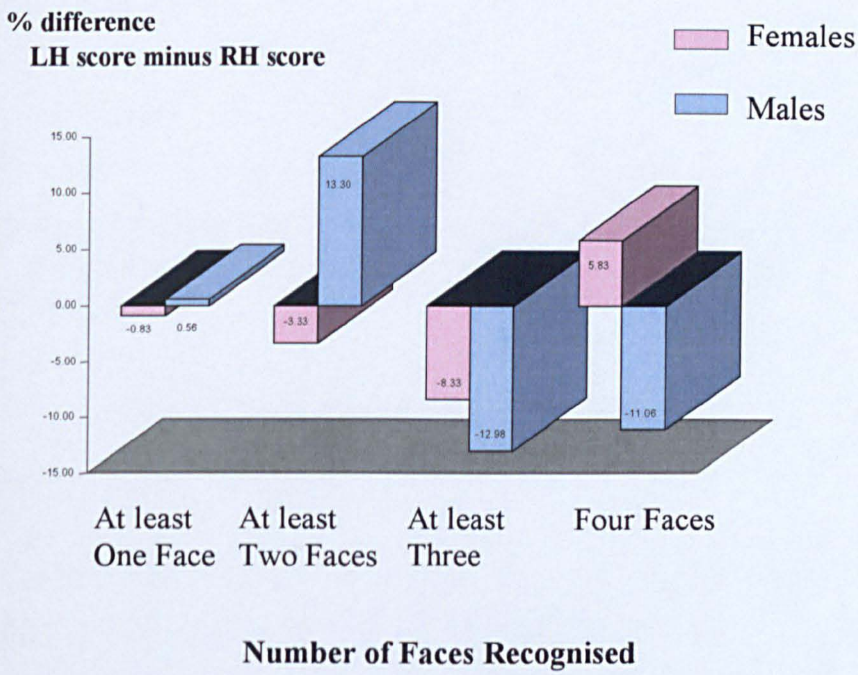


Figure 6.11: Cumulative Comparison of Use of Hand and Gender (Left Hand Score Minus Right Hand Score)

The ANOVA

The number of faces recognised was analysed using a factorial analysis of variance with the two between-participant factors of handedness (right hand versus left hand) and gender (male versus female).

	df	F	Significance
Comparison of Number of Faces Remembered Dependent on Right Hand or Left Hand Tracing	1, 131	0.200	0.655
Effect of Gender	1, 131	2.182	0.142
Interaction Between Number of Faces Remembered and Different Tracing Hand and Gender	1, 131	0.009	0.926

Table 6.2: ANOVA results for Factors of Hand Used for Tracing and Gender

As shown in Table 6.2, above, the use of one hand over the other for tracing is not significant (0.655) and therefore does not affect face recognition. Also the interaction between tracing and gender is not significant (0.926) so gender is not affecting the ability to trace. Also, the factor of gender is not significantly (0.142) affecting face recognition.

Therefore, any apparent differences from the explorations of data are incidental or are exaggerated by the scales on the graphs.

6.6 Discussion

The hypothesis for this Experiment was that those using their left hand for the tracing task would show a better score for recognising faces than those using their right hand was disproved.

The tasks involved were a right hemisphere task of face recognition with a manipulation task of tracing which could invoke the left or right hemisphere. The purpose of the tracing task was to cause arousal of the contralateral hemisphere through the use of one particular hand only. The face recognition task was measured by number of target faces correctly identified after a three week period.

The summary of the findings for this Experiment was that there was no difference in ability to remember faces due to use of tracing hand. Also, that there was no difference in ability to remember faces due to gender.

There was no evidence of an interaction between the hand used for tracing and gender.

Relating back to the literature, the task of face recognition of unfamiliar faces has been evidenced to be a right hemisphere preferred task. Also, any information which would have aroused left hemisphere processing was eliminated from the photographs. As mentioned before, there is evidence for contralateral control for precision skills and tracing was chosen to fit this criteria.

This research does not give an advantage for those participants who are using their left hand for the tracing. It could mean that instead of increasing face recognition ability through arousing the right hemisphere with the tracing task, that instead, it is competing for the same hemisphere's resources and that this is inhibiting the right hemisphere's ability to perform the task.

Springer and Deutsch (1998) gives warnings that because this subject area involves individuals with complex systems that sometimes in testing and retesting experiments can show different results. They give the example that some participants, having shown a right ear advantage in a dichotic listening test shifted to a left ear advantage a week later. They state that tachistoscopic studies have also shown this variability. In these cases it is assumed that the organisation of the brain has not changed but the strategy of individual thinking processes may have. This may be what has happened here.

7 Experiment 3: Perception of Emotional Intonation in Speech – Hemispheric Differences

7.1 Introduction

Emotional intelligence is non-cognitive intelligence which covers such aspects as understanding one's emotions and knowing how to manage them and understanding others' emotions and thereby managing relationships with others. It is considered to be an important factor of success in management and leadership roles. Therefore, management and leader educators need to be helping students to develop emotional intelligence.

Emotional Intelligence, in essence, has been around since 1920 under the term Social Intelligence and much work in this area has been done by Mayer et al (1993). They define Emotional Intelligence as "a type of social intelligence that involves the ability to monitor one's own and others' emotions, to discriminate among these, and to use the information to guide one's thinking and actions" . More recently Goleman (1996) has given this area of research more publicity and it has now become an area of research which is more widely known. Emotional Intelligence Competencies are the evidence of ability in the areas of Emotional Intelligence. These are usually the intelligence having become skilled and developed to form a recognised competence. These competences contribute to a leader's ability to monitor his or her own emotions but also to correctly gauge the emotions of others and therefore respond more appropriately (Goleman 1996, 1998)

In leadership studies today it is considered important for individuals to have this ability to perceive emotions so that they can be more effective in their interpersonal communication. One difficult area in perceiving emotion is when listening to someone on the telephone as there are no indications of facial or bodily expression to aid the perception. Some leadership programmes using popular psychology have suggested that ability to perceive the emotion of the person on the other end of the phone can be improved by placing the phone against the left ear thereby accessing the right hemisphere which is considered to have superiority is perceiving emotion. However, although much literature support the right hemisphere as superior for perceiving emotional intonation, it has become unclear as to whether this is for both negative and positive emotions.

7.2 Hemispheric Asymmetry of Emotional Perception

Much of the literature indicates that the right hemisphere is dominant for the perception of emotion expressed in speech intonation. Springer and Deutsch (1998) points out that the right hemisphere is generally agreed to have dominance for emotional perception. One example is Heilman et al (1975), who reported that patients with damage in the right hemisphere had greater difficulty picking up the emotional messages conveyed by speech intonations than did patients with damage to the left hemisphere. This particular experiment used four faces, one happy, one sad, one angry and one neutral and voices to go with them. The weakness of this experiment was that it involved faces as well as voices which may involve different processes. (Borod 1992). Therefore, further experimentation was carried out by Tucker et al (1977) using pairs of sentences with vocabulary which was emotionally neutral but with emotion expressed through the tone of voice used. Participants were asked to say if the sentences were intonating the same or different emotions. Those with right hemisphere lesions performed poorly. However, when identifying emotions conveyed by a story they performed as well as the controls.

Hellige (1993) reports that two hypotheses on hemispheric asymmetry and emotion have been popular in research studies. Firstly, that of right hemisphere dominance for emotional expression and perception and secondly, that of right hemisphere dominance for production and perception of 'negative' emotions and left hemisphere dominance for production and perception of 'positive' emotions. However, there is far more evidence to support the first hypotheses with conflicting evidence for the second. Further exploration is needed to research the second hypothesis.

7.2.1 Positive versus Negative Emotions

Most of the evidence points to the right hemisphere being overall dominant for emotional perception. However, the main stimulus for such studies is facial expressions. Researchers argue that this is despite the difference being greater than just the advantage for spatial and face recognition. However, added to these advantages for the right hemisphere there is also the fact that the left hemisphere is used to compare facial expressions, see section 6.2.3, and so this will confuse the data.

Looking specifically at intonation of emotion Ley and Bryden (1982) provide evidence for a right hemisphere advantage in perceiving tone of emotion. Participants, 17 male and 15 female, listened to sentences with intonation of happy, sad, angry or neutral and were asked to identify the emotion heard and also the verbal content. A right hemisphere advantage was shown for the perception of emotion and a left hemisphere advantage for the accuracy of the verbal content. There was no advantage for the right hemisphere for perception of negative emotions. A later experiment by Bryden and Macrae (1989) showed that the right hemisphere advantage for identifying the emotional tone was stronger for negative emotions. The stimuli used in the experiment were two syllable words rather than sentences so this may have made a difference. There is some evidence that the valence of emotion is what determines the right or left hemisphere advantage based on electrophysiological responses. These were tested by watching video clips designed to elicit positive or negative emotions. However, this is the participant experiencing emotion rather than perceiving it from intonation and may be a different mental function. Hellige suggests that there is also another argument, in that it is the level of activation within the hemisphere itself that determines the perception of the emotion, ie that if the right hemisphere is activated then the emotion perceived is likely to be more negative.

7.3 Experiment 3

This experiment is designed to try to bring clarification to the debate as to whether there is a difference in the way the right hemisphere and the left hemisphere perceive emotions in speech intonation. In their book Brainsex, Moir and Jessel (1989) assert that the function of emotion resides in the left hemisphere for males and both hemispheres for females and that females are generally better at recognising emotional nuances in a voice. Therefore this experiment will be limited to females only.

Unlike the first two experiments, this experiment does not involve use of hand as an experimental factor. Originally an experiment based on the evidence that emotional perception was a right hemisphere task was planned. This was to incorporate fine motor control. However, in the light of the current debate and conflicting evidence suggesting the right hemisphere is not solely involved in emotional perception, as was previously thought, it was felt not to be an assumption with enough validity. It was decided that a more relevant experiment would be one where the newest idea, of the left hemisphere perceiving positive emotions and the right hemisphere perceiving negative emotions, was tested.

Hypothesis

That the right hemisphere would be more accurate at perceiving the negative emotions and that the left hemisphere would be more accurate at perceiving the positive emotions in speech intonation.

7.4 Method

This is an experimental design with 1 between-subject factor, namely; use of ear. This experiment is not testing for the experimental affect of using a particular hand, for a fine motor control task, but participants did use a hand as a means of recording their responses. Other methods of recording responses were considered such as speaking them out. However, speaking invokes left hemisphere control so this was not helpful. The participants chose their response by ticking one of four options - to do this they used the hand on the *same* side as the ear so that they would be stimulating the *same* hemisphere. The dependent variable is the ability to perceive emotion.

7.4.1 Participants

The participants were undergraduate female English speaking students of the University of Liverpool and University of Salford. Ages were not recorded but none of the students were obviously mature students so that the age range was considered to be between 18 and 24. They were classified as strong right handed according to the classification system described earlier in section 3.5. The participants were voluntary to the extent that they were required to be involved in some experimental work and chose this particular experiment from other experiments.

7.4.2 Materials

A table top tape recorder with press buttons for play, wind, rewind, pause, volume control, balance control and a socket for earphones was used. Earphones were connected to the tape recorder via the appropriate socket and placed over the participant's ears. The balance control was either set to 'left' or 'right' for each participant so that they would hear the tape through only one ear. The volume on the tape recorder was set to 'low' and stuck down with sellotape to ensure it was not raised. This was to ensure that no sound came from one earpiece to be heard by the 'other' ear.

For participants to record their results notebooks of response sheets were made. These were small pieces of paper (4" x 4") stapled in the left hand corner. On each piece of paper there was a vertical 'bullet point' list of 4 emotions: surprise, happiness, sadness, anger, in bold type and size 16 font. See Figure 7.1.

/ Participant:
Tape:
Sentence:

- Surprise
- Happiness
- Sadness
- Anger

Figure 7.1: Layout of the Response Sheet

The response sheets were designed in this way so that the participant did not have on view their previous responses in case they influenced their further responses. It was felt that if all the responses were on one sheet of A4 the participant may subconsciously try to balance out their responses across the choices. Two tapes containing 10 sentences each were used for each participant.

7.4.3 Procedure

All participants were asked to complete the 'handedness questionnaire' and anyone who was not scored as strong right hander was excluded from the study.

An instruction sheet was read out to the participants which said:

Please fill out this handedness questionnaire.

This exercise is about how we hear emotions.

I will be playing you two tapes of someone speaking out statements. There are 10 statements on each tape.

I want you to decide whether the emotion you sense is: surprise (in the sense of delighted surprise), happiness, sadness or anger. If you are not sure then choose the nearest that you think it is. Always try to choose something

The sentence will be played only once. The volume is deliberately low so please listen carefully.

There will be a practice first so that you can ask anything you are unsure about.

I would like you to press the play button with your right (left) hand when you are ready to start.

I would like you to use your right (left) hand to tick the response that you feel matches the emotion in the sentence you hear. Please place your other hand under the table.

You will only hear the sentence in your right (left) ear.

After the sentence has played I would like you to press the pause button with your right (left) hand and then tick the item you feel matches the emotion you have perceived.

Figure 7.2: Script for Experiment

The participant was placed at a desk with the table top tape recorder in front of them so that they could easily reach the buttons. They were handed the response notebook and a pen.

The participant then carried out a practice with a tape that was not to be used in the experiment. It had the same voice as the test tapes. It had 2 sentences on it – each repeated with the intonation of happy, excited, sad and angry. Two practices with this tape were permitted.

Design Features

Sentences were recorded onto tapes each portraying one of four emotions and these were piloted on members of the general public. These were of the voice of the researcher who has experience in amateur dramatics. Pilot participants listened to them through earphones with the volume equal for each ear ie being received by both hemispheres. This gave a confirmation as to whether the perceived emotions correlated with the recorder's intentions. Discussion also took place as to how the individual felt doing the exercise. The sentences were modified in accordance with the feedback from these individuals. In general the emotions were accurately judged in each sentence but one or two clarifications needed to be made. One of the comments was that the 'anger' statements were easier to pick out because it seemed a 'stronger' emotion. It was therefore given slightly less emphasis in the test sentences. On one of the tapes there was an occasion where three sentences conveyed the same emotion which was 'happiness'. Pilot participants reported that after selecting 'happiness' twice they felt it was unlikely to be a happiness sentence again and were tempted to report 'surprise' as the other positive option. Whilst this is not a problem in comparing positive with negatives it would not allow analysis for appreciation of subtleties if this was not corrected. To take account of this repetitions of two were the maximum.

In the pilot there was a comment that the mood of the participant might affect their perception of emotion heard. As this would be random for all participants it was not considered a problem since participants were not connected in any way and not likely to have experienced similarly negative or positive emotions prior to the experiment.

On each tape there was a balanced mixture of sentences intonating positive and negative emotions. The positive sentences were made up of 'delighted surprise' and 'happiness' and the negative sentences made up of 'anger' and 'sadness'. Because it was commented in the pilot that anger seemed a stronger emotion, more emphasis was given to the sadness sentences, with 6 occurrences, leaving 4 occurrences of anger sentences to make up the suite of negative intonated sentences. The positives contained 5 each of happiness and surprise as these were more balanced in their intensity.

Figure 7.3 overleaf shows the way the balance of sentences was achieved.

Tape 1	Tape 2
Surprise	Sadness
Surprise	Happiness
Sadness	Anger
Anger	Surprise
Sadness	Happiness
Sadness	Happiness
Happiness	Anger
Anger	Surprise
Happiness	Sadness
Surprise	Sadness

Figure 7.3: The Order in Which Emotions Were Articulated

Statements were made fairly short and in content were as bland as possible so as to minimize any language that may give emotional cues. It was the intonation that was the experimental factor. Also, sentences were constructed carefully so that each was able to be intonated for all 4 emotions and still make sense. If different sentences were used for different emotions then they would not be so easily compared. The wording of the sentences is given in Figure 7.4 over the page.

Wording used for Sentences	Emotion attributed in Tape 1	Emotion attributed in Tape 2	Emotion attributed in practice
It went absolutely everywhere	Surprise	Sadness	
The door opened and guess who I saw?	Surprise	Happiness	
It was as if it had never happened	Sadness	Anger	
We are going to start from the very beginning	Anger	Surprise	
I didn't have a clue it was happening	Sadness	Happiness	
I wonder why she said it	Sadness	Happiness	
They didn't even see it coming	Happiness	Anger	
It went down all ten floors	Anger	Surprise	
He walked up to it and patted it	Happiness	Sadness	
But guess what happened next?	Surprise	Sadness	
Practice Sentences			
Do you think we could manage that			Happiness
How do I know what's coming next			Sadness
Do you think we could manage that			Surprise
How do I know what's coming next			Anger
Do you think we could manage that			Sadness
How do I know what's coming next			Happiness
Do you think we could manage that			Anger
How do I know what's coming next			Surprise

Figure 7.4: Emotionally Intoned Sentences

7.4.4 Measures

The responses from each participant were counted up for each category of 'surprise', 'happiness', 'sadness' and 'anger'. Therefore the expected score for 'surprise' and 'happiness' was 5, for 'anger' 4 and for 'sadness' 6. The total score expected for 'positive' was 10 and also 10 for 'negative'. Any movement either side of the 10 would give an indication of perception of more positive or more negative than expected. A maximum possible under each category is 20, that is, being all sentences classified as one emotion only.

7.5 Results

The purpose of the analysis is a comparison between those using right ear and those using left ear with the hypothesis that those using the right ear would perceive more of the sentences as intonating positive emotions. It is also of interest to see whether within the categories of 'positive' and 'negative' the different intonations of 'surprise', 'happiness', 'anger' and 'sadness' were easily differentiated.

7.5.1 Means and Standard Deviations

The means and standard deviations were calculated and are given in Table 7.1 overleaf.

	Score of 'surprise'		Score of 'happy'		Score of 'anger'		Score of 'sadness'		Score of Total Positives	
Number of Sentences Presented	5		5		4		6		10	
Ear	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
Hemisphere	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Mean	5.07	4.83	4.57	4.58	3.57	2.08	6.79	8.5	9.64	9.42
Movement	+0.07	-0.17	-0.43	-0.42	-0.43	-1.92	+0.79	+2.5	-0.36	-0.58
SD	0.829	1.337	1.342	1.443	1.089	1.564	1.847	1.508	1.946	0.515
% of those presented	101	97	91	92	89	52	113	142	96	94

Table 7.1: Mean Scores and Standard Deviations of Scores for Each Emotion (in each case the maximum obtainable is 20)

There was a total of 20 sentences presented, so the maximum possible in each category is 20.

The interesting scores to note from the above table is that the left hemisphere only perceived 50% of the anger sentences as anger but 142% of the sadness sentences, that is, other sentences were stated to be sadness when they were not.

Both hemispheres perceived more sadness than actual sentences presented with that emotion. Also, the left hemisphere perceived more than the right which was unexpected. Where the right hemisphere was expected to perceive negative emotions more than the left hemisphere it did for anger but not for sadness. Overall the expectancy for left hemisphere to perceive positive more than the right hemisphere this has not been shown.

7.5.2 Exploring the Distributions of the Data

Figure 7.5 overleaf shows the results for the overall positive scores (that is happiness and surprise added together).

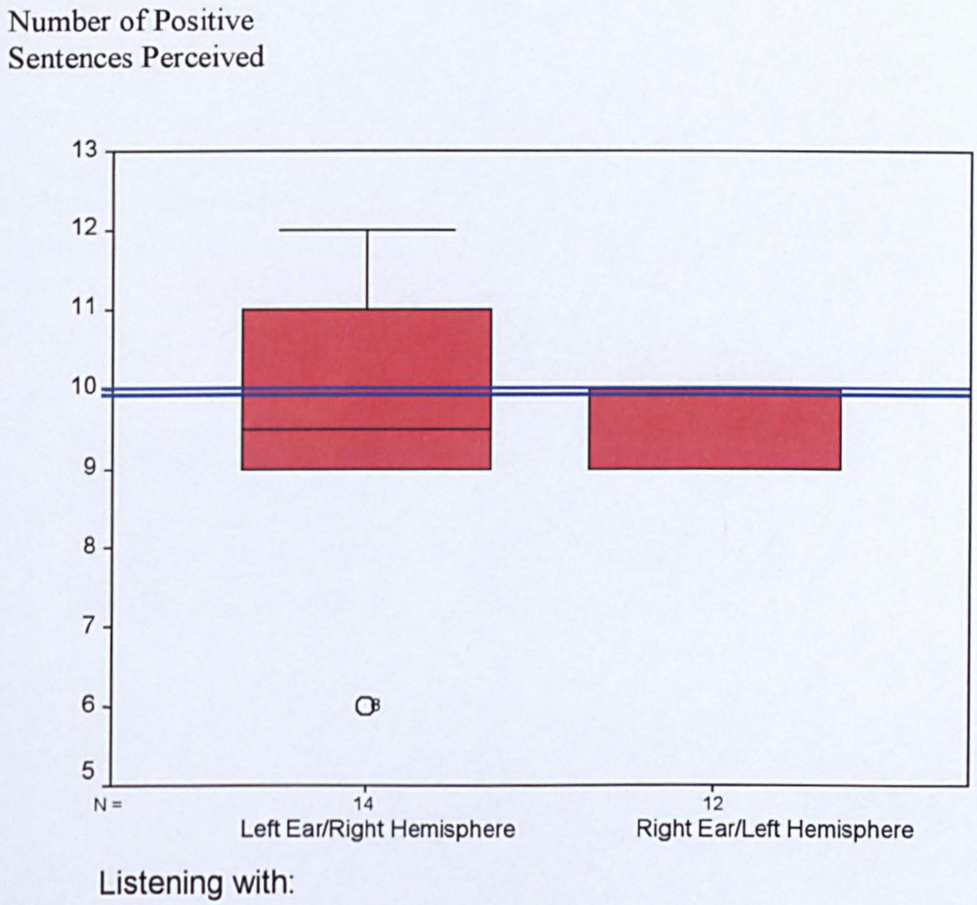


Figure 7.5 :Comparing Left Hemisphere and Right Hemisphere Perception of Overall Positive Emotions ((The Number of Presented Sentences was 10 as Indicated by the Blue Horizontal Line)

The distribution of those using left ear/right hemisphere was far wider than those using the right ear/left hemisphere. The distribution of those using the right ear/left hemisphere and hand is very narrow with all scores being either 9 or 10 with the median score being 9. Neither distributions are normal. It appears from this box plot that the right hemisphere is perceiving more of the positive emotions which is against the hypothesis.

Figure 7.6, below, compares the two positive scores, that is, the 'happiness' score and the 'surprise' score.

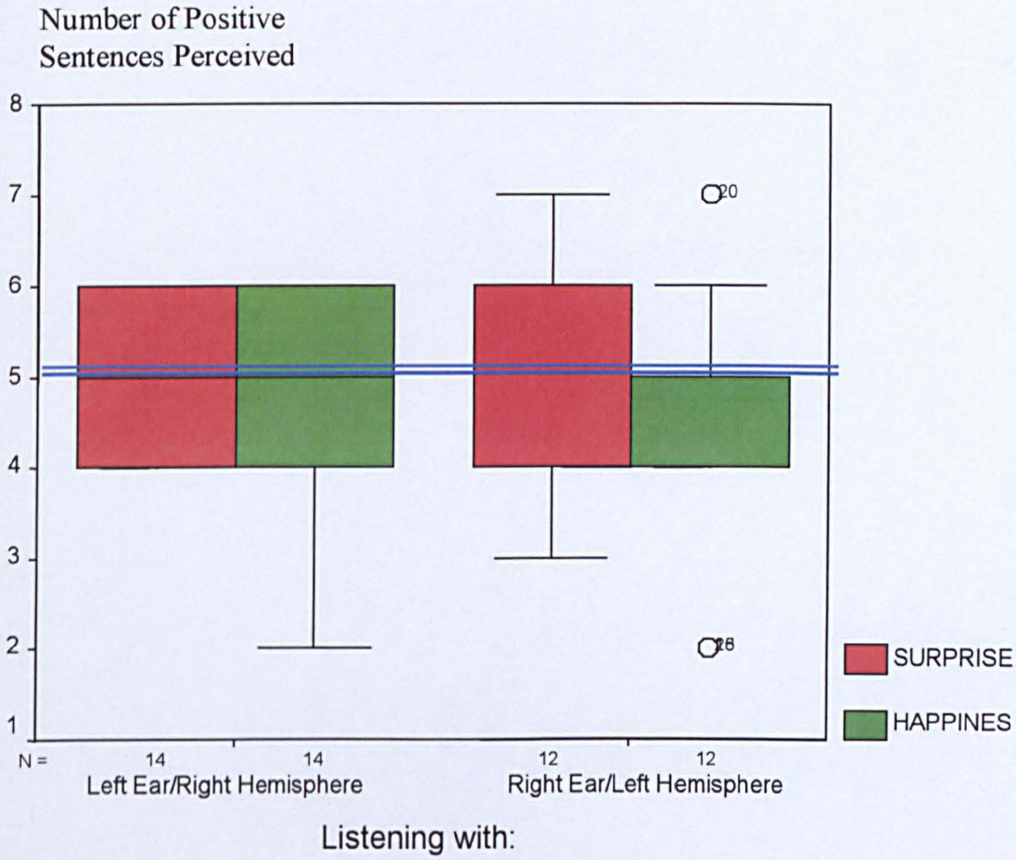


Figure 7.6: Comparing Left Hemisphere and Right Hemisphere Perception of Surprise and Happiness Displayed Together (The Number of Presented Sentences was 5 for each as Indicated by the Blue Horizontal Line)

Three of the median scores are identical (just under the 5 score blue line) which is exactly the number of sentences presented with that emotion intoned. The dispersement of each data set is slightly different from each other. The data set for the right hemisphere perception of surprise (in red on the left) is narrow showing all individuals perceived surprise within one sentence of each other. Even more narrow is the distribution of the data set for the left hemisphere's perception of happiness (in green on the right of the graph) with 50% of the individuals perceiving happiness in all or just one less of the sentences presented.

Figure 7.7, below, shows the distributions for the data sets for overall negative scores (that is, sadness and anger added together).

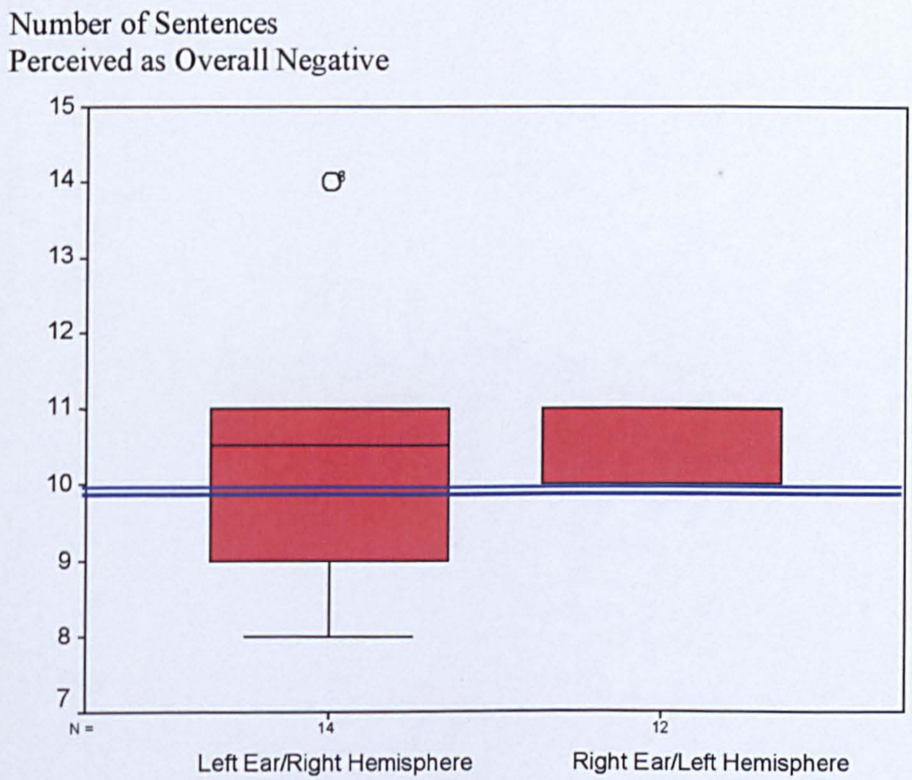


Figure 7.7: Comparing Left Hemisphere and Right Hemisphere Perception of Overall Negative Emotions ((The Number of Presented Sentences was 10 as Indicated by the Blue Horizontal Line)

The distribution for the left hemisphere perception is narrow with all participants scoring the number of sentences presented or one more than that. The right hemisphere shows a wider distribution with 50% of the data within one score (more or less) of perceiving the negative emotions. Visually, this looks as if the left hemisphere is perceiving negative emotions more than the right which if significant would go against the hypothesis.

Figure 7.8, below, shows the distributions of the data sets for the emotion of Anger.

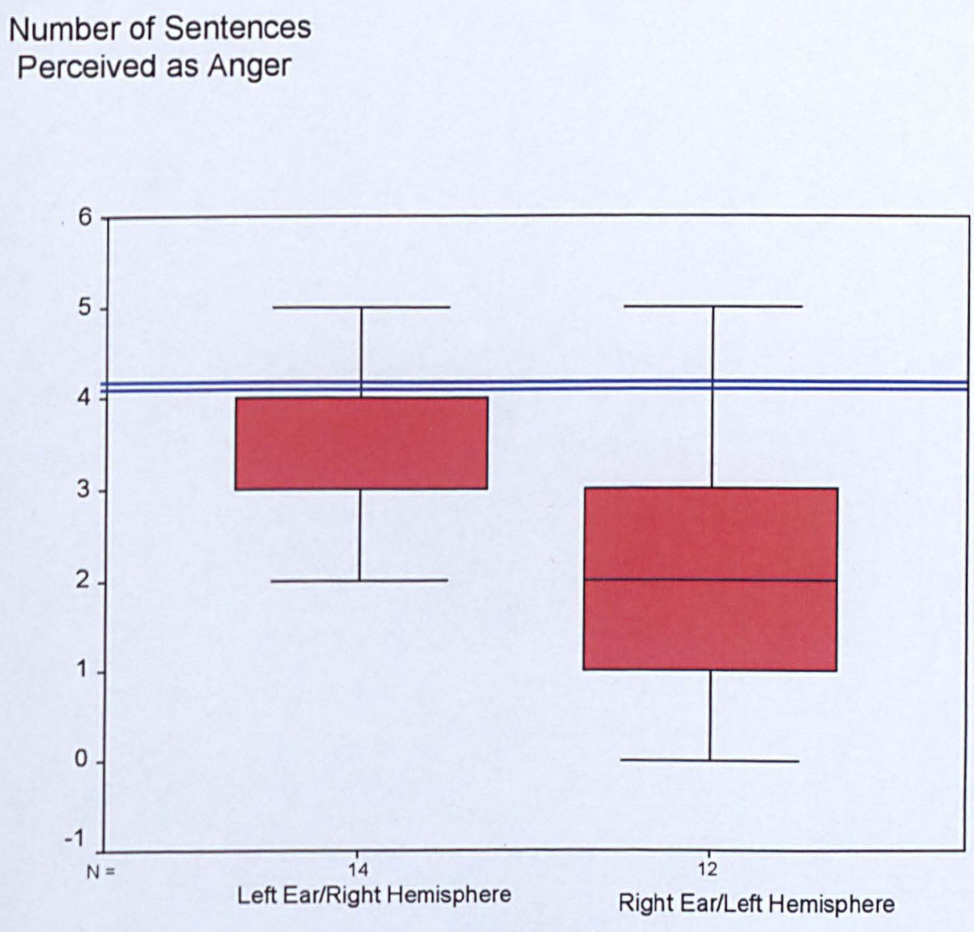


Figure 7.8: Comparing Left Hemisphere and Right Hemisphere Perception of Anger (The Number of Presented Sentences was 4 as Indicated by the Blue Horizontal Line)

It is interesting to see that the left hemisphere data set, on the right of the graph, only just includes, within it, the actual number of sentences presented (4) and does not include this number in the box showing 50% of the distribution. Most people perceived this less than presented, between 1 and 3 sentences only. Anger has not been perceived strongly by either hemisphere which could have implications for the accuracy of the stimuli. For the right hemisphere most of the scores are equal to or slightly lower than was presented with 50% falling in the 3 to 4 sentences range. It would appear from this box plot that the left hemisphere perceived anger more than the right which goes against the hypothesis.

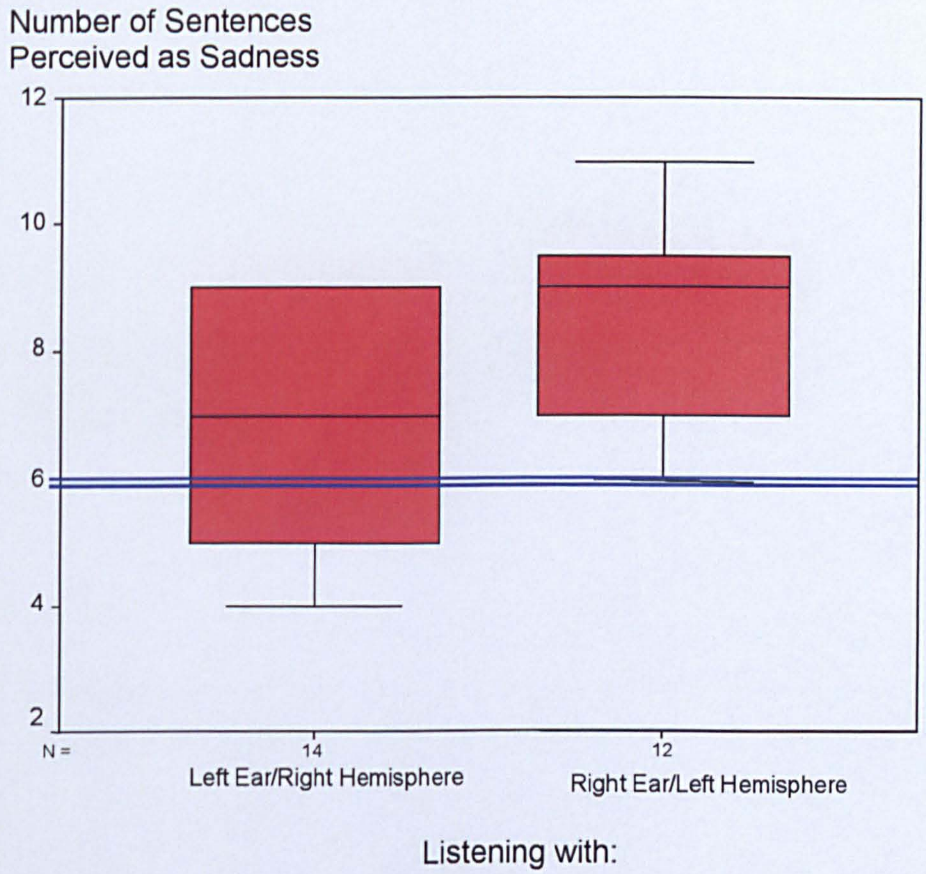


Figure 7.9: Comparing Left Hemisphere and Right Hemisphere Perception of Sadness (The Number of Presented Sentences was 6 as Indicated by the Blue Horizontal Line)

Figure 7.9 above, compares the other part of the negative emotions which is sadness. The right hemisphere (on the left of the graph) has a median point higher than the number of sentences presented (illustrated by the blue line) showing most people perceived sadness more than presented.

The anger and sadness box plots are not displayed together as they do not have the same number of sentences presented.

Figure 7.10 below, compares overall positive with overall negative scores.

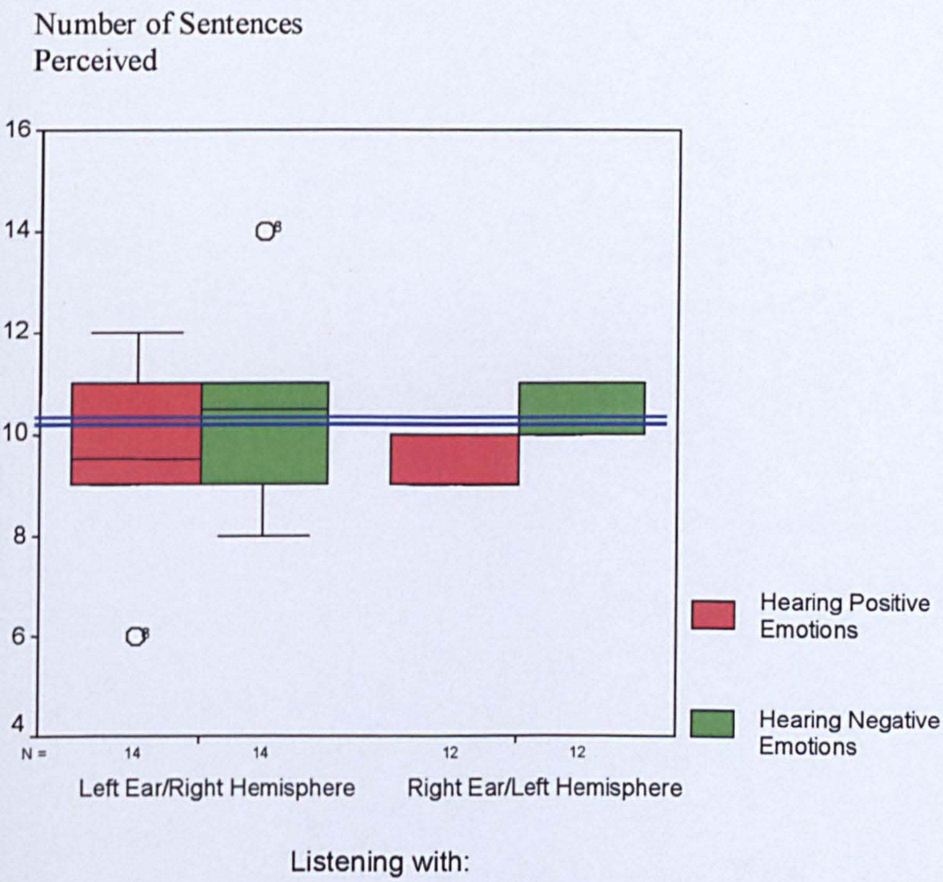


Figure 7.10: Comparing Left Hemisphere and Right Hemisphere Perception of Overall Negative and Positive Emotions (The Number of Presented Sentences was 10 as Indicated by the Blue Horizontal Line)

Again the blue line shows the number of sentences presented for each group.

On the left of the box plot above the distributions for the right hemisphere are skewed in opposite direction for emotion range. The distributions for the left hemisphere (on the right of the box plot above) are more narrow distributions. The right hemisphere has a higher median for the negative emotions than for the positive, having detected some of the positive emotions for negative ones. This is similar for the left hemisphere.

Figure 7.11 below shows the 95% confidence that the true mean lies as shown.

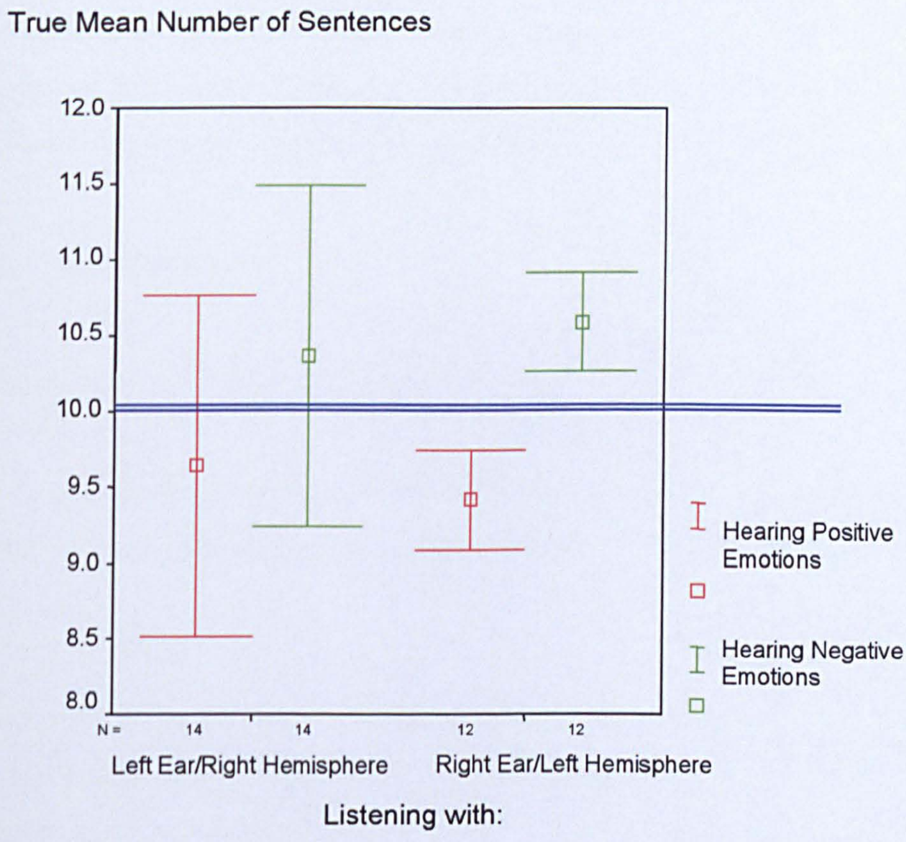


Figure 7.11: True Means (95% Confidence Level) for Perception of Overall Positive and Overall Negative Emotions (Blue Line Indicates Number of Sentences Presented)

Both hemispheres perceived the negative emotions more than the positive emotions with the left hemisphere having the greatest distance between the perception of positive against negative.

The t test was carried out to look for any difference at a statistically significant level in these observations. It was used to test for a difference in perception of positive emotions only, since perception of negative emotions is the opposite of this. In the data set for overall positive emotions there was one outlier. This was left in for the independent t-test.

The value of $t(15.092) = 0.418; p > 0.05$. This shows there is no difference in the perception of positive emotions by either hemisphere. Therefore, by default, there is also no difference in the perception of negative emotions by either hemisphere.

7.6 Discussion

The summary of the results is as follows:

There was no difference between the right hemisphere and the left hemisphere in ability to perceive positive or negative emotions. Therefore, the hypothesis is not supported.

Emotions are very hard to determine, sometimes shown in visual cues and sometimes, as here, in verbal cues. Part of the difficulty is in identifying emotions and overcoming individual perceptions of them. Each person will have an individual filtering and judgement system as to decide whether an emotion is positive or negative. The participants were only female in order to minimise differences in perception cause by gender. They were also of a small age range.

The experiment did not test for right hemisphere advantage for emotional perception generally so the results cannot contribute to that particular debate.

However, as concerns the debate concerning a difference in perception, by each hemisphere, of negative and positive emotions this research can be compared to Bryden and Macrae's work in 1989. This present research does not add to their evidence of a right hemisphere advantage for negative emotions. It differs however in that the latter used two syllable words rather than sentences. This current experiment does, however, corroborate Bryden's earlier findings, (Ley and Bryden 1982) that there is not a right hemisphere advantage for negative emotions. The two experiments, the current experiment here and Ley and Bryden's experiment, both used *sentences* as the stimuli (rather than single words) and also both used similar classifications, though the Ley and Bryden had a neutral category. It could be argued that sentences are a more realistic means of testing how someone would react in everyday situations rather than single words.

Considerations for further research would include two experiments, both with larger groups, but one using sentences as has been done here and the other using single words. This would highlight whether it is the stimuli that is giving different results and this factor alone would be interesting to explore.

8 Experiment 4: Creativity – Idea Generation

8.1 Introduction

This part of the research aims to increase our understanding of individual creativity and in particular two aspects of this namely, idea generation and problem solving. This section gives the rationale for choosing these two aspects for experiments to identify whether there is any benefit to individual creativity of using the non-preferred hand for handwriting regularly over a period of time.

8.2 Creativity

Creativity is a broad term which contains other elements within it. For the purposes of this current research the element of 'creative thinking' and 'creative process' are explored. Firstly, some definitions of creativity.

Creativity brings into being something that did not exist before, either as a product, a process or a thought (Fox 2003). Therefore "*you would be demonstrating creativity if you: invent something which has never existed before, invent something which exists elsewhere but you are not aware of, invent a new process for doing something, reapply an existing process or product into a new or different market, develop a new way of looking at something (bringing a new idea into existence), change the way someone else looks at something*" (Clayton 2003) These definitions emphasise the new existence of things or new context for things and includes new perceptions of things.

Franken (1998) defines creativity as a tendency to generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others. This definition focuses more on ideas than things and highlights the act of idea generation or seeing connections.

Csikszentmihalyi (2002) states that "*creativity is any act, idea, or product that changes an existing domain (of shared symbolic knowledge), or that transforms an existing domain into a new one. What counts is whether the novelty he or she produces is accepted for inclusion in the domain.*" Change is a key feature here in the bringing about of novelty which is deemed acceptable.

"*Creativity can be defined as many ways as it can be conceived. At its simplest, creativity could be described as the ability to create products or ideas which are original and which possess a strong social usefulness.*" (Preti 2003) Hinting at the complexity of creativity, this emphasises originality and usefulness

Frank Barron, one of the most important researchers in this field, offers a fuller description of creativity. Firstly, he states that creativity is considered in terms of the characteristics of the creative product and the social acknowledgement it obtains. A criterion of 'usefulness' is implied in this definition but is not essential to it. Secondly, he states that the creative product can be considered in its own context eg the difficulty of the problem resolved or identified, the elegance of the solution proposed, the impact of the product itself. Thirdly, that creativity can be conceived on the basis of the abilities that favour it, ie whether it be a skill or aptitude. (Barron 1998)

It is useful to note that creativity is not the same as innovation. Hunt distinguishes between creativity and innovation in the following way. Creativity is primarily an individual act, creating something that is novel, useful and valuable, whether it is an idea, a product, or concept. Innovation is the process of actually implementing some novel, new idea, product or process. (Hunt 2003)

8.2.1 Creative Thinking

Creative thinking is "the process we use when we come up with a new idea. It can be accidental or deliberate." (Fox 2003) It is the merging of ideas which have not been merged before. Brainstorming is a tool to encourage creative thinking: it works by merging someone else's ideas with your own to create a new one. You are using the ideas of others as a stimulus for your own.

Clearly creativity has something to do with originality and novelty, but it is just as clear that it cannot just be *equivalent* to something new, because so many new things are random, trivial or uninteresting. Therefore, creativity, or at least its success, is dependent to some degree on the awareness of what is already there A cancer cure is unlikely to be created by someone who does not know what ideas have already been tested. He or she may 'create' a hypothesis or ideas which may have been tried and abandoned long before. So, as Harnad (2003) has argued, novelty is not enough. Something creative must also have some *value* relative to what already exists and what is perceived as being needed.

8.2.2 The Creative Process

Some authors do not believe that creativity can be described as a process which involves a sequence of steps which can be segmented (see Vinacke 1953 and Wertheimer 1945). However, models can be useful as simple partial representations but criticality and caution should be applied at all times and models should be viewed flexibly and not rigidly and made clear that they are 'only' models not a reflection of reality.

According to Wallas (1945), the creative process can be seen as a model with four stages: preparation, incubation, illumination and verification:

The *preparation* stage consists of gathering relevant information and narrowing the problem until the obstacles are visible.

Incubation is a period in which the unconscious processes of the mind seem to work on the problem, but generally there should be no pressure for a solution so this could involve putting the issue aside for a time.

The *illumination* stage may come spontaneously or as a result of conscious effort. This is where intuition and insight produce new ideas as possible solutions to the problem.

Finally in the *verification* stage the intuitive solutions are tested for validity, then organized and elaborated into a finished solution.

It is interesting to see that in this model, which is still used as a basis for creative training today (Torrance 1988), planning takes place at the beginning and analytical thinking is used to judge the validity of ideas. This supports the notion that creativity uses both hemispheres. This view is quite common in the literature. (see Blakeslee 1980 page 45-51 for a review). "Creativity is equally dependent on the left brain's ability to grasp the value of a good idea when it appears and logically work out the problems it presents" (Blakeslee 1980)

There are numerous models of the creative thinking process (eg Arieti 1976, catalogued eight models that were proposed during the period 1908 to 1964) and more are being developed currently. However the purpose of this 'thesis' is not to explore these in particular but just to note that this is still an area of much debate and development.

Alex Osborn (1953), the developer of brainstorming, embraced a similar theory of balance between analysis and imagination in his 'seven-step model for creative thinking': his seven steps are **Orientation:** pointing up the problem, **Preparation:** gathering pertinent data, **Analysis:** breaking down the relevant material, **Ideation:** piling up alternatives by way of ideas, **Incubation:** letting up, to invite illumination, **Synthesis:** putting the pieces together, **Evaluation:** judging the resulting ideas. Looking at this from a hemispheric asymmetry point of view it could be said that the 'preparation', 'analysis' and 'evaluation' stages could be aligned to left hemisphere processes, the 'ideation' and 'synthesis' aligned to right hemisphere process and 'orientation' and 'incubation' involving both hemisphere processes.

A more contemporary and popular model is the 'creative problem solving' (CPS) model attributed to Isaksen and Treffinger (1985). This has 6 steps: namely, 'objective finding', 'fact finding', 'problem finding', 'idea finding', 'solution finding' and 'acceptance finding'. This model again illustrates the use of idea generation with analytical thinking. There is often a confusion of terms when creative thinking is seen as opposed to analytical thinking when in fact the latter is part of the former. What is illustrated here is that idea generation and synthesis are different from analytic and sequential but that all are used in a particular order to develop the process for creative thinking.

According to others, creative work requires applying and balancing three abilities, namely analytic, synthetic and practical, that have the potential to be developed. Sternberg defines these as such:

"'*Synthetic ability*' is what we typically think of as creativity. It is the ability to generate novel and interesting ideas. Often the person we call creative is a particularly good synthetic thinker who makes connections between things that other people don't recognize spontaneously.

'Analytic ability' is typically considered to be critical thinking ability. A person with this skill analyzes and evaluates ideas. Everyone, even the most creative person you know, has better and worse ideas. Without well-developed analytic ability, the creative thinker is as likely to pursue bad ideas as to pursue good ones. The creative individual uses analytic ability to work out the implications of a creative idea and to test it.

'Practical ability' is the ability to translate theory into practice and abstract ideas into practical accomplishments. An implication of the investment theory of creativity is that good ideas do not sell themselves. The creative person uses practical ability to convince other people that an idea is worthy. For example, every organization has a set of ideas that dictate how things, or at least some things, should be done. To propose a new procedure you must sell it by convincing others that it is better than the old one. Practical ability is also used to recognize ideas that have a potential audience. (Sternberg and Lubart 1995).

8.2.3 The Role Of Idea Generation In Creativity

When analysing the definitions of 'creativity' it is clear that there is an array of thinking processes which make testing very difficult. However, it is possible to test for an individual process. The 'generation of ideas' is always a core factor in the definitions. In addition to being 'core' it is usually the first step in the creative process (after establishing facts about the current status of knowledge) and therefore if creativity is to exist then idea generation must be evident as creativity cannot even start without it.

This importance of the 'generation of ideas' has led to many techniques being developed. Brainstorming, being a 'group' technique is probably the most well known. However, it is not really related to 'individual' creativity or 'individual' idea generation. The idea generation ability of the individuals within the group will affect, positively or negatively, the outcome of the group's idea generation capability. It is the group processes of interaction that develops the ideas. It may be that individuals who are very capable of generating new ideas may flourish under the group brainstorming technique and aid the groups outcomes or conversely, they may be stifled by the group and produce better ideas on their own. This present research is not concerned with group techniques but rather with individual ability to generate ideas and therefore indicate creativity.

Idea generation is an essential skill for managers and leaders particularly if competing in tough markets. According to Morrison and Johnston, '*idea generation*' and '*problem solving*' are the aspects of creativity *most* useful to businesses. If a company needs a new name, a new product, or new ways of tackling an issue then ideas are needed. Without ideas the creative process will not move forward. They ascertain that organisational creativity starts with individual creativity and their research looks at which organisational systems promote creativity. The finding that is particularly interesting for this research is that creative individuals can be given very specific deadlines and outcome requirements as these do not limit creativity as is often assumed. What these creative individuals do require, however, is the freedom to be able to decide on the '*process*' to achieve these outcomes. Those organisations that do not allow autonomy of 'process' stifle individual creativity and therefore organisational creativity. (Morrison and Johnston 2003). This is where the ideas can flow freely in guiding the creative person in 'how' they will achieve what is required.

Those who have tried to identify particular characteristics of creative people put the 'ability to generate ideas' as a main characteristic (Hingað-Nogh 1985)

8.2.4 The Role Of The Right Hemisphere In Creativity

There is much popular literature today which makes the assumption that the right brain is the source of creative thinking. One such example is Matte and Henderson (1995), who wrote a book for students showing them how to approach their student life. There are lists for the 'left brained' students to follow and diagrams for the 'right brained' students to follow. Education is the other main area where the concept flourishes (eg Kim & Michael 1995). There are numerous educational websites helping children to learn how to use their 'right brain' and teachers are introducing this notion into classroom lessons. Education World is a resource for teachers and there are lesson plans available to teach children so that they can discover whether they are left brained or right brained. (Education World) Indeed the terms 'right brain' and 'left brain' have almost become synonyms for types of thinking with the 'right brain' signifying creativity, holistic and intuitive thinking and the 'left brain' signifying logical, compartmentalised and sequential thinking. As discussed in Chapter 1 these ideas do have scientific research on split brained patients underlying them but seem to have become generalised to a far greater degree than the empirical research can support by attempting to break down 'creativity' into testable thinking processes or abilities.

The scientific literature giving empirical evidence shows that an important component of creativity is identified as 'deferral of ambiguity resolution' (Springer and Deutsch 1998) and this can more easily be attributed to the right hemisphere. 'Ambiguity resolution' is high when an individual is learning and performing new tasks as their brain cannot relate these to codes and organizational schemes already in the brain. These are referred to as 'descriptive systems. The left hemisphere, it is argued, is particularly efficient at types of processing which require these well-learned codes. However, when new situations arise where models are not available, the right hemisphere processing strengths are crucial (Golberg and Costa, 1981). Experiments conducted on this have showed that the more ambiguous and novel the data the more the right hemisphere is required. Goldberg and Costa developed their model based on their research on patients with left and right hemisphere lesions. The stimuli were: line drawings of meaningful objects ie a house, line drawings of recognisable symbols, line drawings of nonsense shapes, detailed pictures (like photographs) of meaningful objects ie a building and detailed pictures (like a photograph) of faces. Those patients with a left hemisphere lesion were impaired in recognising the line drawings of meaningful objects suggesting that the left hemisphere was dominant at this particular task. Those who impaired on the photographs had either right or left hemispheric lesions. Face recognition was found to be most right hemisphere reliant as discussed in chapter 6. From their experiments described above, Goldberg and Costa (1981) conclude that the right hemisphere has a greater capacity for dealing with informational complexity and for processing many modes of representation within a single task, whereas the left hemisphere is superior at tasks requiring detailed fixation on a single, often repetitive, mode of representation of execution. (Springer & Deutsch 1998). The emphasis of the right hemisphere is the synthesis, ie making cross connections, whereas the left hemisphere is sequential and repetitive.

Therefore there are indicators of a right hemisphere strength for certain crucial prerequisites for creativity, namely idea generation, ambiguity tolerance and synthesis. The view which suggests that both hemispheres are involved in creativity include the importance of the corpus callosum. There is the view (Springer & Deutsch 1998, p 259) that the communication and sharing of information between the hemisphere via the corpus callosum is the crucial factor. Research on split brain patients has shown the importance of the inter-hemispheric communication on creativity as patients show lack of imaginative or complex fantasy, speech is dull and highly concrete in content, lacking in affect, inability to understand and convey models and symbols. (For a review see Hoppe and Kyle 1990).

Certainly no research has been found to attribute creativity solely to the left hemisphere. Hines (1991) supports the view of simultaneously contributing, where both hemispheres are said to have the processes for creativity and to use them simultaneously. But he asserts that they have different contributions to make to the creative process.

Some research suggests there are different degrees of activity of each hemisphere with some emphasising a stable consistent use of both hemispheres (Hines 1991) whilst others support a right hemisphere temporary dominance when creative processes are required (Edwards 1993). The latter distinction also leads to the debate as to which dimension, the stable use of both hemispheres or the temporal dominance of the right hemisphere, relates to the creative personality. Popular literature supports the stable dominance theory and often uses the terms 'creative' and 'right brained' almost interchangeably as in the book titles 'Unicorns Are Real: A Right-Brained Approach to Learning' part of a series called 'Creative Parenting/Creative Teaching' by Vitale (1982) and 'Organizing for the Creative Person: Right-Brain Styles for Conquering Clutter, Making Time, and Reaching Your Goals' by Lehmkuhl (1993).

Therefore the 'left brain' 'right brain' concept is often used simply as a language of differences to indicate creativity.

As concerning testing for creativity, there are tests which cover specific areas eg Wallach-Kogan Creativity Test (Wallach & Kogan 1965). However, testing creativity is very difficult as it is such a complex task which no-one yet really understands and the most popular method for researchers is to use the products 'of' creativity to show evidence 'for' creativity eg paintings and new products.

So there is evidence that the right brain is used for creativity with some evidence ascribing nearly all creative processes to the right brain (Goldberg & Costa 1981), some evidence assigning it to both hemispheres (Hoppe & Kyle 1990, Hines 1991), some to the communication between them (Springer & Deutsch) and none giving evidence for the sole prominence of the left hemisphere.

Empirical evidence for the right hemisphere's crucial involvement in creativity mainly relates to the aspects of 'ambiguity' and 'novelty' where the brain cannot draw on 'descriptive systems' already in the brain which many researchers claim is a left hemisphere task preference.

There is therefore a body of evidence for a link between the right hemisphere and 'idea generation'. Also that idea generation is central to creativity and usually starts the process of creativity (not including the planning stage which could be argued as pre-creativity). The definition of an 'idea' is something that is 'new' therefore this links to the research (Goldberg & Costa 1981) which has looked at the role of the right hemisphere and 'novelty' and draws away from the left hemisphere preference for already present descriptive systems.

It is, therefore concluded, that the right hemisphere is dominant in the role of idea generation since this does not require reference to 'descriptive systems' and in fact is probably impinged by them which may be why some find it hard to 'freewheel' when asked to do such things as 'brainstorm' or 'mindmap'. This is also partly to do with the evaluation of an idea where the idea is being related to the 'descriptive systems' already in the brain in order to evaluate it. This is something that people are asked to avoid when brainstorming but it may, in fact, be impossible for some people to do.

Idea generation is therefore to be used in the empirical studies related here as a measure of individual creativity.

8.3 Experiment 4

Because idea generation is so central to individual creativity and is a process which can be singled out for testing, it is used in the next experiment. As stated, creativity is a useful skill and if there was a means to enable an individual to access a thinking process such as idea generation which is core to creativity, then this would be valuable. If a simple task using the link between fine motor control and the contralateral hemisphere could arouse the right hemisphere on a regular basis to access the ability to generate ideas then this would give a practical aid to individuals wanting to improve their idea generation ability. It was felt that the arousal of the right hemisphere should be on a regular basis over time. Therefore, this experiment has been designed to see whether the fine motor skill of writing with the non-preferred hand over a period of 6 months makes any difference to an individual's ability to generate ideas.

First an idea generation task was given to the participants before they started using their 'non-preferred' hand. After 6 months of using their 'non-preferred' hand for writing at least 4 days out of 7, a similar idea generation exercise was given to them.

Left handers are used in this experiment and an assumption is made that these left handers have 'normal' dominance for language which is in the left hemisphere. (Hellige 1993, p 35-38)

Hypothesis

That the experimental condition of writing with the non-preferred hand would increase idea generation in right handers (using the left hand/right hemisphere) and reduce idea generation in left handers (using right hand/left hemisphere).

8.4 Method

This is an experimental design with 3 between-subject factors, namely; interventional handwriting with the non-preferred hand group/non-interventional (control), handedness (right versus left) and gender (male versus female) and 1 within-subject factors, namely; before and after intervention (0 months and 6 months) with the dependent variable of ability to generate ideas being scored in two ways, namely; number of 'items' generated and number of 'different ideas' generated.

8.4.1 Participants

The participants were employees of the University of Salford. They were aged between 21 and 60. Ages were not asked for specifically but were known to be in this range due to employment conditions.

At the beginning of the six month period 48 participants completed the first idea generation exercise. 19 participants continued throughout the six months to complete the second idea generation exercise.

In order to make further comparisons available, a control group was established which carried out the two idea generation exercises without carrying out the handwriting exercises. There are 11 control participants.

All participants had English as their first language and reported they had normal or corrected-to-normal visual acuity and normal hearing ability. The participants were voluntary.

8.4.2 Materials

There were no specialist materials used for the study. For the task of handwriting with the non-preferred hand participants were allowed to use whatever writing implement and medium they wished – generally this was pen and paper. For the idea generation task there was the choice of pen and paper but since the request for the exercise came via e-mail most participants completed the exercise on the e-mail and returned it automatically. Occasionally the internal post was used when computers were not operating well.

8.4.3 Procedure

All participants were asked to complete the 'handedness questionnaire' and anyone who was not scored as strong right hander was scored as mixed or left hander. See Section 3.5 for definitions.

The participants were asked to write daily or as often as they could with their non-preferred hand. Handwriting is probably the best task for precision and control which has been proved to require the motor skills in the contralateral hemisphere.

On signing up for the research and having filled out the handedness questionnaire the following e-mail, shown in Figure 8.1 overleaf, was sent to every participant.

Hi everyone

Have you got 5 minutes right now to do a small task? If not please close this message and look at it later.

If you have 5 minutes now, please spend them bringing to mind all the words you can think of when you read the word 'decisions'.

Please reply to me putting down all the words you can think of until you can't think of anymore. Please do this on your own. The results are confidential.

Many thanks, Julia

Figure 8.1: Emailed Instructions

Although there was a risk that participants may have not kept to the instructions the participants were all either academic staff or academically related staff and understood the important of adhering to data collection procedures.

After 6 months the participants received a request to do exactly the same thing with the stimulus word 'Judgements'. It was important to choose two words which would be similar and yet not identical. The two exercises were 6 months apart but it was important that the participants approached them independently.

Using a stimulus and generating ideas from this is a 'word association' or 'brainstorming' exercise. It is often used as a measure of creativity. Brainstorming is often used to increase ideas generated by a group but it can also be used for measuring individual creativity. It is also commonly used in a group setting for the development of and implementation of ideas. There is a wealth of literature on brainstorming and idea generation relating to groups but this is not appropriate for this research as only individual creativity is of interest.

8.4.4 Measures

In this research it is important to be able to measure the number of ideas generated (rather than a more complex measurement of the practicality of those ideas). Since idea generation is the first step of creativity , the number of ideas gives an *indication* of creativity as creativity cannot be developed without this first step.

There were two measures used for this experiment. For each idea generation task the total number of separate items listed was counted – this score is named 'Items'. In the main these were single words but occasionally a phrase was used eg making a choice, subjective view. In these cases the phrase was counted as *one* item. This score is useful as a raw score but did not accurately identify the number of *different* 'ideas' listed since some words were synonyms for the same idea. Therefore, another score was also used which was termed 'Ideas'. This scoring attempted to identify the number of different ideas and remove any duplication where synonyms were used such as 'choices' and 'options' or 'deciding' and 'decided' or 'finish' and 'end' and when closely linked items were used which did not indicate an idea change eg 'black' followed by 'white' or 'right' followed by 'wrong' or 'strengths', 'weaknesses', 'opportunities', 'threats' listed together or expressed 'SWOT'. The scoring was done by the researcher and a sample scored by two colleagues to check for objectivity in the scoring. One or two minor adjustments were made which in all cases slightly decreased the score.

8.5 Results

8.5.1 Analysis of the Measure of 'Ideas'

Analysis of three groups: control right hand, experimental right hand and experimental left hand

Measure	Group	Mean	Standard Deviation	Number of Participants
Ideas before Handwriting Intervention (0 months)	Control (Right handed)	9.10	6.691	10
	Experimental (Left Handed)	14.00	6.957	6
	Experimental (Right Handed)	15.69	7.250	13
	Mean	13.07	7.387	Total 29
Ideas after Handwriting Intervention (6 months)	Control (Right Handed)	9.60	7.245	10
	Experimental (Left Handed)	11.00	7.975	6
	Experimental (Right Handed)	13.31	8.854	13
	Mean	11.55	8.043	Total 29

Table 8.1: Means and Standard Deviations of Ideas Generated for Each Group

Comparisons were made on the 'ideas' score for three of the four groups. The left hand control group only had one participant so this is not included in this analysis. It can be seen here that although both experimental groups show less ideas after six months of handwriting that the decrease is very small and the scores are similar for each group.

Figure 8.2: Comparison of Control and Experimental Groups for Ideas Generated Before and After Handwriting Intervention

The hypothesis is that the experimental right handed (blue line) group, using their left hand for handwriting, thereby arousing their right hemisphere, would have an increased ability for ideas generated. It can be seen on the profile plot that this group appear to have an impaired, not improved, ability. It was also hypothesised that the left handed experimental group (green line), using their right hand and therefore left hemisphere, would showed a decreased performance in idea generation. This plot does appear to show this has happened. It was hypothesised that the control group (red line) would not have a change in performance in idea generation since they were not participating in the handwriting task at all. However, the score for this group (red line) appears on the plot to have slightly improved after 6 months.

	df	F	Significance
Comparison of Number of Ideas Before and After Intervention	**1, 26**	**1.385**	**0.250**
Effect of Different Handwriting Intervention	**2, 26**	**1.658**	**0.210**
Interaction Between Number of Ideas and Different Intervention	**2, 26**	**0.635**	**0.538**

Table 8.2: ANOVA Results for Three Groups: Control Right Hand, Experimental Right Hand and Experimental Left Hand (No Left Hand Control Group)

It can be seen from the results in Table 8.2 above that none of the factors reached a level of significance. However, it was considered to be of interest to see whether results for males differed in any way from results from females even though this was not part of the original hypothesis. Also groups became rather small with this subdivision. In order to include the control group, and to limit complexity, only the right handed participants were used for this exploration. The groups were divided as following:

Control Right Handed Female

Control Right Handed Male

Experimental Right Handed Female

Experimental Right Handed Male

Figure 8.3 overleaf, shows the means and standard deviations for the number of ideas generated before and after 6 months of handwriting with the left hand.

Measure	Group	Mean	Standard Deviation	Number of Participants
Ideas before Handwriting Intervention (0 months)	Control (Right handed) FEMALE	12.75	6.602	4
	Control (Right handed) MALE	6.67	6.055	6
	Experimental (Right Handed) FEMALE	13.43	5.940	7
	Experimental (Right Handed) MALE	18.33	8.262	6
	Mean	12.83	7.626	Total 23
Ideas After Handwriting Intervention (6 months)	Control (Right handed) FEMALE	12.50	10.408	4
	Control (Right handed) MALE	7.67	4.274	6
	Experimental (Right Handed) FEMALE	12.00	8.246	7
	Experimental (Right Handed) MALE	14.83	10.068	6
	Mean	11.70	8.232	Total 23

Table 8.3: Means and Standard Deviations of Experimental and Control Groups (Right Handed Participants Only) According to Gender

The means are shown graphically, overleaf, in the profile plot, Figure 8.3.

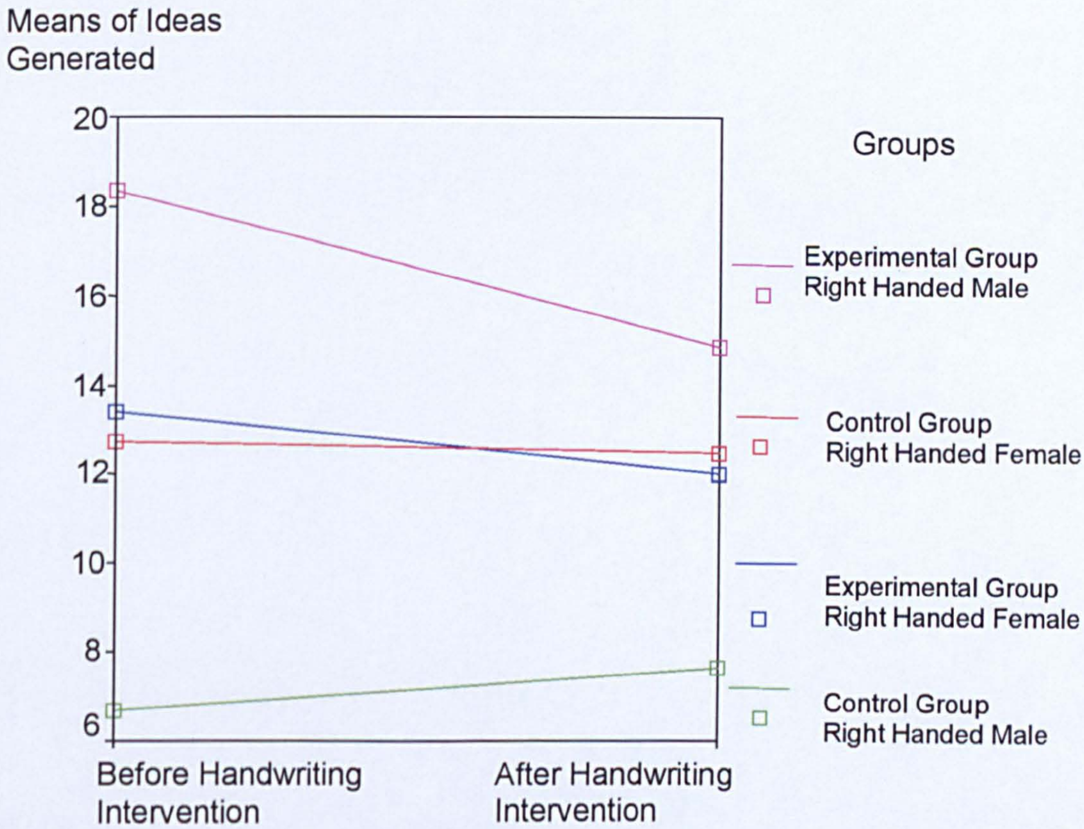


Figure 8.3: Comparison of Before and After Handwriting Intervention of Experimental and Control Right Handers – According to Gender

The right handed experimental females (blue line) appeared to show a decrease in performance. However, the decrease for the right handed experimental females (blue line) appeared to be less than for the right handed experimental males (pink line). There appears to be some interaction between the experimental right handed females (blue line) and the control right handed females (red line). It is understood, however, that the scaling shown in the diagram above may have exaggerated any differences and interactions.

The control group females showed the expected 'no difference' result which was hypothesised for the control group. By separating the results by gender it illustrates that it is the males that account for the increase in the control group, shown in Figure 8.2, rather than the females.

Comparison of control and experimental and male and female: right handed only

	df	F	Significance
Comparison of Number of Ideas Before and After Handwriting Intervention	**1, 19**	**0.416**	**0.527**
Effect of Different Handwriting Intervention and Gender	**3, 19**	**2.072**	**0.138**
Interaction Between Number of Ideas and Different Handwriting Intervention and Gender	**3, 19**	**0.373**	**0.773**

Table 8.4: ANOVA Results for Four Groups: Control Right Handed Female, Control Right Handed Male, Experimental Right Handed Female and Experimental Right Handed Male

The results of the ANOVA show there is no difference at a statistically significance level compared to the apparent differences shown in the profile plot.

8.5.2 Analysis of the Measure of 'Items'

Comparisons were made on the 'items' score for three of the four groups. As before, with the score of 'ideas', the left hand control group was excluded.

Measure	Group	Mean	Standard Deviation	Number of Participants
Items before Handwriting Intervention (0 months)	Control (Right handed)	11.20	8.094	10
	Experimental (Left Handed)	19.00	11.576	6
	Experimental (Right Handed)	19.08	8.381	13
	Mean	16.34	9.811	Total 29
Items after Handwriting Intervention (6 months)	Control (Right Handed)	11.90	8.465	10
	Experimental (Left Handed)	14.50	11.041	6
	Experimental (Right Handed)	16.46	10.501	13
	Mean	14.48	9.811	Total 29

Table 8.5: Means and Standard Deviations for Score of Items Generated Before and After Handwriting Intervention

The means and standard deviations are shown in Table 8.5 above and illustrated overleaf in the profile plot.

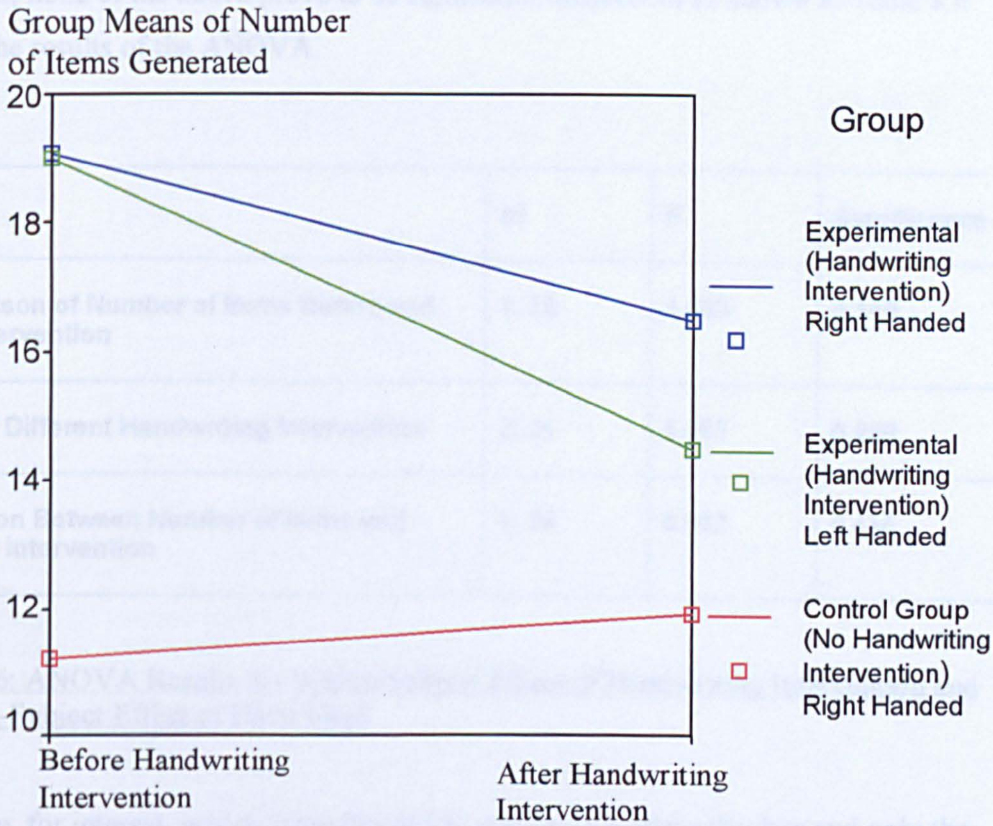


Figure 8.4: Profile Plot Showing Interaction Between Groups

As concerns the measure of 'items' the hypothesis was that the right handed experimental group, using the left hand/right hemisphere (blue line) would improve performance but here it appears to have declined. The experimental left handers (green line) using their right hand/left hemisphere were expected to decline in performance and here it appears they did. As with the measure of 'ideas' the right hand control group (red line) here shows an apparent slight increase in performance where no difference was expected.

However, none of the above prove to be significant differences as shown in Table 8.6 giving the results of the ANOVA.

	df	F	Significance
Comparison of Number of Items Before and After Intervention	**1, 26**	**1.903**	**0.180**
Effect of Different Handwriting Intervention	**2, 26**	**1.563**	**0.229**
Interaction Between Number of Items and Different Intervention	**1, 26**	**0.912**	**0.414**

Table 8.6: ANOVA Results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effect of Hand Used

As before, for interest, groups were divided by gender to explore the data and only the right handed groups were used.

Groups divided by gender

Measure	Group	Mean	Standard Deviation	Number of Participants
Items before Handwriting Intervention (0 months)	Control (Right handed) FEMALE	15.50	6.856	4
	Control (Right handed) MALE	8.33	8.066	6
	Experimental (Right Handed) FEMALE	16.43	7.185	7
	Experimental (Right Handed) MALE	22.17	9.239	6
	Mean	15.65	9.003	23
Items After Handwriting Intervention (6 months)	Control (Right handed) FEMALE	15.25	11.147	4
	Control (Right handed) MALE	9.67	6.282	6
	Experimental (Right Handed) FEMALE	16.29	11.101	7
	Experimental (Right Handed) MALE	16.67	10.801	6
	Mean	14.48	9.737	23

Table 8.7: Means and Standard Deviations of All Right Handed Participants in Four Groups to Compare Gender

When dividing the groups by gender the means and standard deviations are as in Table 8.7. The number of people in each group is small in these detailed groupings but are explored for interest.

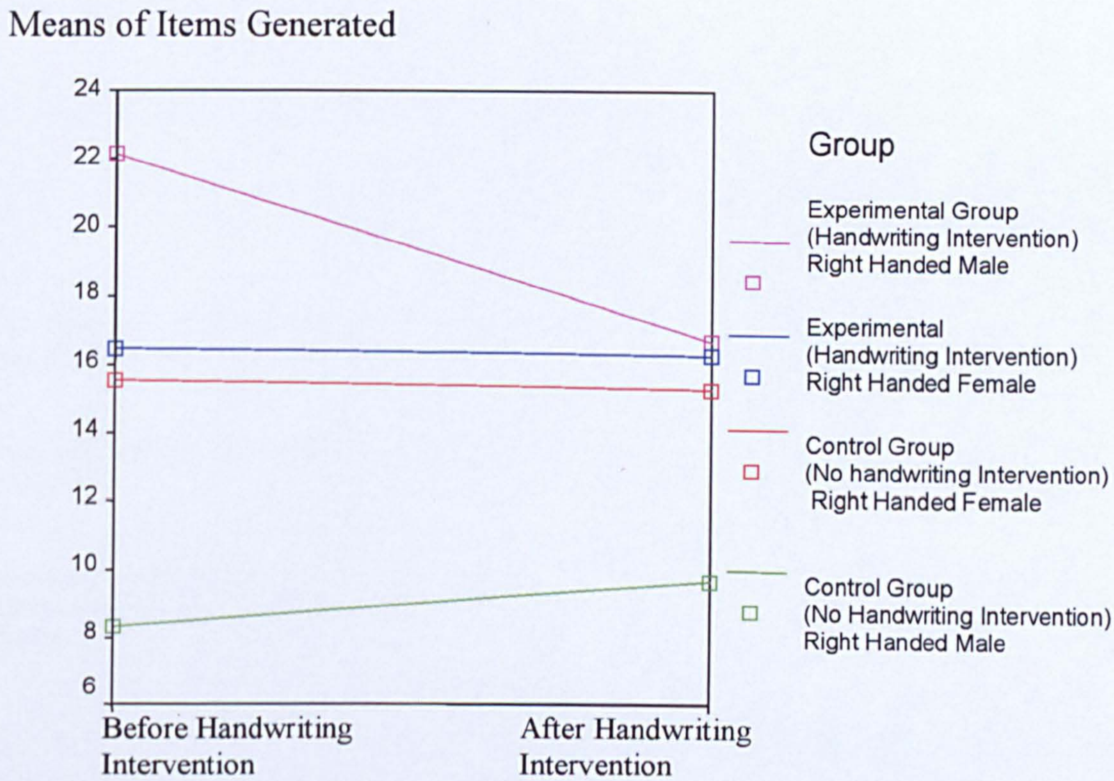


Figure 8.5: Comparison of 'Items' Score Before and After Handwriting Intervention of Experimental and Control Right Handers – According to Gender

From the profile plot, Figure 8.5 above, it appears that the decrease in performance for the experimental group in the former Figure 8.4 is from the males (pink line) rather than the females (blue line) as having split them up the lines for each gender are different. The result for the males (pink line) was the opposite of the hypothesis that the right hemisphere improves idea generation. For the females (blue line) there appears to be hardly any difference in the performance, again not proving the hypothesis.

The hypothesis for the control group is that there would be no difference in performance. In the above profile plot this appears to be true for the females (red line) but not for the males (green line).

The results of the ANOVA are shown in Table 8.8 below.

	df	F	Significance
Comparison of Number of Ideas Before and After Handwriting Intervention	1, 19	14.314	0.514
Effect of Different Handwriting Intervention and Gender	3, 19	1.768	0.187
Interaction Between Number of Ideas and Different Handwriting Intervention and Gender	3, 19	26.811	0.494

Table 8.8: ANOVA Results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effects of Hand Used and Gender

8.5.3 Exploring Measure of 'Ideas' and 'Items' Together

Having found there is no statistical significance in the results, boxplots were drawn to see whether the reason for this non-significance could be made clearer.

The experimental group is illustrated in Figure 8.6 overleaf.

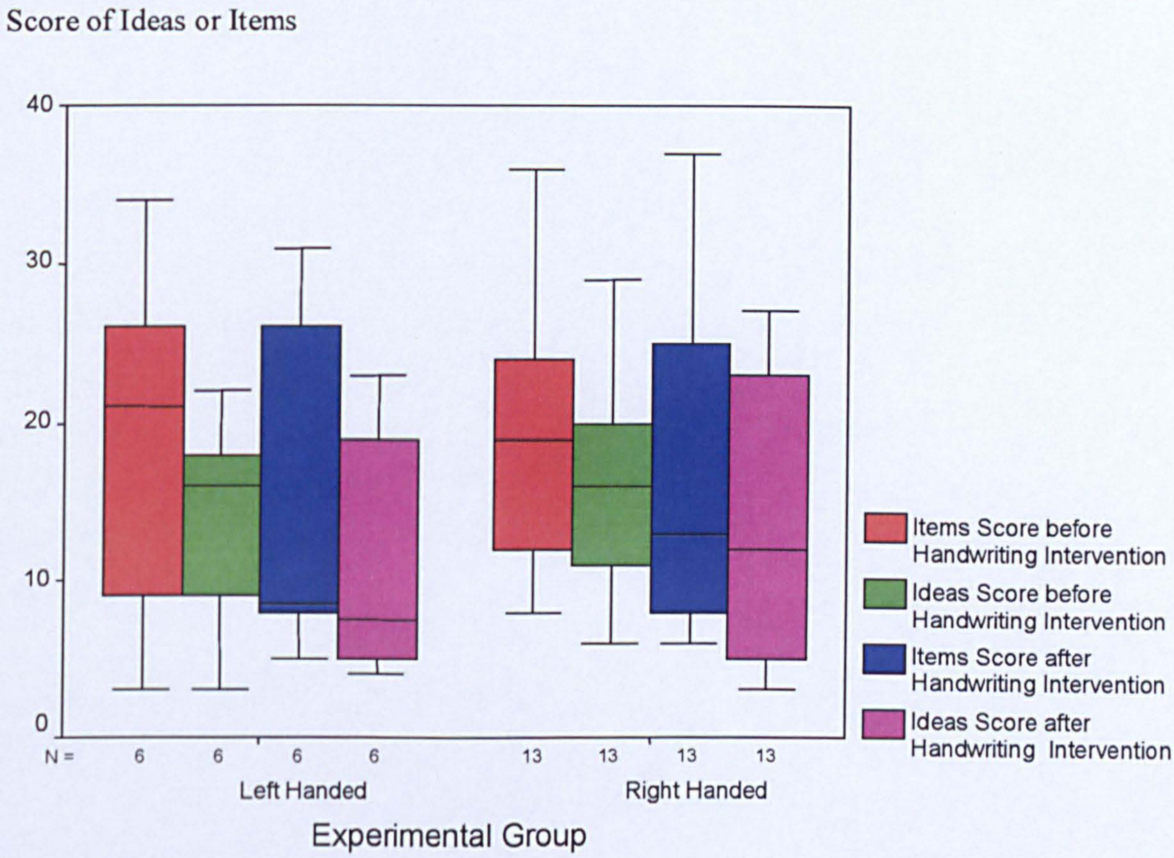


Figure 8.6: Comparing Hand Used Within Experimental Group

Figure 8.6 illustrates both scores for comparing left handed and right handed groups, before and after handwriting intervention, in the experimental group. The distributions are shown as box plots to illustrate where 50% of the scores lie for each result.

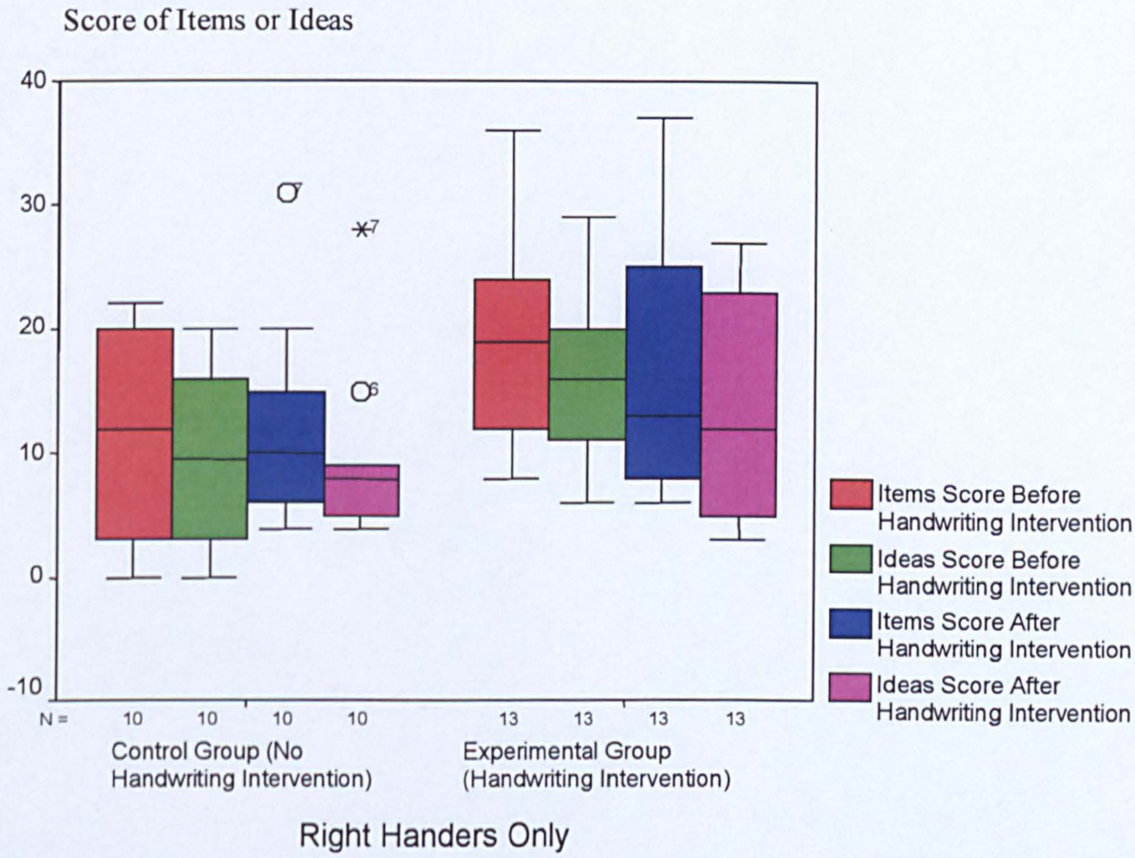
For the score of 'items' the left handed group showed little change in the bulk of the distribution of scores before and after the handwriting intervention. The boxes are shown on the left hand side of the diagram, the yellow being before the intervention and the blue being after.

In the right hand participants, shown on the right hand side of the diagram, the blue distribution (after intervention) is slightly wider than the yellow (before intervention).

For the score of 'ideas', shown here in green (before intervention) and while (after intervention) again there was more difference shown in the right handed participants. For the left handed group therefore, they exhibited little change in the overall distribution of 'items' and some widening of the distribution in the measure of 'ideas' with more scores appearing at the lower end than the higher end. The median scores dropped for both 'ideas' and 'items'.

The right handed group showed a wider spread of scores for both measures after the 6 months but around a similar range on the scale. The median scores in both cases had gone down.

A graph showing right handers only, the experimental and control group, is given overleaf.



<u>Figure 8.7: Comparing Control Group with Experimental Group for Ideas and Items Generated: Right Handers Only</u>

Figure 8.7 illustrates the results of the right handed control group with the right handed experimental group for scores of both the ideas and the items generated.

It can be seen that the measures are similar for each group given the large scale of the graph.

Putting all the three groups together provides an overall view of where 50% of the results fell. It is immediately apparent how similar the experimental groups' profiles are to each other. The control group's profile is lower on the scale but the lower ranges of data are similar to the other groups.

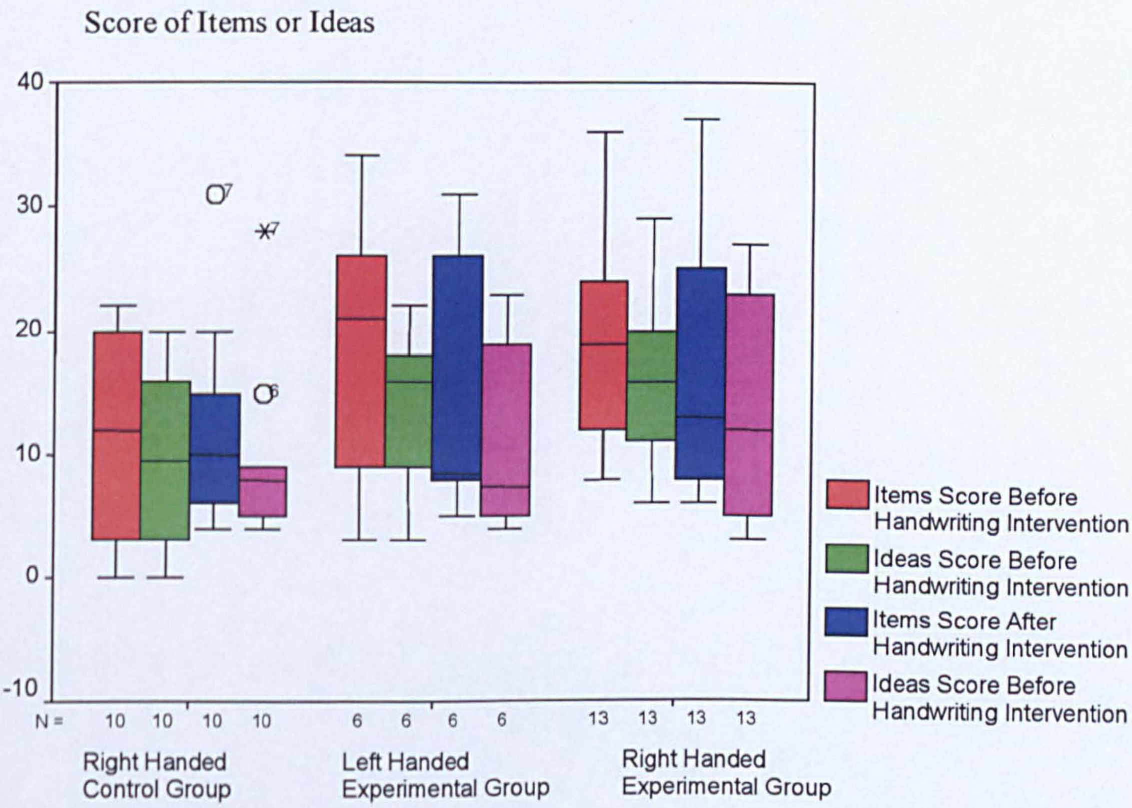


Figure 8.8: Comparing all 3 Groups (No Left Hand Control Group)

Figure 8.8 illustrates the results of the three groups for scores of both the ideas and the items generated.

8.6 Discussion

The hypothesis for Experiment 4 was that the right handers, using their left hand for handwriting for 6 months, would have improved idea generation ability. Also that the left handers using their right hand, for handwriting for 6 months, would have impaired idea generation ability. Idea generation ability was measured in two ways. Firstly a measure of all the different words or phrases given in response to the stimulus word, this measure was labelled 'items'. This list contained some words and phrases which were synonyms. Secondly, the list of 'items' was analysed in order to find the number of 'different ideas' presented and this became the measure labelled 'ideas'.

The summary for the results of Experiment 4 are:

There was no difference in ability to generate ideas, (for both measures), for those using their left hand for handwriting for 6 months compared to those using their right hand.

There was no difference found between those doing the handwriting task, with either hand, compared to those in the control group not doing the handwriting task at all.

There was no difference found between males and females concerning ability to generate ideas for any of the handwriting interventions for either measure.

The hypothesis was concerning differences between right hand use and left hand use, therefore, the experimental groups. However, a right hand control group was added to the experiment. It is this group that stands outs in Figure 8.4 as having a different ability in idea generation *before* the experimental factor was introduced, so these are not matching groups. This was not expected and suggests there is another factor which is affecting this group. The control group was started slightly later than the experimental groups as this may have added some additional factor into the experiment. Also, the researcher's approach may have developed from the experience of dealing with the experimental groups and may have introduced or omitted a factor.

The three main questions to ask concerning the insignificance of the results are:
Did the task sufficiently measure idea generation ability?
Is idea generation sufficiently established as a Right Hemisphere task?
Does arousal of the Right Hemisphere with fine motor control thinking processes arouse idea generation thinking ability?

The task involved the spontaneous generation of ideas. However, in the presenting of ideas the left hemisphere may have become involved. Other options of presenting the ideas could have been to speak them out but this would have definitely involved the left hemisphere (Loring et al 1990) and drawing would have forced the right hemisphere. The right hemisphere does have some language processes (Sperry 1968) but the left hemisphere has dominance for language overall (Ivry and Robertson 1998).

As concerns 'idea generation' the research does indicate this is a right hemisphere preferred task and the ambiguity of the scenarios was used designed to encourage this type of response in particular. The quality or type of ideas were not analysed but rather the volume – a quality evaluation would be an interesting analysis, if it were possible to ascertain what would constitute quality, as it could be that the ideas were 'better' or more diverse after the handwriting exercise.

The ability for fine motor control processing in the right hemisphere to arouse right hemisphere idea generation processes was the main focus of the experiment but was disproved here.

9 Experiment 5:

Creativity – Problem Solving

9.1 Introduction

In Section 8.2.3 it was stated that according to Morrison and Johnston (2003) that idea generation and problem solving are the aspects of creativity most useful to businesses. Having looked at 'idea generation' it is useful to now look at 'problem solving'. It is interesting that here it is assumed that problem solving is an aspect of creativity whereas another view is that creativity is an aspect of problem solving. It could be that both views are accommodated in that you cannot carry out the process of problem solving without unconsciously bringing in creative skills at some level.

9.2 Problem Solving

9.2.1 The Role Of Problem Solving In Creativity

Problem solving is a complex task but it is generally agreed that the use of creativity can aid problem solving. Logical reasoning is also important in problem solving and there are a variety of systems, models and computer programs to do this for us. Computers however have to be programmed and cannot be creative.

There is debate concerning whether problem solving is a creative activity or not. Although many think it is Harnad (2003) says it is not. He states that problem solving involves applying a known rule in order to solve problems of an overall type that vary in a minor or predictable way. Some elements of novelty and decision-making may be involved but are not necessary. He does, however, say that problem solving cannot be done by 'rote' and that the rules need understanding to be able to apply them – but not necessarily creativity. He goes on to say that sparks of creativity may be involved in recognizing that a class of new problems can be solved by an old rule. However, the type of problems discussed here seem to be solvable ones with a possible 'right' answer. The major problems which organizations often face often do not have a 'right' or 'wrong' answer and it is never known whether the decisions made were the best ones because there is no control group. In organizations there is often ambiguity about what the problem is or whether there is a problem at all. The term 'problem' in academic terms means a situation that may require attention. In everyday language the term 'problem' often has a negativity attached to it.

When analysing the thinking used for problem solving the literature tends to assume two broad categories, those of divergent (sometimes called 'lateral') and convergent (sometimes called 'convergent') thinking. Hudson (1966) charted the shift of focus from level of intelligence to different cognitive styles and contributed to the debate with a fascinating study of English school students (Contrary Imaginations). Divergent thinking, is defined as thinking in a non-linear fashion finding associations across connections and widening the perspective rather than narrowing it. Convergent thinking is thinking in a linear fashion so that ideas flow logically step by step without jumping across steps.

9.2.2 Right Hemisphere Versus Left Hemisphere Thinking

Divergent versus Convergent Thinking

The differences between divergent thinking and convergent thinking lend themselves to an associated link with each hemisphere. This is extremely difficult to ascertain but can be said to be useful basis for dialogue concerning the variety of different types of thinking.

The difference between convergent thinking and divergent thinking are well documented. In studying these there are different aspects to be highlighted. One of these is the 'direction' of the thought flow. In convergent thinking, one moves in a clearly defined direction towards the solution. In divergent thinking there is a change in the line of thought. (de Bono 1970)

The way in which the thinking 'progresses' is also different. Convergent thinking is sequential, moving one step ahead at a time - the soundness of conclusion is proved by the soundness of the steps taken – each one is associated to the next. Divergent thinking can make jumps to unassociated points and attempt to fill in gaps afterwards.

The 'route' that the thinking takes is different. De Bono (1970) asserts that convergent thinking selects a pathway by excluding other pathways whilst divergent thinking does not select but seeks to open up other pathways. Convergent thinking selects the 'one' most promising approach to a problem or 'one' best way of looking at a situation while divergent thinking generates as many alternative approaches as possible.

The 'perceived conclusion' is different in that convergent thinking is a finite process whilst divergent thinking is a probabilistic process. With convergent thinking, one expects to come up with an answer, a minimum solution. With divergent thinking, there may not be any answer at all or even a problem perceived.

The emphasis on 'analysis' is different. In convergent thinking, we analyze and then come up with a hypothesis. In divergent thinking, the hypothesis is challenged by questioning it (Hwa & Joo 2003):

The way in which the two types of thinking work together is usually viewed as complementary, certainly de Bono takes this view. He says that divergent thinking is useful for generating new ideas and approaches and convergent thinking is useful for developing them. Divergent thinking enhances the effectiveness of convergent thinking by offering it more to select from. Convergent thinking multiplies the effectiveness of divergent thinking by making good use of the ideas generated. (de Bono 1970).

In the context of problem solving then, there must be some divergent thinking unless the solution to the problem is in existence and just needs finding. The more vague the problem to be solved and the more ambiguous the issue of whether there is a problem at all the more the divergent thinking is required. Earlier in this thesis it was identified that the ability for 'deferral of ambiguity solution' was an essential part of creativity and can be attributed to the right hemisphere so the more ambiguity and open-endedness the problem has the more the right hemisphere and divergent thinking would be required.

However, to be creative one cannot just use divergent thinking as creativity is more than idea generation, although idea generation as we saw earlier is fundamental to creativity and usually the first step in the process, because the ideas have to be developed in order to create.

Blakeslee (1980) talks about the description of the process of creativity put forward by Wallas in 1945, which was described in section 8.2.2. An interesting point is that this view was in existence before knowledge about split-brains became available, and yet the stages in the process seem to relate to the left brain or the right brain. The right brain is capable of unconsciously providing ideas but it is the left brain that then has to carry those ideas forward. Blakeslee thus concludes that "The synergistic relationship between the left and the right brains is the real basis of creativity".

Goldberg and Costa (1981) suggested that the left hemisphere is highly efficient at processing that takes advantage of well-routinised codes, such as the motor aspects of language production, and that the right hemisphere is crucial for situations for which no readily apparent descriptive system is available, that is, more novel situations. Therefore in an experiment to encourage right hemisphere processing the problem solving stimuli would have to involve a novel situation.

Bogen (1975) states that the thinking processes which comprise convergent and divergent thinking are as shown below:

Convergent	Divergent
Intellect	Intuition
Concrete	Abstract
Directed	Free
Propositional	Imaginative
Analytic	Relational
Lineal	Nonlineal
Rational	Intuitive
Sequential	Multiple
local	holistic
Objective	subjective
Successive	simultaneous

Figure 9.1: Thinking Processes Categorised into Convergent or Divergent Thinking - Adapted from J E Bogen

These can be seen to link in with Edwards left brain and right brain thinking processes in section 3.3.

Experiments have been done where people have been classified as divergent or convergent thinkers with the assumption that the divergent thinkers were right brain dominant and the convergent left brain dominant. The classification was based on their non ability/ability for science, logic and art. One such experiment was done at Edinburgh University by Austin (1971) to find out if brain dominance affected the ability to remember dreams. The divergent thinkers, who were classified based on being less logical and more artistic remembered dreams 95.2% of the time compared to the convergent thinkers, classified as such on scientific and logical ability remembered dreams 65% of the time. Therefore the different classifications have been used in experimental research before. (Blakeslee P33 citing Austin 1971)

The literature therefore indicates:

- That problem solving is more effective if creative thinking is involved
- That creativity is combining divergent thinking and convergent thinking – with one building on the other – the former generating ideas from nothing and connecting ideas in a mixture of directions and the latter developing those ideas in a linear fashion
- That to have 'only' divergent thinking or 'only' convergent thinking is not considered to be creativity in this context
- That if divergent thinking is to be attributed to one hemisphere it would be the right and if convergent thinking is to be attributed to one hemisphere it would be the left.

- In order to stimulate right hemisphere strengths the problem solving scenario should have the following qualities:
- Be holistic with the scenario not even defined as needing solution
- Be vague and ambiguous
- Be open ended
- Be novel
- Not have a defined step-by-step process
- Not have an expected outcome
- Be subjective and experiential so as to promote emotion
- Have a negative rather than a positive 'feel' ie not a scenario about finding themselves on a luxury cruise
- Have a minimum amount of information – as near to a blank canvas as possible
- Not to use logical

It is common practice in creative problem solving analysis to use scenarios as a stimulus. It is providing a minimum amount of information and structure in order to encourage the most creative response.

9.3 Experiment 5

The aim of this experiment is to test for differences between three groups in the types of thinking used in a problem solving scenario. The types of thinking being tested being those which have patterns of connection with the left hemisphere or right hemisphere. The three groups are right handed participants using left hand for handwriting, left handed participants using right hand for handwriting and participants not doing handwriting. The scenarios are presented in a style which encourages divergent thinking.

The task of handwriting is being used in this experiment to see whether the link of the contralateral control of fine motor control skills used in the handwriting would have any effect on the higher level thinking skill of divergent or convergent thinking. The divergent thinking is assumed to relate more to the right hemisphere and the convergent thinking more to the left hemisphere.

Hypothesis

That the left handers using their right hand/left hemisphere for handwriting would show less divergent thinking and the right handers using their left hand/right hemisphere for handwriting would show more divergent thinking. It was decided to use left handers and right handers so as to be able to explore differences in the groups.

9.4 Method

Two similar scenarios were designed which favoured a divergent thinking approach rather than a convergent thinking approach. They were designed to present an ambiguous, novel, slightly negative, situation for the participants to imagine experiencing yet which has no logic or defined processes and has minimum information. Figures 9.2 and 9.3 present these scenarios.

<u>Scenario 1</u>

You are in the basement of a building. There is one window 2 ft by 2 ft and a door 6 ft by 3 ft. The door is locked, there is no key, there is a 1 inch gap under the door. You have with you a cat, a chair, a pair of scissors and a 6 inch cube of wood. There is one light in the middle of the room with a 6 inch flex. What do you do?

<u>Figure 9.2: Stimulus 1: Scenario Presented to the Participants Before Handwriting Intervention</u>

Scenario 2

You are in a loft and the hatch is locked. There is no window. There is a tiny door 2 ft by 2 ft leading somewhere. You have a torch, a pen and a bar of soap. What do you do?

Figure 9.3: Stimulus 2: Scenario Presented to the Participants After Handwriting Intervention

The scenarios had to be sufficiently different so that participants would not try to remember how they had responded to the previous one. However, they also had to be comparable in 'type' with a similar amount of obscurity and information, or lack of it. Figure 9.4 illustrates the comparability of the scenarios

Basement Scenario *You are in the basement of a building. There is one window 2 ft by 2 ft and a door 6 ft by 3 ft. The door is locked, there is no key, there is a 1 inch gap under the door. You have with you a cat, a chair, a pair of scissors and a 6 inch cube of wood. There is one light in the middle of the room with a 6 inch flex. What do you do? Please give first reactions, thoughts and feelings.*			
Loft Scenario *You are in a loft and the hatch is locked. There is no window. There is a tiny door 2 ft by 2 ft leading somewhere. You have a torch, a pen and a bar of soap. What do you do?*			
	Basement Scenario	**Loft Scenario**	**Designed to be:**
Being locked in	*door is locked*	*hatch is locked*	*Similar but not identical*
Possible egress	*window 2 ft x 2 ft* *door 6 ft x 3 ft*	*door 2 ft x 2 ft*	*Similar but not identical*
Miscellaneous Items	*Cat, chair, scissors, cube of wood*	*Torch, pen, bar of soap*	*Similar but different items*
Lighting	*Light in room*	*Torch*	*Similar*
Question	*What do you do?*	*What do you do?*	*Identical*

Figure 9.4: Comparability of Scenarios

9.4.1 Participants

The 30 participants, some of whom were the same as in Experiment 4, were employees of the University of Salford, academic and academic related staff. They were aged between 21 and 60. Actual ages were not recorded but were known due to being employed. They were classified according to the handedness questionnaire described in Section 3.5 as strongly right handed or as left/mixed handed. There were four groups, two experimental, one using the left hand for handwriting and one using the right hand, and a control group for each, not carrying out handwriting at all.

All participants had English as their first language. The participants were voluntary.

9.4.2 Materials

There were no specialist materials used for the study. For the task of handwriting with the non-preferred hand participants were allowed to use whatever writing implement and medium they wished – generally this was pen and paper. For the problem solving task there was the choice of pen and paper but since the request for the exercise came via e-mail most participants completed the exercise on the e-mail and returned it automatically. Occasionally the internal post was used when computers were not operating well.

9.4.3 Procedure

Participants were asked to spend 5 minutes only typing into the screen or writing down, their response to the scenario. The scenario was never described as a problem to allow the ambiguity aspect – they were simply presented with the scenario and asked the question 'what do you do?'. If asked for clarification to be given this was gently declined. After 6 months the participants received a request to do the same thing with a similar but not identical scenario.

All data was recorded as text.

9.4.4 Measures

The first task was to 'clean up' the data and to extract the comments which only related to the question 'what will you do?'. Any comments which did not relate directly to this question and which were considered to be periphery were excluded from the analysis eg "I'm not very good at these sorts of puzzles".

The data was then analysed in two stages. The first stage was to ascertain how the data – which was in the form of written narrative – could be broken down into categories that related to left hemisphere/convergent thinking or right hemisphere/divergent thinking. This, being a complex task was not entirely possible. However, on analyzing the text using standard 'content analysis' five clear categories of different types of thinking emerged. These were 'questions raised', 'emotion/senses expressed', 'ideas to use resources', 'actions/intentions stated', and 'options considered'. These were compared to the indications of divergent and convergent thinking. There were patterns of connection to the two different thinking approaches. The way the test was categorized and the way it linked into divergent or convergent thinking is illustrated in Figures 9.5 to 9.9 with the category codes given in Figure 9.10.

Code	Category	Indication of:	Examples of Content/Key Word/Type of Text
Q	QUESTIONS	Indication of Right Hemisphere relating to the opening up and exploring of factors and ideas pertaining to the situation/problem in order to understand it better.	Actual questions: Why am I here? How did I get here? Did someone put me here? Is the light working? Is it dark? Can anyone hear me? How will I get out? Do I know the loft? Do I have a key? Can I force the door? Assumed questions: I wonder if......

Figure 9.5: Examples of Content of Text that was Classified as Questions and Attributed to Right Hemisphere

Code	Category	Indication of:	Examples of Content/Key Word/Type of Text
E	EMOTIONS/SENSES	Indication of Right Hemisphere relating to the number of times emotions are mentioned/considered and experienced.	like dislike bored sad frightened unhappy tired comfortable safe worried allergic claustrophobic

Figure 9.6: Examples of Content of Text that was Classified as Emotions and Attributed to Right Hemisphere

Code	Category	Indication of:	Examples of Content/Key Word/Type of Text
I	IDEAS GENERATED relating to resources either given or created.	Indication of Right Hemisphere relating to the 'amount' of ideas, items or people generated or used in the scenario. Each time an item is referred to by name it is scored. However, the word 'it' is not scored as this is usually a further development of the idea and relates more to convergent thinking.	Mention of, reference to or use of any item or person, real or imaginary. Scored every time it is referred to. Door Wall Floor Loft Basement Room Cat Soap Flex Light Key Hatch window Torch Pen Chair Block of wood Someone/anyone/person Leg Lock

Figure 9.7: Examples of Content of Text that was Classified as Ideas Generated and Attributed to Right Hemisphere

Code	Category	Indication of:	Examples of Content/Key Word/Type of Text
A	ACTIONS - the idea is captured under ideas generated – this relates to the 'follow-through' of what is done with that idea It is an active verb which may also indicate an intention to act	Indication of Left Hemisphere relating to sequencing – a moving forward.	statements of action: climb shout wait do nothing stroke find sit attract attention write shout

Figure 9.8: Examples of Content of Text that was Classified as Actions and Attributed to Left Hemisphere

Code	Category	Indication of:	Examples of Content/Key Word/Type of Text
O	OPTIONS GENERATED and presumptions clarified. The more options generated the more creativity is present. Each different option considered indicates divergent thinking. The creativity is enhanced when each option is followed through with some convergent thinking eg not just 'if' but 'if..then' but the number of options is the more important indicator here.	Indication of Right Hemisphere relates to 'amount' of consideration given to available options or reference to presumptions which confirms an awareness of options. Although 'creativity' relates to *both* number of ideas generated (right hemisphere) and 'follow through' of each idea (left hemisphere) the former is the most important indicator.	If if…then if…not or whether presuming assuming depending on I reckon Consider I know I don't know

Figure 9.9: Examples of Content of Text that was Classified as Options and Attributed to Right Hemisphere

Secondly, the text of each response was analysed and collated into the five categories that had emerged from the content analysis with the following labels.

Questioning = Q

Emotions = E

Actions = A

Ideas = I

Options = O

Figure 9.10: Labels Given to Coding Categories

The method of labelling was to label the text for each category. One example of how each piece of text was categorised is shown in Figure 9.11 below.

"What can I find (A) for the cat (I) to play (A) with? (Q) I love (E) cats. How could (O) the cat help? (A) (Q)"

- 'Find', 'play' and 'help' are labelled (A) for actions/verbs
- 'Cat' is labelled (I) for idea about an object/item/person
- Both questions are labelled (Q) - indicates opening up of ideas (An inferred question would also be labelled (Q) eg I wonder what I can find for the cat to play with).
- 'Love' is labelled (E) for emotion expressed
- 'could' is labelled (O) as it expresses an option – opening up alternatives

Figure 9.11: Example of Coding Text into Categories

In order to ensure reliability of analysis two individuals analysed a sample of the responses and compared this analysis to look for any differences. This method brought about a few amendments but these were very minor. Therefore, it was considered the analysis was sufficiently consistent.

9.5 Results

Following the content analysis into categories, each of which related to a different type of thinking, the groups were compared to see if the handwriting intervention had affected their problem solving approach.

Each category was analysed separately in order to compare groups. The figures and tables in the next section illustrate the results.

9.5.1 Results of Content Analysis of Text Categorised as 'Questions'

The first category to be illustrated is that of 'questions generated', indicative of right hemisphere processing. The means and standard deviations for this category are given in Figure 9.1 for all four groups of experimental right hand, experimental left hand, control right hand and control left hand. Although the numbers for the control left hand are small they are included here.

Measure	Group	Mean	Standard Deviation	Number of Participants
Questions before Handwriting Intervention (0 months)	Control (Left handed)	0.67	1.155	3
	Control (Right handed)	0.09	0.302	11
	Experimental (Left Handed)	2.63	3.739	8
	Experimental (Right Handed)	2.25	2.387	8
	Mean	1.40		Total 30
Questions After Handwriting Intervention (6 months)	Control (Left handed)	0.00	0.00	3
	Control (Right handed)	0.27	0.647	11
	Experimental (Left Handed)	1.75	3.105	8
	Experimental (Right Handed)	0.63	1.408	8
	Mean	0.73	1.837	Total 30

Table 9.1: Means and Standard Deviations for Questions Generated in Experiment 5

The interaction graph shown overleaf illustrates the data more visually.

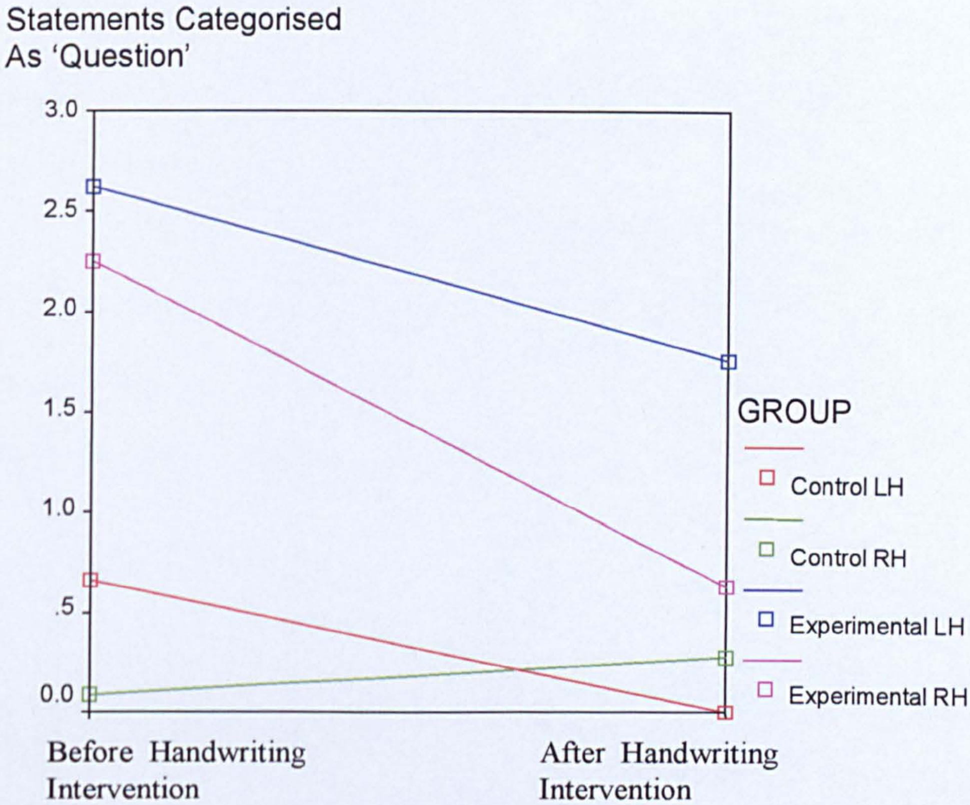


Figure 9.12: Interaction Graph Showing Number of 'Questions' Generated Before and After Handwriting Intervention for Experimental Groups (Left Hand and Right Hand) and Control Groups (Left Hand and Right Hand)

Here it appears that the handwriting intervention may have affected both experimental groups (blue and pink lines) by reducing their questioning approach. This was hypothesised for the left handers (using their right hand/left hemisphere) but goes against the hypothesis for the right handers (using their left hand/right hemisphere). The control groups appear to be very different from the experimental groups.

The control left handed group's (red line) questioning approach also decreased but it increased for the control right handed group (green line). There appears to be an interaction between the two control groups.

When testing for significance using the ANOVA there was no significance in the difference between groups or any significant effect of the handwriting intervention. The results for the ANOVA are shown in Table 9.2 below.

	df	F	Significance
Comparison of Number of Questions Generated Before and After Handwriting Intervention	**1,26**	**3.947**	**0.058**
Effect of Different Handwriting Intervention (Left Hand, Right Hand, Control)	**3,26**	**2.193**	**0.113**
Interaction Between Number of Questions Generated and Different Handwriting Intervention	**3,26**	**2.602**	**0.224**

Table 9.2: ANOVA Results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effect of Hand used

9.5.2 Results of Content Analysis of Text Categorised as 'Emotions'

In order to see if the articulation of 'emotions' increased for those using their left hands and decreased for those using their right hands, the data was analysed for this thinking category. The means and standard deviations are given in Table 9.3 below.

Measure	Group	Mean	Standard Deviation	Number of Participants
Emotions before Handwriting Intervention (0 months)	Control (Left handed)	0.00	0.00	3
	Control (Right handed)	0.55	1.036	11
	Experimental (Left Handed)	2.63	3.739	8
	Experimental (Right Handed)	6.63	6.823	8
	Mean	2.67	4.663	Total 30
Emotions After Handwriting Intervention (6 months)	Control (Left handed)	0.00	0.000	3
	Control (Right handed)	0.55	0.934	11
	Experimental (Left Handed)	1.25	3.151	8
	Experimental (Right Handed)	1.62	2.066	8
	Mean	0.97	2.008	Total 30

Table 9.3: Means and Standard Deviations for Emotions Generated in Experiment 5

Illustrating the data the following interaction graph compares all four groups for the category of 'emotion' where emotions have been expressed as part of the problem solving approach.

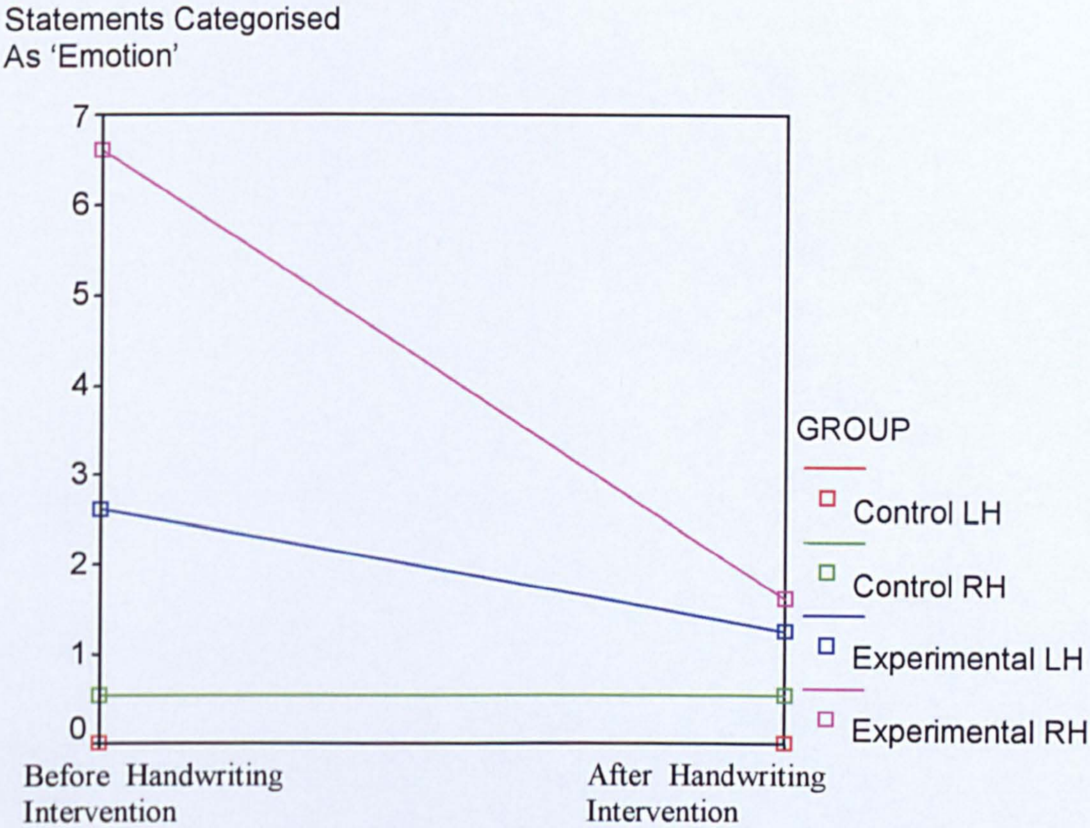


Figure 9.13: Interaction Graph For Number of Statements Categorised as Emotion for Experimental and Control Groups Before and After Handwriting Intervention

The two control groups appear to show no change in articulation of emotions. The left handed control group only has three participants but there was a nil score for emotion in these three cases. Again, as with the 'questions' category both experimental groups appear to have decreased their score in this category. The right handed group using their left hand/right hemisphere appear in the graph to decrease the most which is exactly the opposite of what is hypothesised. The experimental left handed group, using their right hand/left hemisphere appear in the graph to decrease slightly where a decrease was hypothesised. Table 9.4, shows the results of the ANOVA giving significance for the difference between groups endorsing the apparent difference of the right handed experimental group which decreased in use of 'emotion' statements.

	df	F	Significance
Comparison of Number of Emotions Generated Before and After Handwriting Intervention	**1,26**	**3.350**	**0.079**
Effect of Different Handwriting Intervention (Left Hand, Right Hand, Control)	**3,26**	**3.955**	**0.019**
Interaction Between Number of Emotions Generated and Different Handwriting Intervention	**3,26**	**2.379**	**0.093**

Table 9.4: ANOVA results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effects of Hand used

This right handed experimental group was using the left hand/right hemisphere for the handwriting task and was therefore expected to use more 'emotion' statements. This therefore, disproves the hypothesis.

The same analysis was carried out for the category of 'ideas' again indication right hemisphere processing. This is where ideas concerning the use of different items or people are referred to. Table 9.5 shows the means and standard deviations for this category.

9.5.3 Results of Content Analysis of Text Categorised as 'Ideas'

Measure	Group	Mean	Standard Deviation	Number of Participants
Ideas before Handwriting Intervention (0 months)	Control (Left handed)	2.00	2.000	3
	Control (Right handed)	4.27	3.717	11
	Experimental (Left Handed)	10.25	9.130	8
	Experimental (Right Handed)	4.75	3.105	8
	Mean	5.77	5.969	Total 30
Ideas After Handwriting Intervention (6 months)	Control (Left handed)	3.67	3.512	3
	Control (Right handed)	5.45	3.831	11
	Experimental (Left Handed)	6.88	6.175	8
	Experimental (Right Handed)	6.38	7.745	8
	Mean	5.53	5.575	Total 30

Table 9.5: Means and Standard Deviations For Ideas Generated in Experiment 5

The data is further illustrated in Figure 9.14 to explore any interactions.

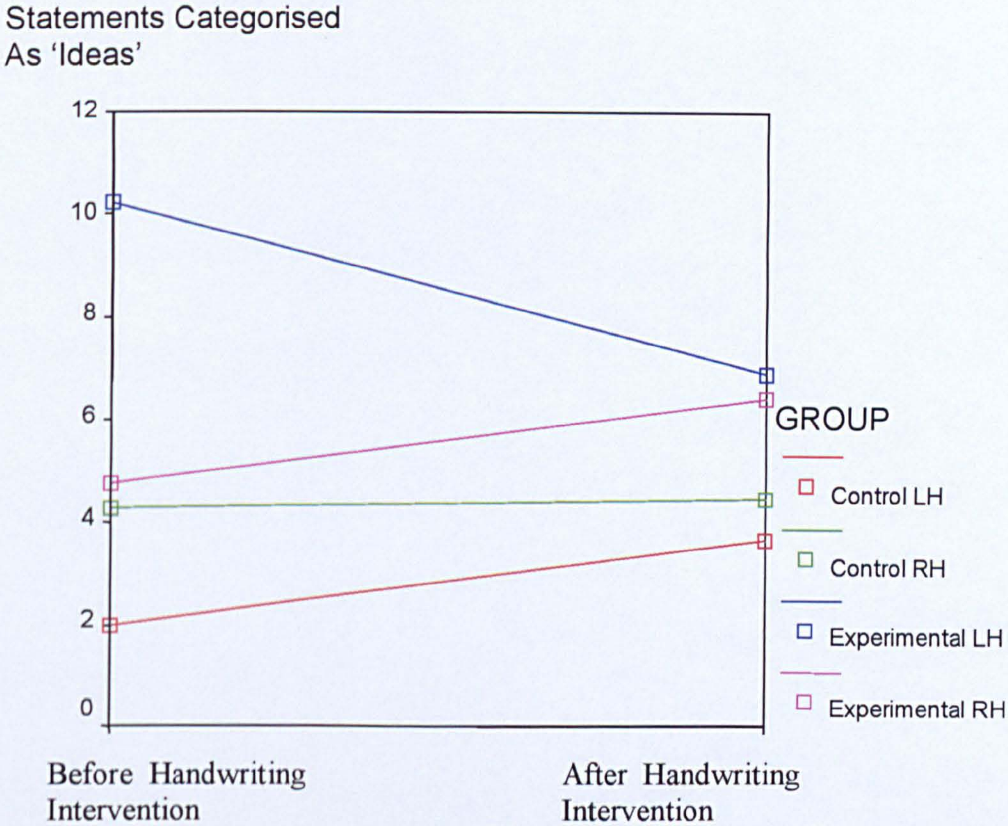


Figure 9.14: Interaction Graph for Statements Categorised as 'Ideas' Comparing Experimental and Control Groups

Apparent differences are that both the control groups showed an increase in the number of ideas as did the experimental right handed group (using their left hand and right hemisphere). Although the hypothesis expected this latter group to increase the control group appears to have increased as well. The experimental left handed group (using the right hand and left hemisphere) appears to have reduced which was hypothesised.

Again, testing for difference at a statistically significant level, none of the apparent differences were shown to be so.

	df	F	Significance
Comparison of Number of Ideas Generated Before and After Handwriting Intervention	**1,26**	**0.000**	**0.986**
Effect of Different Handwriting Intervention (Left Hand, Right Hand, Control)	**3,26**	**1.746**	**0.182**
Interaction Between Number of Ideas Generated and Different Handwriting Intervention	**3,26**	**0.917**	**0.447**

Table 9.6: ANOVA results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effects of Hand used

Therefore, the handwriting intervention did not affect the number of ideas generated as part of the problem solving approach.

The same analysis was carried out for the 'action' words in the problem solving text.

9.5.4 Results of Content Analysis of Text Categorised as Actions

The 'action' category was the only one that indicated left hemisphere processing. Therefore, it was expected that those using their right hand/left hemisphere would increase the emphasis on 'action'.

Measure	Group	Mean	Standard Deviation	Number of Participants
Actions before Handwriting Intervention (0 months)	Control (Left handed)	1.00	1.000	3
	Control (Right handed)	3.73	2.901	11
	Experimental (Left Handed)	10.00	9.502	8
	Experimental (Right Handed)	8.13	7.511	8
	Mean	6.30	6.964	Total 30
Actions After Handwriting Intervention (6 months)	Control (Left handed)	3.000	2.646	3
	Control (Right handed)	5.182	4.446	11
	Experimental (Left Handed)	6.875	6.792	8
	Experimental (Right Handed)	7.000	6.887	8
	Mean	5.900	5.616	Total 30

Table 9.7: Means and Standard Deviations for Actions Generated in Experiment 5

Table 9.7 above shows the means and standard deviations for the 'action' category and Figure 9.15 illustrates the data in an interaction graph.

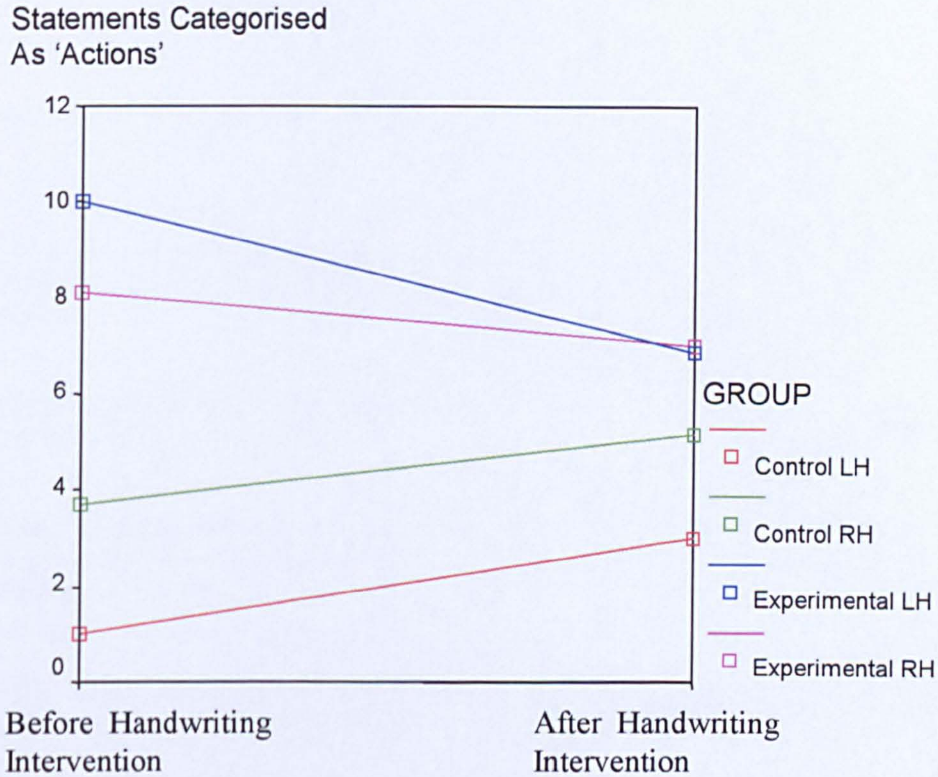


Figure 9.15: Interaction Graph for Statements Categorised as 'Actions' Comparing Experimental and Control Groups

In the interaction graph above, both control groups appear to have used more 'action' statements in their problem solving approach whilst both experimental groups appear to have used less.

These apparent differences were tested for difference at a statistically significant level and found to be insignificant as shown in Table 9.8 overleaf.

	df	F	Significance
Comparison of Number of Actions Generated Before and After Handwriting Intervention	1,26	0.12	0.913
Effect of Different Handwriting Intervention (Left Hand, Right Hand, Control)	3,26	2.501	0.082
Interaction Between Number of Actions Generated and Different Handwriting Intervention	3,26	0.513	0.677

Table 9.8: ANOVA results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effects of Hand used

Therefore there was no difference in the use of 'action' thinking in the problem solving approach after the handwriting task.

9.5.5 Results of Content Analysis of Text Categorised as 'Options'

The last thinking category was that of 'options' where the statements indicated the participant was considering different alternatives. The means and standard deviations for each group are given in Table 9.9 overleaf.

Measure	Group	Mean	Standard Deviation	Number of Participants
Options before Handwriting Intervention (0 months)	Control (Left handed)	0.00	0.000	3
	Control (Right handed)	1.18	1.328	11
	Experimental (Left Handed)	6.13	7.990	8
	Experimental (Right Handed)	1.88	1.356	8
	Mean	2.57	4.636	Total 30
Options After Handwriting Intervention (6 months)	Control (Left handed)	0.333	0.577	3
	Control (Right handed)	1.636	1.912	11
	Experimental (Left Handed)	4.125	5.842	8
	Experimental (Right Handed)	3.000	4.598	8
	Mean	2.533	4.023	Total 30

Table 9.9: Means and Standard Deviations for Options Generated in Experiment 5

As with the other categories an interaction graph was generated to illustrate the data further.

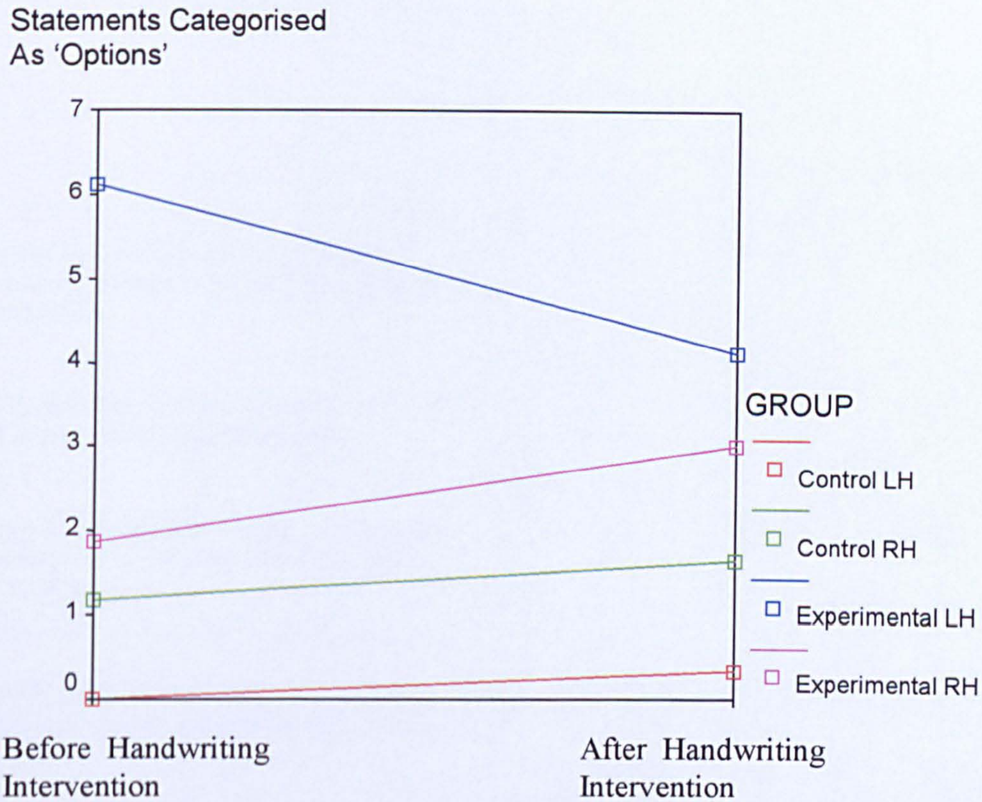


Figure 9.16: Interaction Graph for Statements Categorised at Options Comparing Experimental and Control Groups

The experimental left handed group (using their right hand/left hemisphere) appeared to reduce their 'option' thinking as hypothesised whilst the right hand experimental group (using their left hand/right hemisphere) appeared to increase their use of options, again as hypothesised. Both control groups increased which was not expected and would therefore lessen any comparative effect for the right hand experimental group and increase the comparative effect of the left hand experimental group. However, as before these apparent differences were tested for statistical significance.

	df	F	Significance
Comparison of Number of Options Generated Before and After Handwriting Intervention	**1,26**	**0.000**	**0.987**
Effect of Different Handwriting Intervention (Left Hand, Right Hand, Control)	**3,26**	**3.762**	**0.023**
Interaction Between Number of Options Generated and Different Handwriting Intervention	**1,26**	**0.378**	**0.769**

Table 9.10: ANOVA results for Within-Subject Effect of Handwriting Intervention and Between-Subject Effects of Hand used

As Table 9.10 shows the only significant difference found was between the groups and relating back to the interaction graph this is shown to be the experimental left handed group. The left handed group comprised participants who were using their right hand/left hemisphere and the use of 'options' decreased which was hypothesised.

9.6 Discussion

The hypothesis for Experiment 5 was that the left handers using their right hand/left hemisphere for handwriting would show less divergent thinking and the right handers using their left hand/right hemisphere for handwriting would show more divergent thinking. It was decided to use left handers and right handers so as to be able to explore differences in the groups.

The response texts generated by the participants were analysed into 5 categories of thinking, four of which indicated right hemisphere thinking and one of which indicated left hemisphere thinking. The scenarios were deliberately constructed to arouse the divergent thinking. As a reminder the categories were: questions, references to emotion, ideas, action statements, and option statements/clauses.

A difference was found for the left handed experimental group who decreased in their use of 'options' as a thinking process. This group were using their right hand/left hemisphere and the use of 'options' decreased which was hypothesised.

Another difference was found for the right handed experimental group which reduced the use of 'emotion' statements. This disproved the hypothesis. This is interesting as emotions statements are an indicator of right hemisphere processing and the hypothesis expected this to increase for the right handers not decrease.

One interesting finding from the methodology of this experiment is that 15 of the original participants had to be excluded since they completed the first exercise but declined the second. The reasons given were that they had felt the first one was vague and they were not sure how to respond and therefore felt unable to 'do it well'. When presented with another one, they decided not to engage with it. This is perhaps an indicator that the experiment itself, in attempting to arouse right brain processes through its design, had sufficiently 'turned off' some people so as to stop them becoming part of the experiment. There were also two participants who felt that the question must be a trick one that was finding out how clever they were.

Their response to the question 'what do you do?' (which was deliberately vague as to not assume a 'problem' needed 'solving') at the end of the scenario description, was to state their professions. So the responses received were 'I am an engineer' and 'I am an optician'. These two latter examples were from the control group and may go some way to explaining why the control groups were different from the experimental groups right from the beginning of the experiment, thereby making it difficult to use these for comparison as they are not matching groups. It does also highlight that there may have been other factors involved which affected the control group and that this may have been due to the analysis of these groups being later on in time and the researcher having some influence on the content analysis of this particular data.

10 EXPERIMENTS 6 & 7:

STRESS REDUCTION

10.1 Introduction

One of the important thing to manage today is personal stress. There are many serious sources of stress experienced by managers. Schabracq and Cooper (2000) describe what they consider to be serious sources of stress:

too many working hours and travel
inadequately co-ordinated tasks leading to conflicts
ambiguous unclear goals, priorities, procedures, feedback
too variable and loosely connected tasks
too difficult and complex tasks demanding instant creativity
taking too many decisions with serious consequences based on insufficient information
working in changing diversity
exposure to stress of others
exposure to frequent changes in every area of work
spill-over into other areas of life and adverse effects on family, health etc

10.2 Cognitive Stress

There are different types of stressors and some are physical such as tiredness and muscle exhaustion. However, this research is concerned with mental processes and is therefore concerned with those stressors in the above which are considered to be cognitive, that is, when mental processes are under excessive demand.

The purpose of the next two experiments is to find out whether handwriting with the non-preferred hand can help to reduce stress or increase relaxation. This is part of a search to try to find a simple practical method which an individual could use to interrupt unhelpful thought patterns.

It has been noted that the control of fine motor skills is contralateral and also that most individuals have a preference for handedness – on average 90% right handed and 10% left handed as noted in section 1.2. In experiment 1 and 2 there was an attempt to interrupt hemispheric processing by using a manipulation task on a short term basis. The hypotheses were not proven. Therefore, this experiment provides a longer period for the manipulation task. Handwriting was not used for the interruption in the former experiments because the inability to write with the non-preferred hand may have made the participants feel awkward. However, with regular practice this could be overcome. Therefore it is useful to carry out a longer term study using handwriting as the manipulation task and see whether using the non-preferred hand for a longer period and thereby arousing that task in the contra-lateral hemisphere more often has any effect on thinking. Remaining within the theme of interrupting thinking or arousing thinking this would have potential benefits for those times when an individual cannot seem to 'switch off' from a particular thought pattern that is causing stress.

10.3 Experiment 6

The aim of this experiment is to find out if handwriting with the non-preferred hand regularly over a period of time (thereby arousing the non-dominant hemisphere for fine motor control) has any affect on an individual's experience of cognitive stress. Research for this has not been found and in conversation with a well regarded researcher in the area of stress, Professor Cary Cooper, it was considered a novel hypothesis. This experiment differs from all the other experiments in that it is not testing a theory that stress is related to one particular hemisphere. It is trying to establish whether using the non-preferred hand in some way brings a new type of processing activity to the contralateral hemisphere which in turn has an effect, such as an interruption, thereby causing a sense of 'switching off' from the usual mental activity experienced when writing.

Hypothesis

The hypothesis is that the task of handwriting with the non-preferred hand, regardless of handedness, would cause the effect of decreased stress because it would introduce a different thinking process that the individual would not normally experience and therefore distract them for their 'normal' stressful thoughts .

10.4 Method

The task was designed specifically to arouse the hemisphere which the individual would not normally arouse with fine motor control skills. Writing was chosen as the most appropriate skill to use as it comprised precise control of the fingers which maximised the contralateral effect of the hemisphere so that a right hander, using their left hand would arouse the right hemisphere whereas they would normally arouse the left hemisphere with their handwriting.

10.4.1 Participants

There were 24 participants involved in this study, some of which were involved in the previous experiments 4 and 5. Four participants were left handed and twenty were right handed. They were all English speaking employees of the University of Salford who volunteered to carry out the study. They were aged between 21 and 60. They were classified as right handed or mixed/left handed according to the classification system described earlier in Section 3.5.

10.4.2 Materials

No specialist materials were used for this study.

10.4.3 Procedure

The participants were briefed and sent information concerning the experiment and how data would be collected. They were told that in preparation for the experiment they would write for a few minutes, with their non-preferred hand, everyday, if possible, or if not, as often as they could. Anyone who reported that they had not done the task for 4 out of 7 days were screened out of the study. They were allowed to write with any implement on any surface at any time of the day or night.

Once the participants were started off they were contacted on a regular basis by email. The same emails were sent to all participants and these were usually in the form of encouraging participants to continue with the writing and asking if anyone was experiencing problems. At times individuals would ask questions concerning the research and these were answered individually or by a general email if it was thought the question might be relevant to others. No information was given to participants relating to the hypothesis of the experiment as this would have skewed the data. Fortunately, as participants were from the university this was understood without much need for explanation.

Many participants were concerned that they would not remember to do the task so email reminders were sent and also a credit card sized 'reminder card' was given out over holiday periods for people to place in their wallets.

Data Collection

The data was collected via a specially devised questionnaire. This was emailed or posted to participants after 5 months of handwriting with their non-preferred hand. This was one month before the end of the full period of handwriting. The 6th month involved a further experiment so it was important to complete this questionnaire first.

The Questionnaire

This questionnaire had many questions concerning when the individual carried out the task, what time of day and for how long etc. Some of the questions related specifically to feelings of stress or relaxation. Giving the participants this questionnaire at this time meant that they had become accustomed to the task and that the initial feelings of anxiety and apprehension were expected to have been alleviated.

The aim of the questionnaire was to find out if there was any indication of an increased or decreased experience of stress in an individual *whilst* they were carrying out the task of writing with their non-preferred hand.

The questions were open questions designed deliberately to encourage the participants to express thoughts and feelings in their own words.

The questionnaire was designed to focus the participant on how they felt whilst actually doing the task because it would be at this point when the contralateral hemisphere would be aroused for the task. Two questions directly asked for an indication of whether stress or relaxation was experienced ie:

Q1 Have you noticed whether the process of actually doing the task makes you feel stressed?

Q2 Have you noticed whether the process of actually doing the task makes you feel relaxed?

Having two questions ensured extra clarity in the response and gave a check as to the validity of perceiving these terms as opposites. All those who responded positively to the first question also responded negatively to the second, and vice versa, which showed the responses were clear perceptions.

Figure 10.1 illustrates the way the two questions were used to check that the potentially emotive wording of 'stressed' or 'relaxed' did not cause different responses. By asking the for data through two slightly different questions any negative connotations of the word 'stress', which could be perceived as failure, would be reduced.

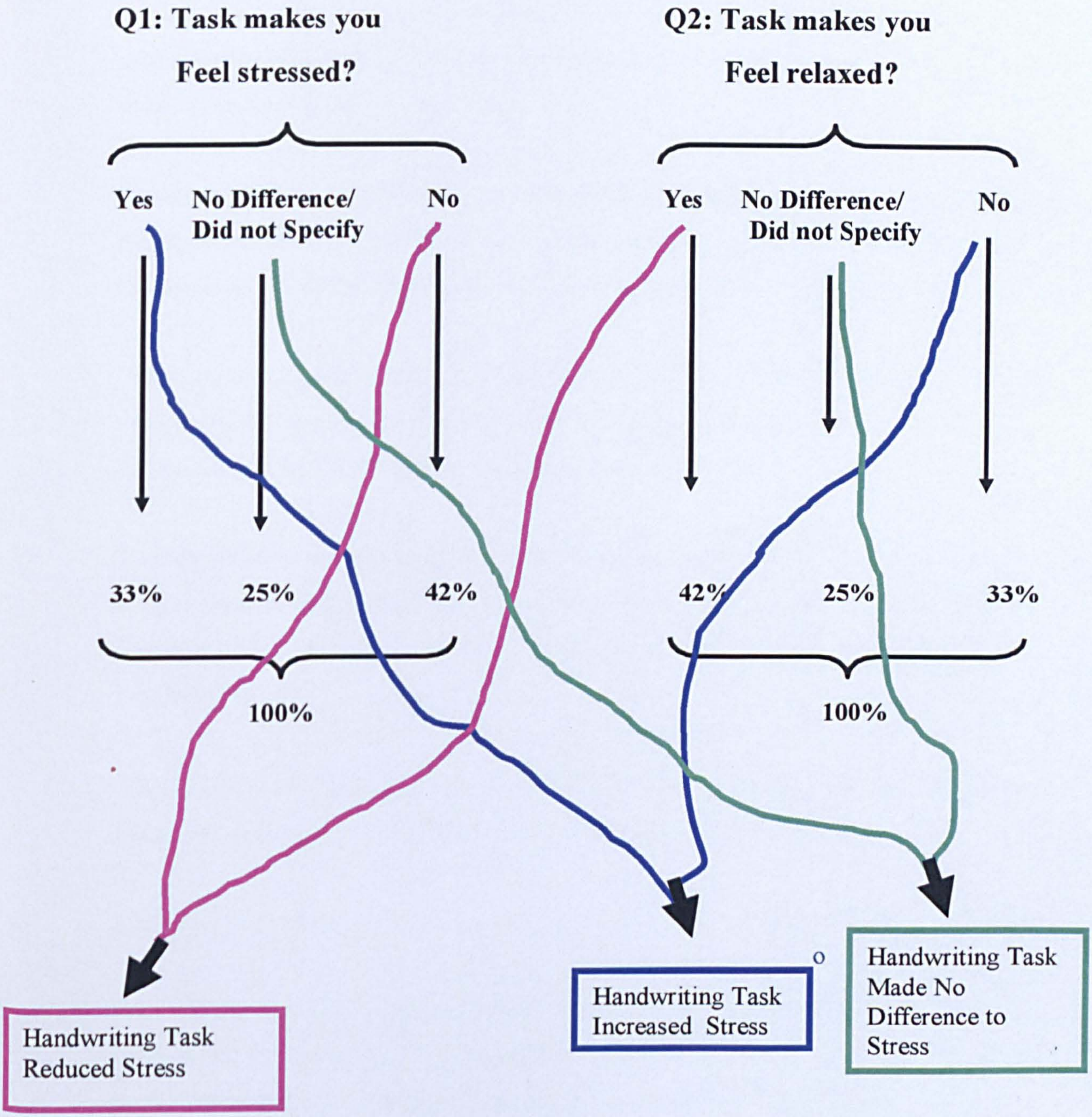


Figure 10.1: Categories from Responses to Q1 and Q2

It can be seen from Figured 10.1 that there was consistency between the responses for each question. If there had not been then an average of the results for each question would have been used.

In order to collect as much data as possible there were additional questions specifically asking about 'thoughts' and 'feelings' that the individual experienced whilst doing the handwriting task so that these factors could be analysed. These questions were:

- What do you generally 'think' about whilst carrying out the handwriting task?
- Are any particular 'thoughts' more common than others at this time?
- How do you 'feel' when you are carrying out the task?

In order to then check again that any other responses were recorded there was a very general question at the end of the questionnaire. A last question gave an opportunity to express any response which may have been brought to memory by earlier questions. This question was:

- Please give any comments about 'thoughts' and 'feelings' that you experience whilst doing the handwriting. Any observations, however obscure, will be useful.

Type of Data Collected

When talking about their experience it is worth noting here that the participants are in fact to some degree 'recalling' their experience and therefore the process of reflection is worth noting. Moon (2002) suggests that reflection is when someone breaks away from the usual thought patterns to take an overview of an event or experience. Dewey (1933) describes reflection as "the kind of thinking that consists in turning a subject over in the mind and giving it serious thought". The role of emotion does not come through strongly in Dewey's work but Boud, Keogh and Walker (1985) see reflection as an activity where people "recapture their experience, think about it, mull it over and evaluate it". They suggest that there are three aspects involved. The first is recalling the event or activity in this case the handwriting task. The second is connecting with feelings and in this stage they suggest that the unhelpful or obstructive feelings are often removed. This is worth noting as in having to recall the experience it may be that some of the negative feelings of stress are not so easily remembered. The third aspect is evaluating the experience to make sense of it and relate it to more current knowledge and experience.

10.5 Analysis

Because this experiment involved content analysis it is appropriate to describe the process undertaken.

Individuals were given an overall classification dependent on their response to the first question asking whether they experienced stress and whether they experienced relaxation. Each individual was classified into one of three possible categories; experience of increased stress, experience of reduced stress (increased relaxation) or experience of no difference/did not specify.

The additional data given by the individuals was analysed within each of these three classifications. This was for three reasons: i) to confirm that the classifications given to individuals based on question 1 and question 2 were supported by the additional comments given in following questions; ii) to see if the additional data would enable those in the 'do difference/did not specify' category to be classified into one of the other two more definitive groups and iii) to enable analysis into the 'ways' in which the stress was experienced.

For 'each' person, each of their statements was categorised as showing an 'indication of increased stress', an 'indication of decreased stress' or an 'indication of no difference'. Examples of words and phrases within statements categorised as indicating increased stress are: 'anxious', 'difficult', 'frustration', 'anger', 'strain' and 'discomfort'. Also the word 'concentration' was attributed to the 'increased stress' classification because it showed extra effort having to be made. Examples of words and phrases within statements classified as indicating decreased stress are: 'relaxed', 'contentment', 'calming', 'feeling of less stress'. Words and phrases indicating no difference in stress are; 'made no difference', 'no particular stress', 'not particularly relaxed'.

Examples of Statements Indicating Increased Stress

- "facial muscles tighten while concentrating"
- "deep concentration on the handwriting"
- "anxious"
- "I concentrate on the writing"
- "frustrated that I can't do it as well as I would like to"
- "It's not getting me anywhere"
- "I find it more tiring that I thought"
- "Sometimes I get a real arm ache"
- "It makes me feel stressed because I had to write very slowly"
- "I had to concentrate on the shapes of the letters"
- "My poor standard"
- "I am shocked at the scribble before my eyes"
- "how uncomfortable it is/how some letters are persistently difficult to do"
- "why is 'e' so difficult"
- "it is slightly stressful"
- "this is quite demanding and difficult"
- "annoyed because I don't write well"

- "my writing doesn't seem to get any better"

Examples of Statements Indicating Reduced Stress

- "I find it quite relaxing – it has allowed me to think about things"
- "I generally feel quite relaxed" "During the first few weeks I felt very agitated but more calm now"
- "soft, relaxed feelings, flowing, calming sensations, concentrated and focused, thinking of my daughter learning to write"
- "may be relaxing"
- "it doesn't stress me"
- "possibly makes me more relaxed"
- "I feel so at peace with the world – it's difficult to describe but it's a bit like the feeling you get when you are holding a baby in your arms"

10.6 Results

Having examined the data given for all questions by those in the 'no difference/did not specify' category established on the basis of the response to Q1 and Q2 it was found that some could be placed in one of the other two categories. Table 10.1 shows the resulting increase for these two categories of 9 (38%) indicating increased stress and 13 (54%) indicating reduced stress. This left 2 (8%) indicating no difference/did not specify who had not given sufficient data to be classified further.

	Indication of Increased Stress	Indication of Reduced Stress	Indication of No Difference	Totals
Q1 and Q2 data	33%	42%	25%	100%
	n=8	n=10	n=6	n=24
Content Analysis of all data	38%	54%	8%	100%
	n=9	n=13	n=2	n=24
Reclassified	n=+1	n=+3	n=-4	n=4

Table 10.1: Reclassification of Categories based on Content Analysis of all Data

Table 10.2 overleaf illustrates the observed and expected frequencies for each level of stress experienced; increased stress, reduced stress and no difference in stress.

Frequencies	Indication of Increased Stress	Indication of Decreased Stress	Indication of No Difference in Stress	Total
Observed	9	13	2	24
Expected	8	8	8	24

Table 10.2: Observed and Expected Frequencies of Level of Stress Experienced

The chi-square goodness-to-fit test gives the following result: X^2 (2) = 7.750; $p < 0.05$ therefore showing there is a difference between the frequencies of each stress experience. This difference, however, relates to the experience of 'no difference in stress'. The hypothesis relates to a decrease in stress, the opposite of which is the increase in stress. When removing this category, leaving only the 'increased stress' and 'decreased stress' categories, a binomial test shows that the results are not significantly different from chance; p =0.26.

10.7 Discussion

The results are that handwriting with the non-preferred hand does not bring a benefit of stress reduction. On an individual basis there were some interesting observations of subjective experience, both positive and negative.

The aim of the experiment was to find a way to reduce stress. Although 54% of the participants reported that stress had been reduced, this is not sufficient for statistical significance. It would, however, be useful from the content analysis to extract factors which may be further researched individually. The factors identified by individuals were:

i) the ability of being able to think more clearly and more focussed
ii) a reminder of positive memories of learning to write
iii) a link to a specific memory of something relaxing and soothing

For the 38% who reported an increase in stress the factors which were extracted from the content analysis and which would benefit from further research in order to test for statistical significance are:

i) the effort and concentration that the individual underwent to carry out the task
ii) the physical discomfort from using different muscles
iii) the feeling of disappointment at not reaching an expected personal standard or not progressing at an expected rate

Another consideration for further research is the number of participants involved in the study. The numbers completing the experiment was small due to high 'drop-out' rate. The design of the experiment required a 6 month commitment with no real incentive other than 'goodwill'. Considerations to improve retention might include rewards of some kind or shortening the time span needed for the experiment. Perhaps accepting that many will 'drop out' and starting with a much higher number of participants would be a better approach. An interesting point is that twelve out the sixteen that 'dropped out' gave as their reason the fact that since they felt a sense of guilt if they forgot to carry out the handwriting it was easier to give up completely.

10.8 Experiment 7

Experiment 7 is a further development of Experiment 6 exploring whether handwriting with the non-preferred hand can affect the experience of stress. In this experiment participants are asked to select a situation that is particularly mentally stressful or to select a time when they are unable to 'switch off' and are already mentally stressed and then to carry out the task of handwriting whilst in that mental state. This experiment seeks to find out if a state of mental stress would benefit from the intervention of handwriting arousing the opposite hemisphere to the one dominant for writing.

Hypothesis

That under a condition of mental stress that handwriting with the non-preferred hand would decrease the mental stress experienced.

10.9 Method

10.9.1 Participants

The participants were some of the participants who had taken part in Experiment 6.

10.9.2 Materials

No specialist materials were used for this study.

10.9.3 Procedure

This experiment took place in the last, 6th, month of the research project. Participants were requested to be prepared to use the handwriting task during a time of increased mental stress and to be ready to do so if a situation arose. Mental stress was defined as the inability to 'switch off' from particular thoughts or stress from thinking particular thoughts. It was not to be a stressful situation cause by 'physical' factors or 'emotional' factors but specifically mental factors. They were instructed to carry out handwriting with the non-preferred hand, there and then, during this stressful experience and to report the effect that the handwriting had on their experience. The question they were asked to consider was *"If you are already mentally stressed does writing with the non-preferred hand increase or decrease the feelings of stress?"*

10.9.4 Measures

Data was collected in the form of emails and some hand written texts giving a response to the question. The method of content analysis was used to analyse the responses given by participants. First they were categorised as indicating an increase or reduction in stress in the same way as for Experiment 6. The data was then analysed to see if themes emerged as to what was causing the increase or decrease in stress experienced to see if connections could be made to using a different hemisphere for handwriting.

Reactions under conditions of stress

Very few participants managed to carry out this task. Only 11 (46%) of those who had completed Experiment 6 managed to carry out this exercise. Two main reasons given for non-completion of the task: one that although an occasion had arisen, it was unpractical to be writing at the time and the other, that once stressed it was not something that they felt like doing. No-one reported that they had no occasion of mental stress.

10.10 Results

Table 10.3 shows the results from those who completed the experiment.

Participant (in order of recruitment)	**Preferred Hand**	**An Increase in Stress**	**A Decrease in Stress**	**No difference to the stress**
1	RH		✓	
3	RH	✓		
6	RH		✓	
7	RH			✓
8	RH		✓	
10	LH		✓	
11	RH		✓	
16	RH	✓		
19	RH		✓	
20	LH		✓	
21	LH			✓
Totals		2	7	2

Table 10.3: Increase or Reduction of Stress Whilst Already Under Mental Stress

Seven participants experienced a decrease in their mental stress level, 2 participants an increase in their mental stress and 2 participants felt no difference. On a binomial test for a difference between the groups who did notice a difference in their stress level $p = 0.09$ which is not significant.

The results from Experiment 7 were compared to those of Experiment 6, for each participant, and are shown in Table 10.4. The pale blue shading shows those individuals who experienced the same decrease or increase in stress when already under mental stress as they reported in Experiment 6 when under normal conditions. This formed the majority of cases.

Participant	Preferred Hand	**Increase** in stress		**Reduction** in Stress	
		in **everyday** situation (Experiment 6)	in **stressful** situations (Experiment 7)	in **everyday** situation (Experiment 6)	in **stressful** situation (Experiment 7)
1	RH			✓	✓
2	RH	✓			
3	RH	✓	✓		
4	RH			✓	
5	RH			✓	
6	RH	✓			✓
8	RH			✓	✓
9	RH	✓			
10	LH			✓	✓
11	RH			✓	✓
12	RH			✓	
13	RH			✓	
14	RH	✓			
15	RH			✓	
16	RH	✓	✓		
17	RH	✓			
18	RH			✓	
19	RH			✓	✓
20	LH			✓	✓
22	RH	✓			
23	RH	✓			
24	LH			✓	
Total		**9**	**2**	**13**	**7**

Participant 7 and 21 removed as recorded 'no difference' in both Experiment 6 and Experiment 7.

<u>Figure 10.2: Comparison of Results for Both Experiments</u>

Although significant differences were not found with the intervention of handwriting, it is nevertheless interesting to see that individuals have experienced what they consider to be important personal effects. Some of these are illustrated below and give some indication of potential factors for further experimentation. Also, from a qualitative perspective there are insights which may be valuable for a more qualitative approach.

"I tried the writing one night when I woke up in the small hours with daytime worries on my mind – I'm afraid it made me feel even more stressed out as I was really concentrating on getting my letters to look good, so much so that I couldn't get back to sleep, so I haven't tried it again."

"I have written twice at stressful times which pretty exactly conformed to the ideal conditions which you described. I was extremely sceptical about the hypothesis which I guessed underlay your request. However, I have to admit that it helped! The effect can be described quite simply. The wrong handed writing simply made the thing that was bugging me seem less important."

"It takes my mind off the stressor, sometimes it can reduce the stress I am under....??
It's therapeutic perhaps?"

"Calming influence...seems to clear my mind"

"I do feel rather calmer"

"I felt relief temporarily from the stress I was experiencing largely because I need to concentrate on what and how I am writing"

"I feel that whether I am stressed or not that this task augments whatever mood I am already in so although I would say it relaxes me overall, I did find it made me more stressed when I was already"

It is useful to look at these themes because they may give an understanding of why we may attribute these things to a hemisphere when in fact there are many other factors at play

There were individual cases where individuals have found the task extremely helpful to them and have continued with regular writing of the non-preferred hand since these experiments were completed. The following comments describe their ongoing experience with writing with the non-preferred hand.

Case 1: Male right hander

"I just get the feeling you get when you are holding a baby and you are at peace with the world. It was amazing – I didn't expect it at all"

Case 2 - Female left hander

I found it relaxing and although it was hard to get down to it I was glad when I did. It takes more concentration when it's with the other hand.

Case 3 - Female Right hander

I think it was partly the reflective diary approach but also just the fact that I was doing it with my other hand – maybe it meant I was doing it more carefully. I still do it even now because I saw a real benefit it keeping a diary but I still do it with my left hand because otherwise it's not the same – it makes me more thoughtful.

10.11 Discussion

Experiment 7

The results showed that the experience of decreased stressed for the participants was not significant and therefore the hypothesis not proved. The number for this experiment were small which makes it difficult to apply statistics. Some did benefit from decreased stress – 7 participants – but it is unclear as to why. Two participants found it increased stress which could relate to considering the writing task difficult.

Comparison with Experiment 6

It is interesting to compare those who took part in this Experiment 7 with their results from Experiment 6. Of the participants who found that using the handwriting task whilst in a stressful situation reduced their stress, all but one of them had previously recorded they had found the task reduced their stress in normal conditions. This is evidence that the task produced the same results whether the participant was already stressed or not. Of those whose stress increased half also reported an increase in Experiment 6, the other reported 'no difference'.

With such small numbers statistical analysis is not particularly helpful. It can be seen however that there is a correlation between those who experience a reduction of stress in both conditions ie everyday situation and situation of enhanced stress.

Earlier in Section 3.3.3 it was discussed that handwriting is considered by many to be a left hemisphere task – although it is not clear if this is just for right handed people. This would mean that the left hemisphere is more aroused with the task and that those using their right hand – the left handed people should find the task less demanding for this reason. Also, although not proved, if there is a case for the left hemisphere processing more positive emotions then there may be a link here to consider as well.

Points for Further Research

Although handwriting is a useful task in terms of precision and control and something which people can do without having to be observed etc because there are no standards, the individual's own standards perhaps got in the way. If this research was to be explored further it may be better to use tracing and this is why it was used for the third study.

11 Summary and Conclusions

11.1 Summary

11.1.1 Research Objectives Reviewed

This research addressed the following questions:

General Question:

- Can we use fine motor control of the hands to help individuals to stimulate different kinds of thinking?

Specific Questions:

- Can a person's verbal recall ability be affected by using one hand or the other?

- Can a person's ability to recognise an unfamiliar face be affected by using one hand or the other?

- Do people perceive orally expressed emotions differently depending on which hemisphere hears them?

- Can a person's idea generation ability be affected by using the one hand or the other?

- Can a person's problem solving ability be affected by using one hand or the other?

- Does a person experience reduced stress by using one hand or the other?

The first aspect of the research was to identify thinking processes that research suggests are controlled by one hemisphere more than the other. Many thinking processes were considered but there was strong evidence for only a few processes to be more supported by one hemisphere than the other. These thinking processes were verbal repetition, unfamiliar face recognition, and the idea generation part of creativity. In older literature (Blakeslee 1980) emotional perception was accepted as a strength for the right hemisphere but more current research separates negative and positive emotions and ascribes them to both hemispheres. This ideas is explored further, here in this research. Creativity is often assumed to be right hemisphere and creative thinkers are sometimes referred to as 'right hemisphere' thinkers. Creativity is a very complex task which comprises both divergent (usually associated with the right hemisphere) and convergent (usually associated with the left hemisphere) thinking. This research aimed to explore those aspects of creativity which were linked to the right hemisphere in particular.

11.1.2 Hypotheses

The results of all the hypotheses are as follows:

Chapter 5 Experiment 1 This experiment tested for any difference in the execution of the verbal task when a different hand is used for the manipulation task.

The hypothesis was that those using their right hand for the manipulation task would improve in verbal repetition ability. The hypothesis was not proved but there was interesting data provided to show that the verbal task remained unimpaired whilst the fine motor task became impaired.

Chapter 6 Experiment 2. This experiment tested for any difference in the ability to recognise faces when a different hand is used for the tracing task. The hypothesis was that those who traced with their left hand would be able to remember more faces that those using their right hand.

The hypothesis was not proved and interestingly the results did not support the female advantage in face recognition shown in some experiments in the literature. This is raised in the Conclusions section.

Chapter 7 Experiment 3. This experiment aimed to test the newest opinion that whilst the right hemisphere is dominant overall for emotional perception that the left hemisphere is dominant for positive emotions. The hypothesis was that individuals who listened to the sentences through their right ear more would perceive emotion orally as more positive.

The hypothesis was not proved with both hemispheres perceiving both negative and positive emotions equally.

Chapter 8 Experiment 4. This experiment aimed to find out if there are differences in the ability to generate ideas before and after repeated handwriting for 6 months with the non-preferred hand. The hypothesis was that those who use their left hand for repeated handwriting would improve in their idea generation ability.

The hypothesis was not proved and it was interesting to note that all participants in the experimental groups reduced in their idea generation ability whilst the control group increased in theirs.

Chapter 9 Experiment 5. The aim of this experiment was to find out if repeated use of handwriting with the non-preferred hand has any effect on the type of thinking used in problem solving. The hypothesis was that writing with the non-preferred hand will alter the balance of types of thinking used for problem solving.

The hypothesis was not proved for this experiment.

Chapter 10 Experiments 6 and 7. The aim of these experiments was to find out if using the non-preferred hand for writing over a period of 6 months could decrease the experience of mental stress. The hypothesis for Experiment 6 was that using the non-preferred hand would decrease the feeling of stress and increase the feeling of relaxation in all participants.

The hypothesis was not proved here although individuals did report some benefits.

The hypothesis for Experiment 7 was that using the non-preferred hand would decrease the feeling of stress in that stressful situation for all participants.

The hypothesis was not proved and there was no reduction in stress found.

11.2 Conclusions

The research set out to test whether using a fine motor control skill can affect higher level thinking. The research is in two parts. The first part is testing out whether a short term interruption is possible to a thinking skill by using a fine control skill and so the experimental conditions are tightly controlled and very specific measurements are taken. The second part of the research is looking at more complex skills where an application of the theory would be useful eg generating ideas, problem solving and stress reduction. This second part uses a longer term interruption with the repeated use of the fine motor control task.

11.2.1 General Conclusions

Specialisation of hemispheres

The theory concerning hemispheric asymmetry is still controversial. Much of the initial research was done 20 years ago when it was a very popular topic stemming from the split-brain studies and it still continues today. Assumptions concerning thinking processes are being challenged as empirical research gives confusing and often contradictory results. From this present research it has become clear that thought processes need to be broken down into smaller elements to be tested. This is concluded as it was difficult to find empirical evidence in the literature, for just one thought process that could be attributed to the left hemisphere or the right hemisphere, respectively.

From the literature review of the present research, it was discovered that, as more and more experiments were undertaken, tasks such as 'language' were too broad to be tested and had to be qualified into 'verbal language' which had to be further reduced to 'verbal repetition'. Similarly, the task of 'remembering faces' had to be filtered down to 'recognising faces' which then had to be broken down further to the more discrete process of recognising 'unfamiliar' faces'. The cognitive process of 'emotional perception' had to be broken down into 'oral perception' and then 'intonation perception'. The process of having to do this in order to validate the experiments carried out in this study, concludes that attributing thinking processes in a very general way can be misleading. However, despite this, the notion of specialisation is still used as a basis for current research projects on asymmetry (Magnus and Laeng 2006). One reason given is that interhemispheric conduction delays, even though measured in milliseconds, still contribute towards some specialisation (Ringo et al 1994). This present research concludes that specialization does not show through 'normal' brains as differences in thinking abilities.

Split-brained patients

An overall conclusion from this research is that although Blakeslee says "all of the left-right differences we saw in the split-brained patients can be demonstrated, although less dramatically, in normal people" that differences have not been demonstrated here. (Blakeslee 1980 p168). It concludes that is cannot be assumed that split brains have the same laterality as normal brains. Perhaps the initial reason the brain had to be split in the first place has brought with it some innate differences not accounted for. Also, that in normal brains the discrete testing of mental functions is more complex. The functioning of the corpus callosum and the ability of one hemisphere to assist the other through it, and the extent to which it does, is difficult to test for. It is clear, from experiments carried out by Bogen (1990), described in Section 1.4.1, that even without a functioning corpus callosum, a person's right hemisphere can communicate with the left hemisphere simply by moving the eyes. Bogen found that his patient's right hemisphere was giving the left hemisphere the answer to the question, as to which shape the left hand/right hemisphere was feeling, by looking either at the door, the ceiling or the clock, each of which were worked out by the left hemisphere as being codes for the three shapes, sphere, cube and pyramid. This concludes that 'normal' brains, under normal circumstances, ie not blindfolded, can have externally based interhemispheric communication.

Link between thinking and fine motor control

It was found that when a thinking task is combined with a fine motor control task the ability in the thinking task prevails and the ability of the motor task is impaired. This concludes that the thinking task takes priority when there is competition for mental resources. This relates equally whether both tasks are competing for resources within the same hemisphere or whether they are using different hemispheres. Because a fine motor control task did not interrupt or arouse the thinking task on a temporary or long term basis this concludes that such tasks cannot be used in a therapeutic or developmental way. However, for those who did find it therapeutic, it was a very strong experience for them, and so may be worth trying. It is difficult to ascertain why they felt it therapeutic and it could have simply been a diversion.

Gender and handedness

A conclusion from the literature search is that gender and handedness differences do signify differing laterality. Therefore, the best research separates out all these groups where possible. However, a conclusion for this current research is that for left handers this may not be possible without the use of neuroimaging equipment as left handers are an idiosyncratic group.

11.2.2 Conclusions from selected hypotheses

A conclusion drawn from the first hypothesis, of attempting to interrupt the left hemisphere task of verbal repetition with the fine motor skill of manipulating beads by each hemisphere respectively, is that it does not make any difference which hemisphere is being used. Therefore, it is concluded that competition within the same hemisphere and competition between hemispheres both had the same effect and that it was only the competition affect that impaired the motor skill not the handedness.

This research has contributed to the established body of research in that it has provided experiments using a fine motor control skill other than tapping which the majority of experiments have used (Keefe 1985, O'Boyle et al 1994, Dilks et al 2006). The fine motor skill used ensured precision and control of the fingers which meant the contralateral hemisphere had to be used. In tapping it could be argued there could be bilateral control.

One conclusion that can be drawn from the fact that it was the fine motor skill that was impaired when the skills were combined, is that if the motor skill is the important one then the verbal skill should be minimised to assist this. This might have connotations for education, particularly of manual skills.

This experiment also adds to the literature in that it is using the discrete verbal skill of speech. The literature was carefully screened to find what researchers had learned from using complex processes and how they had suggested breaking these skills down for subsequent research. Speech was the only skill that could be attributed to the left hemisphere with confidence. Even then some speech had to be excluded, for example, reciting nursery rhymes because they used bilateral control as the synapses used followed the ipsilateral pathways through the basal ganglia and cerebellum (Thach 1996). Reciting nursery rhymes has been used in experiments to look for the effect when combined with a motor task (Hiscock and Kinsbourne 1980, White and Kinsbourne 1980), however, these also use the cerebellum's ballistic control mechanisms therefore providing bilateral control. This present research provides a skill that is completely contralateral, which adds to the body of research and could be used in other experiments.

One of the novel aspects of this current research is the attempt to use a fine motor control skill to 'arouse' a higher level thinking skill. This has not been found in any other experiments. Generally, in other experiments there has been the assumption that if the fine motor control skill is working then the higher level thinking is already functioning. This experiment does not assume that relationship and attempts to 'arouse' the thinking through the motor skill. In doing this there was an attempt to keep the fine motor control skill as stable as possible so that it would be the higher level thinking skill that was affected by the combination of the two. However, this was difficult and it is difficult to see how this could be accomplished without some equipment automating the skill.

Priming a hemisphere

A conclusion drawn from this experiment is that support has not been established for the experiments by Macrae and Lewis (2002) where the priming of a hemisphere with a particular task enabled that hemisphere to perform a subsequent similar task more effectively. In this experiment, there was no residual effect shown from one task to another so the priming effect was not evidenced. Macrae and Lewis experimented with visual and spatial stimuli so perhaps this was the difference.

A conclusion drawn from the second hypothesis, as to why tracing with the left hand/right hemisphere did not improve face recognition, is that the internal competition within the right hemisphere, negated the advantage of both skills being in that hemisphere. This research has added to the literature by using the control task of tracing, which is more contralateral than tapping, and which does not have any complications of language. It does involve spatial skills and it could be concluded that this also competed for right hemisphere resources. Tracing, looking in a mirror, has been used in experiments to provide evidence for a female advantage in spatial abilities, with the mirror providing spatial difficulties as the participants can only view what they are tracing by looking into the mirror (Moir and Moir 2000). The male cannot trace using his right hand because the left hemisphere controlling its movements does not have spatial awareness ability, his right hemisphere does. In men it is the right hemisphere only, in women it is both hemispheres. This is an experiment that, rather than using 'split brains', uses 'normal' brains so can be compared here. In this current research the experiment included both males and females. The skill of tracing was not measured specifically so it could be concluded that if it had been there may have been a female advantage for it.

This highlights the problem with ascertaining exactly which skill is being tested in experiments. In the literature there is a circular argument that if the hand cannot perform a task then it is the contralateral hemisphere that is not functioning concerning the thinking task rather than an inability in the motor task. It is concluded from this research that these assumptions still need to be challenged as it cannot be so readily assumed. If a left hand can determine a shape this has been assumed to mean it is the right hemisphere that has spatial ability (Lacreuse 1996).

The conclusion concerning face recognition is that people remember faces easily for a 3 week length of time even when distracted with another task such as the tracing used here. In Section 6.2.6 it was shown that people can remember school friends' faces with 75% success rate after (Bahrick et al, 1975) in their experiments it was not so much the face, as the character, that was being remembered. Also hair has been shown as a clear indicator of recognition. Experiment 2 took account of the recorded experiments in the literature and honed the stimulus carefully to ensure it was purely the faces itself that was being recognised. It can be concluded that the right hemisphere task of recognising faces was not improved by the either hemisphere using fine motor control for the tracing task. This experiment will add additional data to the body of research in the form of offering an appropriate stimulus for the testing of face recognition and that motor skills, controlled by either hemisphere, interrupted the task to the same degree. This is interesting as some were using their preferred hand and some their non-preferred hand. This did not affect their ability to recognise faces. The tracing task itself was not measured, so it cannot be ascertained as to what extent this task was affected. It could not be compared as those using their non-preferred hand would be at a disadvantage.

The female advantage for face recognition was not shown in this experiment. However, some of this literature has now shown this female advantage may have been due to the females giving the faces names (Lewin 2001). Also the female advantage has only been shown on female faces (Lewin & Herlitz 2002). This concludes that there needs to be testing of males recognising male faces to see whether this current research's findings, of no gender difference, is further supported.

The conclusions for the third hypothesis, tested by Experiment 3, are that the debate concerning negative and positive emotions must be further explored. Also that separating out emotions is helpful in that it indicates where asymmetries may lie. In Figure 7.1 it is seen that although both hemispheres perceive the emotions to be the same that they have a different distribution types. This may be an indicator that further testing may be worthwhile as to why the left hemisphere distributions are narrower. Out of all the categories of emotions, the emotion of anger, shown in Figure 7.8, showed the distributions to be wider apart for each hemisphere than the other emotions. Anger would be an interesting emotion to test further.

Many experiments reported in the literature, to test emotional perception, involved visual stimuli. This involves complex cognitive processes. Experiment 3 was purely on emotional perception of auditory tone so contributes to an area of literature which is not very large. In a recent article, negative emotional stimuli of a written word shown very briefly (17 ms) was perceived more strongly by the right hemisphere whereas the positive words showed no hemispheric asymmetries. (Smith and Bulman-Fleming 2006). This is, of course, not the same stimulus being written rather than auditory, but Experiment 3 does agree with the findings for the positive emotions but not for the negative. This concludes that testing for negative and positive emotions separately is useful.

This research may broaden the research done by Heilman who found that patients who had right hemisphere lesions found it difficult to perceive emotional intonation. (Heilman et al, 1975). Here in normal brains no difference was found so perhaps it is the nature of the injured brain that causes the difference.

As for the second part of the research, in Experiment 4, on idea generation, it was interesting to note that all participants in the experimental groups reduced in their idea generation ability whilst the control group increased in theirs. This concludes that the combination of tasks was reducing the ability to generate ideas, that the specific handwriting task was or that there were other undiscovered factors involved which differentiated the groups. The recruitment practice was the same for both the experimental and control groups though the control group started slightly later than the experimental group. This could suggest that the researcher's experience in analysing the data, since it was content analysis, influenced the data slightly.

In Experiment 5, testing problem solving, it can be concluded, that if there was any development of processes within the individual caused by the regular use of the non-preferred hemisphere for handwriting then it was not sufficient enough to be measured. It can be concluded that other stronger processes were being used, for example, the interhemispheric communication via the corpus callosum or that the tasks, handwriting and problem solving, had to be carried out simultaneously to record any affect.

The hypothesis, in Experiment 6, attempting to reduce stress by long term handwriting with the non-preferred hand, was disproved but it was found that some individuals derived a strong personal benefit of positive relaxing feelings, so much so that they continue to carry out the task. This concludes that there may be social factors involved here rather than experimental. Perhaps participants were reliving happy childhood experiences of learning. Alternatively, it could be an unexpected laterality difference in the individuals concerned. Even when handedness is carefully classified, there remains the fact that this is based on a population of people, who, being human, cannot comply with an exact model. For instance, there is the assumption that people have language in the left hemisphere, because most do, but there is a minority that do not. Levy and Reid (1978) state that around 7% of people do not have language in the left hemisphere, but rather, in the hemisphere ipsilateral to their writing hand. These sorts of anomalies exist in humans and although a sample may be classified correctly according to handedness this does not guarantee the same hemispheric composition as every individual in unique.

Therefore, it could be possible that those who were so positively affected by the handwriting task had a different brain composition than expected for their classification.

Concerning groupings according to gender and handedness, the latter four experiments include right and mixed/left handers. Also, except in Experiments 1 and 3, the participants were of both genders. To include all categories is very unusual in the literature and serves to fill a gap. However, it was concluded that more participants were needed in order to make the discrete groupings larger and more able to withstand statistical analysis. Also, it may be worth exploring the learning preferences of participants as all these experiments use kinaesthetic tasks and some participants may have had a preference for a kinaesthetic approach to learning.

It has been noted that the two hemispheres of the brain communicate via the corpus callosum and have also been recorded assisting one another with clues using visual gaze. Added to this there is also evidence in the literature from split-brain studies, that each hemisphere could have a different desire to the other. There are examples of this in the literature where; one hand was pulling on trousers whilst the other was trying to take them off (Sperry 1964); one hand was trying to light a cigarette and the other trying to put it out (Joseph 1990) and one had was starting to put a dress on with the other snatching it away (Ferguson et al 1985). Whilst this behaviour is not seen in 'normal' brains it may be happening inside, and concludes that task ability would be dependant on whether both or only one of the hemispheres wants to carry out that particular task.

11.2.3 Implications of the Study

One implication of this study for the literature is that it adds data to the debate of hemispheric advantage for emotional perception. The results for Experiment 3 here can be related to others in the field. Bryden and Macrae (1989) used single words as their stimuli for emotional tone rather than sentences, and they found a right hemisphere advantage for negative emotions but not for positive. Tucker et al (1999) used pairs of sentences where the participants had to decide whether the two sentences intonated the same or different emotions. They were not required to identify which emotions were intonated. They found a right hemisphere advantage.

The research that is most similar to Experiment 3 is by Ley and Bryden (1982) where whole sentences were used for participants to match each of them with one of four possible emotions. In their experiment they found a right hemisphere advantage for matching the emotional tone perception and a left hemisphere advantage for matching content. Experiment 3 in this research did not test for content but the findings for emotional intonation do not support their findings.

Implications of this study for other researchers is that it provides future experiments in this field with carefully designed stimuli, a system of self-reporting handedness classification, a model for categorisation of problem solving and ideas for fine motor control tasks with their strengths and weaknesses discussed.

11.2.4 Limitations of this Research

Complexity of Experiments

One difficulty encountered whilst doing this research was that of limiting the number of variables to assist with statistical analysis. Because gender and handedness both have implications for laterality, sometimes one gender or one type of handedness had to be eliminated from the experiment. When they were all included the statistical analysis became complex and the groupings became small.

Retention of Participants

Another difficulty was in the longitudinal study in terms of participant retention. This was a useful study because participants carried out the writing task for 6 months which meant they were practised and it would test for a longer term effect giving the brain an opportunity to potentially make new connections. However, participants found it hard to stay with the project and, in particular, if they found the task to be unsatisfying as they were highly critical of the results of their non-preferred handwriting and were comparing it to their preferred hand handwriting which looked so much better.

Unknown Factors

A limitations of the research is that it could not account for the difference between the two experimental groups and the control group used in Experiments 4 and 5, testing for idea generation and problem solving. The experiment was mainly a comparison between the two handedness groups so it did not adversely affect the experiment. However, it was clear that the experimental groups and the control group were not matched and therefore cannot be compared. The reason for the difference is unknown but could be because the control group was started later than the experimental groups bringing with in an additional factor which was not identified. It does also show that had differences been found between the experimental groups, they would have had to have been qualified in the light of the difference in the control group.

11.2.5 Recommendations for Further Research

Left-handers

It has been important throughout the research to separate male and females and left handers and right handers as their brain biology may be different. Also left-handers fall into more than one category as their left handedness may be due to hereditary, brain damage/birth problems, social acceptance, or to the fact they are an idiosyncratic group with a relatively unique pattern of lateral specialisation (Peters and Pang 1992). Also some people are ambidextrous and many people are mixed handed using both hands for different tasks. Therefore, for the more controlled experiments, only female right handers have been used. Further research would be interesting on strong left-handers but it would require finding a large number of them so that after splitting them into categories there would be enough to make viable calculations.

Face Recognition in Crime

It is interesting that in an endeavour to find two tasks, supported by empirical evidence in the literature, each of which could be attribute to control from one particular hemisphere, that the only two tasks found were verbal repetition and face recognition. These two skills are used together when a verbal description of a person's face is given in an attempt to identify that face, as, for example, in the case of witnessing a crime. It would be interesting to put these tasks together to see whether the hemispheres compete against each other to carry out the two opposing tasks. Only one gender was used, in Experiment 1's verbal repetition task, because the empirical evidence in the literature shows a difference in gender for vocabulary and verbal abilities. In the face recognition task, no difference was found between male and female ability. The literature supports a female advantage but only for females recognising female faces (Lewin & Herlitz 2002). It would be interesting to research whether female witnesses of crime are more affective at identifying female criminals.

11.2.6 Final Statement

The objectives of the research were to show originality in two ways. Firstly, by trying to establish how valid the connections are between the facts about hemispheric asymmetry and the generalisations that are being promulgated concerning the left brain/right brain concept and to see if there is misuse of the concept, particularly in learning. Secondly, to add empirical data for the testing of whether there is a connection between arousing the contralateral hemisphere with a fine motor control task and the thinking strengths within the same hemisphere. Also, although the theoretical framework is an overall positivist one, the use of content analysis has been introduced in the latter experiments to bring a more qualitative method to add some richness and depth to the quantitative methods.

Contributions that this study has made to the field are as follows:

- This study provides a review and draws comparisons between the theories concerning hemispheric asymmetry and whether certain discrete cognitive processes can be ascribed to one or the other hemisphere.

- In the literature review it also demonstrates evidence that attributing complete or generalised thinking processes to one particular hemisphere is erroneous.

- This study contributes to the current debate on whether the right hemisphere is dominant for all emotional perception or only for negative emotions. A right hemisphere preference for negative emotions was not found here.

- This study challenges the circular argument that the inability to perform a fine motor task provides evidence of an impairment in a mental function. It may in fact be due to competition with that mental function.

- This research learns from, and takes the experiments in the literature forward, by using their findings to hone the stimulus used in these experiments to make the testing more valid.

- This study uses experiments with groups of male and female and right handed and left handed participants which is unusual in the literature.

- This study provides a new handedness classification system which furthers the classification systems of Annett and Oldfield from new research findings.

- This research provides a categorisation system for problem solving approaches in order to measure a decrease or increase in certain types of thinking.

- This study fills a gap in the literature on the link between fine motor control skills and thinking. It provides empirical evidence concerning the attempt to influence a variety of thinking processes with fine motor controls tasks.

REFERENCES

Abernethy; Kippers; Mackinnon; Neal; Hanrahan, The Biophysical Foundations of Human Movement. MacMillan Education, South Melbourne, (1997), pages 289-294.

Ahern G L, Herring A M, Trackenberg J, Seeger J F, Oommen K J, Labiner D M, Weinand M E, The association of multiple personality and temporolimbic epilepsy: Intracarotoid amobarbital test observations. *Archive of Neurology*; (1993), 50:1020-1025

Annett M, A Classification of Hand Preference by Association Analysis, *Quarterly Journal of Experiential Psychology*, (1967), 19, 327-333

Annett M, The Binomial Distribution of Right, Mixed and Left Handedness, *Quarterly Journal of Experimental Psychology*, (1968), p 326-333

Annett M, The Classification of Hand Preference by Association Analysis, *British Journal of Psychology*, (1970), 61, 303-321

Annett M, A co-ordination of hand preference and skill replicated, *British Journal of Psychology*, (1976), 67, 587-592

Annett M, *Left, Right, Hand and Brain: The Right Shift Theory*, Lawrence Earlbaum, (1985), p 19-36

Arieti S, *Creativity: The Magical Synthesis*, (1976), New York: Basic Books

Austin M D, Dream Recall and the Bias of Intellectual Ability, *Nature*, (1971), 231, 59-60

Bahrick H P, Bahrick P O and Wittlinger R P, Fifty years of memory for names and faces: A cross-sectional approach. *Journal of Experimental Psychology: General* (1975), 104, 54-75

Bandler R. & Grinder J, *Frogs Into Princes; Neurolinguistic Programming,* Real People Press, (1979)

Barker L, *Changing Rooms Colour,* (1999), BBC Worldwide, London

Barron, F, "Putting creativity to work." in Sternberg, RJ (ed.) *The Nature of Creativity.* Cambridge, England: Cambridge Univ. Press, (1988)

Benoit-Dubrocard S, Liegeois F and Harlay F, What does haptic modality do during cognitive activities on letter shapes? A study with left- and right-handers., *Cortex,* (1997), 33, 301-312

Benton A L, Hamsher K de S, Varney N et al, *Contributions to neuropsychological assessment: A clinical manual.* (1983), Oxford University Press, Oxford.

Berenbaum S A and Harshman R A, On Testing Group Differences in Cognition Resulting from Differences in Lateral Specialization, *Brain and Language,* (1980), 11, 209-220

Berg B L, *Qualitative Research Methods for the Social Sciences,* Allyn & Bacon Pearson, (2001), USA

Bishop D V M, Handedness and Development Disorder; *Clinics in Developmental Medecine* 110, Mac Keith Press, Oxford, (1990), p 156-162

Blakemore et al, cited in Berenbaum S A, Harshman R A, 1980, On testing group differences in cognition resulting from differences in lateral specialization: reply to fennel et al, *Brain and Language,* (1972), 11, 209-220

Blakeslee T R, *The Right Brain,* Macmillan Press Ltd, (1980), pp 10-11, 33, 45-51, 147, 164-173, p 168

Bogen J E, Partial Hemispheric independence with the neocommissures intact, in Brain Circuits and Functions of the Mind, edited by Trevarthen C, Cambridge Press, Cambridge, (1990), cited in Schiffer F, Cognitive Activity of the Right Hemisphere:

Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996).

Bogen J E & Bogen G M, The Other Side of the Brain III, The Corpus Callosum and Creativity. *Bulletin of the Los Angeles Neurological Societies*, (1969), vol 34 (4), Oct, p 191-220

Bogen J E, Some educational aspects of hemisphere specialization, *UCLA Educator*, (1975), 17: 24-32

Borod J C, Interhemispheric and Intrahemispheric Control of : A Focus on Unilateral Brain Damage, *Journal of Consulting and Clinical Psychology*, (1992), 60:339-348

Boud D, Keogh R and Walker D, What is reflection in learning? In D Boud, R Keogh and D Walker ed. *Reflection: Turning experience into learning* (p. 7-17). London: Kogan Page, (1085)

Bradshaw J L and Nettleton N C, *Human Cerebral Asymmetry*. Prentice Hall, New Jersey, (1983), 92-95.

Bruce V, Changing faces: Visual and non-visual coding processes in face recognition. *British Journal of Psychology*, (1982), 73, 105-116

Bruce V and Young A, Understanding face recognition. *British Journal of Psychology*, (1986), 77, 305-327.

Bryden M P, Tachistoscopic recognition, handedness, and cerebral dominance. *Neuropsychologia*, (1965), 3:1-8, cited in Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996), accessed via author's internet site

Bryden M P and MacRae L, Dichotic laterality effects obtained with emotional words, *Neuropsychiatry, Neuropsychology and Behavioural Neurology*, (1989), 1, 171-176

Buckland H O, Examples of Brain Attribute Differences, Threesology Journal Research Website, (2003), url: www.cenocracy.topcities.com

Bullock, Davey, Einon, Robinson, Stirling, Taylor, *Motor and Sensory Systems - the Ins and Outs of the Brain*. In: Biology: Brain and Behaviour, Book 2, Neurobiology. (Ed: Robinson, David) Open University, (1992), 241-249.

Cambridge International Examinations at www.tsa.udes.org.uk

Chapman L J and Chapman J P, The Measurement of Handedness, *Brain and Cognition*, (1987), 6, 175-183

Clayton P, Infinite Innovations Ltd, Innovation House, 71 Sheldon Road, Sheffield, S7 1GU, url www.brainstorming.co.uk, (2003)

Connellan, J, Baron-Cohen, S, Wheelwright, S, Batki, A, & Ahluwalia, J, Sex differences in human neonatal social perception, *Infant Behavior & Development*, 2000, 23, 113-118.

Crotty M, *The Foundations of Social Research*, Sage, (1998), p1-17

Csikszentmihalyi M, Creativity - Flow and the Psychology of Discovery and Invention, (2002), p 28

Dancy C P and Reidy J, *Statistics Without Maths for Psychology*, Prentice Hall, (2002), p 150

Davidson R J, Cerebral Asymmetry and Emotion: Conceptual and Methodological Conundrums, *Cognition and Emotion*, (1993), 7:115-138

Davidson R J, Schwartz G E, Pugash E and Bromfield E, Sex differences in patterns in EEG asymmetry, *Biological Psychology*, (1976), 4, 119-138

De Bono, *Lateral Thinking*, Pelican, (1970), p7 – 258, p37-43

De Bono E, *Teach Yourself to Think*, Pelican, (1995), p 24

Dewey J, *How We Think. A restatement of the relation of reflective thinking to the educative process* (Revised edn) Boston: D. C. Heath, (1933)

Dimond S J, Farrington L, Johnson P: Differing emotional response from right and left hemispheres. *Nature, (*1976); 261:690-692 cited in, Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996), accessed via author's internet site

Easterby-Smith M, Thorpe R and Lowe A, *The Philosophy of Research Design*, Management Research: An Introduction, Sage, (2002), p 23, chapter 3.

Edwards B, *Drawing on the right side of the brain*, Harper Collins, (1993), p 40

Education World: The Educator's Best Friend http://www.education-world.com/a_tsl/archives/00-1/lesson0020.shtml, accessed 12 December 2005

Ekstrom et al, cited in Berenbaum S A, Harshman R A, 1980, On testing group differences in cognition resulting from differences in lateral specialization: reply to fennel et al, *Brain and Language*, (1976), 11, 209-220

Ellis H D, Theoretical Aspects of face recognition. In *Perceiving and Remembering Faces* (Editors: G M Davies, H D Ellis, JW Shepherd eds). Academic Press, London and New York, (1981).

Ellis H D, Shepherd J W and Davies G M, Identification of famililar and unfamiliar faces from internal and external features: some implications for theories of face recognition. *Perception*, (1979), 8, 431-439

Ernest C H, Spatial ability and lateralization in the haptic modality, *Brain and Cognition*, (1998), 36, 1-20

Ernest C H, Spatial ability and laterality effects on a face recognition task. *Personal Individual Differences*, (1997), 23(5), 839-848.

Ferguson S M, Rayport M, Corrie W S, Neuropsychiatric observations on behavioural consequences of corpus callosum section for seizure control, In: Reeves A, ed. Epilepsy and the corpus callosum. New York: Plenum, (1985) Finlay D C and French J, Visual field differences in a facial recognition task using signal detection theory. *Neuropsychologia,* (1978), 16, 103-107.

Flintoff J P and Elliott J, Success: It's a brain of two halves. The Sunday Times, March 12 2006.

Fox M L, Sly as a Fox: A Practical Approach to Creative Thinking, url: www.slyasafox.com, (2003)

Franken R E, *Human Motivation*, 3rd ed, (1998), New York: John Wiley & Sons, p 396.

Freedman R J, Rovegno L, Ocular Dominance, cognitive strategy, and sex differences in spatial ability, *Perceptual and Motor Skills*, (1981), 52, 651-654

Freedman R J, Davidson R J, Taylor N E, and Reuter-Lorenze P, sex differences in performance as related to cerebral lateralization. Paper presented at APA, New York City, 1979, cited in Freedman RJ, Rovegno L, Ocular Dominance, cognitive strategy, and sex differences in spatial ability, *Perceptual and Motor Skills*, (1981), 52, 651-654

Freeman J, Cerebral asymmetries in the processing of faces. PhD Thesis, University of Aberdeen, (1980).

Furnham A, Brain Storms: Are you a Trendy Leftie or Happily Right-on?, *FT Mastering Management*, (1997): No 2.

Gardner H, Artisty after Brain Damage. In: H Gardner (Ed) *Art, Mind and Brain*. New York: Basic Books, (1982): p 318-335.

Galin D and R Ellis, "asymmetry in evoked potentials as an index of lateralized cognitive processes: relation to EEG Alsph Asymmetry", *Neuropsychologia,* (1975): 13:45-50 cited in Blakeslee T R, *The Right Brain*, Macmillan Press Ltd, (1980).

Galper R E and Hochberg J, Recognition memory for photographs of faces. *American Journal of Psychology*, (1971): 84(3), 351-354

Gazzaniga M S, Right hemisphere language following brain bisection: A 20-year perspective. *American Psychologist*; (1983): 38:542-546

Gazzaniga M S, Bogen J E, & Sperry R W, Observations of visual perception after disconnexion of the cerebral hemispheres in man, *Brain*, (1965): 88, 221-236

Gazzaniga M S, LeDoux J E: *The Integrated Mind*, New York, Plenum, (1978): p 70-72

Geschwind N, The Apraxias: Neural Mechanisms of disorders of learned movement, *American Scientist*, (1975): 63, 188-195

Geschwind N and Galaburda, Standard and Anomolous Dominance. In: *Cerebral Lateralization*. MIT Press, London, (1987): pages 67-80.

Goldberg E and Costa L D, Hemispheric Differences in the Acquisition and use of Descriptive Systems, *Brain and Language*, (1981): 14, 144-173

Goldstein G, The Use of Clinical Neuropsychological Methods. In: *Hemisphere Function in the Human Brain*. (Eds: Dimond; Beaumont) Elek Science, London, (1974): pages 297-300.

Goldstein A G, The fallibility of the eye witness. Psychological Evidence. In *Psychology in the Legal Process* (Editor: BD Sales). Spectrum: New York, (1977).

Goleman D, *Working with Emotional Intelligence*, London: Bloomsbury, (1998).

Goleman D, What Makes a Leader, *Harvard Business Review*, (1998), Nov-Dec, pp 93-102

Goleman D, *Emotional* Intelligence: Why it can matter more than IQ, London: Bloomsbury, (1996).

Gott P S: Language after dominant hemispherectomy. *Journal of Neurology Neurosurgery and Psychiatry*, (1973); 36: 1082-1088

Gross Y, Franko R, and Lewin I, Effects of voluntary eye movements on hemispheric activity and choice of cognitive mode, *Neuropsychologia,* (1978): 16: 653-55

Grossman M, Drawing Deficits in brain-damaged patients' freehand pictures, *Brain and Cognition*, (1988): 8 (2). 189-205.

Guiard Y and Millerat F, Writing Postures in left-handers: inverters are hand-crossers, *Neuropsychologia,* (1984): Vol 22, No 4, pp 535-538

Gur R E and Gur R C, Correlates of conjugate lateral eye movements in man" In *Lateralization in the Nervous System*, Edited by Harnad et al, Academic Press, New York (1977), cited in Blakeslee T R, *The Right Brain*, Macmillan Press Ltd, (1980).

Harnad S, Creativity: Method or Magic, Cognitive Sciences Centre, Department of Psychology, University of Southampton, url: www.ecs.soton.ac.uk. (2003)

Hay D C and Ellis H D, Asymmetries in facial recognition: Evidence for a memory component. *Cortex,* (1981): 17, 357-368

Healy M, How have studies of split-brain patients furthered our knowledge of hemispheric lateralization?, University of Westminster, London, (2000), published on the internet.

Hecaen H and Angelergues R, Agnosia for faces (prosopagnosia). *Archives of Neurology,* (1962), 7, 92-100.

Heilman K M, Scholes R and Watson R T, Auditory Affective Agnosia: Disturbed Comprehension of Affective Speech, *Journal of Neurology, Neurosurgery and Psychiatry,* (1975): 38: 69-72

Hellige J B, *Hemispheric Asymmetry: What's Right and What's Left?* Harvard University Press: Cambridge, Massachussets, (1993), p 45-54. p 109, p 233

Hellige J B, Corwin W H and Jonssen J E, Effects of perceptual quality on the processing of human faces presented to the left and right cerebral hemispheres. *Journal of Experimental Psychology: Human Perception and Performance,* (1984): 10, 90-107

Herrman N, Herrmann Brain Dominance Instrument, The Ned Herrmann Group Inc, 794 Buffalo Crek Road, Lake Lure, NC 28746, (2004)..

Hilliard R D, Hemispherice laterality effects on a facial recognition task in normal subjects. *Cortex,* (1973): 9, 246-258

Hillier W F, Total left cerebral hemispherectomy for malignant glioma. Neurology, (1954): 4:718-721, cited in Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry,* (Sept/Oct 1996).

Hines T, The Myth of Right Hemisphere Creativity, *Journal of Creative Behaviour,* (1991): 25(3),223,227

Hingað-Nogh L, The Creative Mystique: How to Manage It, Nurture It, and Make It Pay, Wiley: New York, (1985) accessed via url:www.hi.is on 18 October 2003

Hochberg J and Galper R E, Recognition of faces: 1. An Exploratory Study. *Psychonomic Science,* (1967): 9 (12), 619-620.

Hogan K, *The Psychology of Persuasion; How to Persuade Others to Your Way of Thinking,* Grenta, Louisiana, Pelican Publishing Company, (1996)

Hogan K, NLP Eye Accessing Cues: Uncovering the Myth, *Journal of Hypnotism (online), available* http://www.kevinhogan.com/EyeAccess.htm (Accessed 12 December 2005).

Hoppe K & Kyle N, Dual Brain, Creativity and Health. *Creativity Research Journal*, (1990): 3, 150, 157

Hudson L, Contrary Imaginations: A Psychological Study of the English Schoolboy, Harmondsworth, Penguin, (1966)

Humphrey M, Handedness and Cerebral Dominance, BSc Thesis, Oxford University, as cited in Oldfield, R C 1971, The Assessment and Analysis of Handedness: The Edinburgh Inventory. *Neuropsychologia*, (1951): 9 , 97-113

Hunt J, Plowden Professor of Organisational Behaviour at London Business School, interview for the 'Innovation Exchange', London Business School, (2003), url: iexchange.lbs.ac.uk accessed October 2003

Hwa T E, Joo Q G, School of Computing, National University of Singapore, 2003 url www.comp.nus.edu.sg accessed September 2004

Isaksen S B and Treffinger D J, Creative Problem Solving: The Basic Course, Buffolo: NY, Bearly Ltd, (1985)

Ivry R B and Robertson L C, *The Two Sides of Perception*. MIT Press, Cambridge, Massachussets, (1988), p 109, p 116-120, p193-213

Jaynes J, The origin of consciousness in the breakdown of the Bicameral Mind, Boston: Houghton Mifflin, (1976), p 120, cited in Blakeslee T R, *The Right Brain*, Macmillan Press Ltd, (1980).

Johnstone J, Galin D and Herron J, Choice of Handedness Measures in Studies of hemispheric specialization, *International Journal of Neuroscience*, (1979): 9, 71-80

Jones B, Lateral symmetry in testing long-term memory for faces. *Cortex*, (1979): 15, 183-186.

Joseph R, Neuropsychology, Neuropsychiatry, and Behavioural Neurology. New York, Plenum Press, (1990), cited in Schiffer F, Cognitive Activity of the Right Hemisphere:

Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996).

Katonada , Yoshikawaka K, and Sugishita M, Neural substrates for the recognition of newly learned faces: a functional MRI study. *Neuropsychologia,* (2000): 38, 1616-1625.

Keefe K, Motor and cognitive interference effects on unimanual tapping rates, *Brain Cognition,* (1985), Apr, 4 (2), 165-170

Keenan J P, McCutcheon, Freund S, Gallup G G, Sanders G and Pascual-Leonne A, Left hand advantage in a self-face recognition task. *Neuropsychologia* (1999):37, 1421-1425

Kim J and Michael W B, The relationship of creativity measures to school achievement and to preferred learning and thinking style in a sample of Korean high school students. *Educational and psychological measurement,* (1995): 55, 60-74

Kimura D, The asymmetry of the human brain, *Scientific American,* (March 1973): pp 70-78

Kinsbourne M, Eye and head turning indicates cerebral lateralisation, *Science,* (1972): 176, 539-541

Kinsbourne M, Direction of gaze and distribution on cerebral thought processes, *Neuropsychologia,* (1974): 12, 279-282

Kitchener P, University of Melbourne Science Department, Lecture Notes, 2002.

Lacreuse A, Fagot J, Vauclair J, Left versus right hand differences in exploratory strategies: Facts and relevance to the development of haptic devices. *Proceedings of the fifth Annual Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems,* (1996).

Lehmkuhl D, Cotter Lamping D, Organizing for the Creative Person: Right-Brain Styles for Conquering Clutter, Mastering Time, and Reaching Your Goals, Three Rivers Press; (1993).

Levy J, Language, Cognition, and the right hemisphere. *American Psychologist,* (1983); 38:538-541

Levy J, Reid M, Variations in Cerebral Organization as a Function of Handedness, Hand posture in Writing, and Sex, *Journal of Experimental Psychology: General*, (1978): Vol 107, No 2, 119-144

Levy J, Trevarthen C and Sperry R W, Perception of bilateral chimeric figures following hemispheric deconnection. *Brain*, (1972): 95, 61-78.

Lewin, C, Wolgers, G, & Herlitz, A, Sex differences favoring women in verbal but not in visuospatial episodic memory, *Neuropsychology*, 2001, 15, 165–173.

Lewin C and Herlitz A, Sex Differences in face recognition – women's faces make the difference, *Brain Cognition*, 2002, Oct, 50(1):121-8

Ley R G and Bryden M P, A disassociation of right and left effects for recognizing emotional tone and verbal content, *Brain and Cognition*, (1982): 1, 3-9

Liepman H, Apraxia, *Ergebnisse der Gesamten Medizin*, (1920): 1, 516-543 cited in Poizner H, Clark M A, Merians A S, Macauley B, Gonzalez Rothi L J, Heilman K M, Left Hemispheric Specialization for Learned, Skilled, and Purposeful Action. *Neuropsychologia*, (1988): Vol 12 No 2, pp 163-182.

Liepmann H and Maas O, Fall von linksseitiger Agraphie und Apraxie bei rechsseitiger Lahmung, *Zeitschrift fur Psychologie und Neurologie*, (1907): 10, 214-227 cited in Poizner H, Clark M A, Merians A S, Macauley B, Gonzalez Rothi L J, Heilman K M, 1998, Left Hemispheric Specialization for Learned, Skilled, and Purposeful Action. *Neuropsychologia* (1988): Vol 12 No 2, pp 163-182.

Loring D W, Meador K, Lee G, Murro A, Smith J, Flanigin H, Gallagher B, King D, Cerebral Language Lateralization: Evidence from Intracaratoid Amobarbital Testing, *Neuropsychologia*, (1990); 28:831-838.

Lutsep H L, Wessinger C M, Gazzaniga M S, Cerebral and callosal organization in a right hemisphere dominant "split-brain" patient. *Journal of Neurology, Neurosurgery and Psychiatry;* (1995); 59:50-54

Macrae C N and Lewis H L, Do I Know You? Processing Orientation and Face Recognition, *Psychological Science*, (March 2002): vol 13 (2).

Matte N L & Henderson S H G, *Success, Your Style! Right and Left Brain Techniques for Learning*. Belmont CA: Wadsworth, (1995).

Mayer J D, Salovey P, Caruso D R, & Sitarenios G, "Emotional Intelligence as a Standard Intelligence", *Emotion*, (1993): 1, 232-242

McGlone J, Sex differences in human brain asymmetry. A critical review. *The behavioral and Brain Sciences* (1980): 3, 215-227.

McKeever W F, Handwriting posture in left-handers: sex, familial sinistrality and language laterality correlates. *Neuropsychologia*, (1979), 17, p 429-424

Merten K, Reactivity in content analysis. *Communications: The European Journal of Communication Research*, (1996): 21(1), 65-76.

Milner A D and Dunne J J, Lateralised perception of bilateral chimaeric faces by normal subjects. *Nature*, (1977): 268, No 5616, 175-176.

Milner B, Visual recognition and recall after right temporal lobe excision in man. *Neuropsychologia*, (1968), 6, 191-209.

Mintsberg H, Planning on the Left Side, Managing on the Right Side, *Harvard Business Review*, (1976): 54 (4), pp 49 - 58

Mohr B, Landgrebe A and Schweinberger S T, Interhemispheric cooperation for familiar but not unfamiliar face processing. *Neuropsychologia*, (2002): 40 (11), 1841-1848

Moir A and Jessel D, *BrainSex*, Arrow, (1989), p 44-49

Moir A and Moir B, *Why men don't iron: the fascinating and unalterable difference between men and women*, Birch Lane Press, (2000).

Moon J, The academic rationale for reflection on and learning from work experience. In Watton P, Collings J and Moon J (eds.) *Independent Work Experience: an evolving picture.* [SEDA paper 114] Birmingham: Staff and Educational Development Association, (2002), pp 57-61

Morrison A and Johnston B, Personal creativity for Entrepreneurship, *Active learning in higher education,* (July 2003): Vol 4, No 2.

Moscovitch M, Scullion D and Christie D, Early versus late stages of processing and their relation to functional hemispheric asymmetries in face recognition. *Journal of Experimental Psychology (Human Perception and Performance),* (1976): 2, 401-406

Myers Briggs Type Indicator Psychometric Preference Test, European suppliers at www.opp.eu.com.

O'Boyle M W, Gill H S, Benbow C P, Alexander J E, Concurrent finger-tapping in mathematically gifted males: evidence for enhanced right hemisphere involvement during linguistic processing, *Cortex,* (1994) Sep 30 (3), 519-526

Oldfield R C, The Assessment and Analysis of Handedness: The Edinburgh Inventory. *Neuropsychologia,* (1971), 9 , 97-113

Osborn A, *Applied Imagination.* New York, Charles Scribner Press, (1953)

Oxford, Cambridge and RSA Examinations at www.ocr.org.uk, incorporating Thinking Skills Assessment (TSA)

Papanicolaou A C and Molfese D L, Neuroelectrical Correlates of Hemisphere and Handedness Factors in a Cognitive Task. *Brain and Language,* (1978), 5, 236-248

Parlow S, Differential Finger Movements and Hand Preference, *Cortex,* (1978): 14, 608-611,

Peters, M, Phenotype in Normal Left-Handers: An Understanding of Phenotype in the Basis for Understanding Mechanism and Inheritance of Handedness. In: Left-Handedness, Behavioural Implications and Anomalies. (Ed: Coren, Stanley) North Holland Elsevier Science Publishers B.V., Amsterdam, (1990): pp 167-192.

Peters M, Subclassification of non-pathological left-handers poses problems for theories of handedness, *Neuropsychologia*, (1990): vol 28, no 3, pp 279-289

Peters M, Handedness and Its Relation to Other Indices of Cerebral Lateralization in *Brain Asymmetry* edited by Richard J Davidson and Kenneth Hugdahl, MIT Press, Cambridge, (1995): pp 183-214.

Peters M, Pang J, Do "Right-Armed" Lefthanders have different Lateralization of Motor Control For The Proximal and Distal Musculature?; *Cortex*, (1992): 28, 391-399

Phillips M L and David A S, Viewing Strategies for Simple and Chimeric Faces: An Investigation of Perceptual Bias in Normals and Schizophrenic Patients Using Visual Scan Paths. *Brain and Cognition* , (1997), 35, 225-238.

Pink D 'A Whole New Mind: How to Thrive in the New Conceptual Age, Cyan Books, 2005

Podbros, L Z.;Wyke, M A; Laterality Differences For Speed But Not For Control in Sequential Finger Tapping, *Perceptual and Motor Skills*, (1988): 67, 927-933

Poizner H, Clark M A, Merians A S, Macauley B, Gonzalez Rothi L J, Heilman K M, 1998, Left Hemispheric Specialization for Learned, Skilled, and Purposeful Action. *Neuropsychologia*, (1998): Vol 12 No 2, pp 163-182.

Preti A, The Gift of Saturn: Creativity and Psychopathology, url www.serendip.brynmawr.edu, (2003), accessed on 18 October 2003

Rasmussen T and Milner B, The Role of Early Left-Brain injury in Determining Lateralization of Cerebral Speech Functions in *Evolution and Lateralization of the Brain*, ed Dimond S and Blizzard D, New York Academy of Sciences, (1977), cited in Springer and Deutsch 1998, p28

Rehnman J and Herlitz A, Higher face recognition ability in girls: magnified by own sex and own ethnicity bias, *Memory*, Vol 14, No 3, April 2006, pp 289-296(8)

Reichert J and Kelly D, Sex differences in object and face recognition, poster presentation, BBSC/SCCC 16th Annual Meeting

Ringo J L, Doty R W, Demeter S, Simard P Y, Time is of the essence: a conjecture that hemispheric specialization arises from interhemispheric conduction delay. Cerebral Cortex; (1994): 4; 331-343, cited in Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996).

Risse G L, Gazzaniga M S, well-kept secrets of the right hemisphere: A carotid amytal study of restricted memory transfer. Neurology, (1978); 28:950-953 cited in Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996).

Robson C, *Real World Research*, Oxford, Blackwell, (1993): p 18-19

Rushworth M F S, Nixon P D, Wade D T, Renowden S, Passingham R E, The left hemisphere and the selection of learned actions, *Neuropsychologia*, Pergamon Press, (1998): Vol 36, No 1, pp11-24

Saunders M. Lewis P, & Thornhill A, *Research Methods for Business Students*, Pitman Publishing, (1997).

Schabracq M J and Cooper C L, The changing nature of work and stress, *Journal of Managerial Psychology*, (2000): vol 15, issue 3.

Schiffer F, Right Brain Cognition, *Harvard Review of Psychiatry*, (Sept/Oct 1996)
Willis SG, Wheatley GH, Mitchell OR, Cerebral Processing of spatial and verbal-analytic tasks: an EEG study, *Neuropsychologia*, Pergamon Press Ltd, (1979): Vol 17:pp 473-484

Schiffer F, Cognitive Activity of the Right Hemisphere: Possible contributions to Psychological function, *Harvard Review of Psychiatry*, (Sept/Oct 1996), accessed via author's internet site.

Schwartz M and Smith M L, Visual asymmetries with chimeric stimuli. *Neuropsychologia,* (1980): 18, *103-106.*

Sergent J, Influence of task and input factors on hemispheric involvement in face processing. *Journal of Experimental Psychology: Human Perception and Performance,* (1985): 11, 846-861

Sergent J and Bindra D, Differential hemisphere processing of faces: Methodological considerations and reinterpretation. *Psychological Bulletin,* (1981): 89, 541-554.

Shepherd J W and Ellis H D, The effect of attractiveness on recognition memory for faces. *American Journal of Psychology,* (1973): 86, 627-634.
Shepherd G M, Motor Hierarchies. In: *Neurobiology.* 2nd ed. Oxford University Press, Oxford, (1988): pp 428-449.

Shepherd G M, Manipulation. In: *Neurobiology.* 2nd ed, Oxford University Press, (1988): 450-467.

Smith A: Speech and other functions after left (dominant) hemispherectomy. *Journal of Neurology Neurosurgery and Psychiatry,* (1966); 29:467-471

Smith S D and Bulman-Fleming M B, Hemisperic Asymmetries for the Conscious and unconscious perception of emotional words, Laterality: Asymmetires of Body, Brain and Cognition, Psychology Press, (2006), Vol 11, No 4 July

Sperry R W, "The Great Cerebral Commissure", *Scientific American,* January (1964), pp 42-52 cited in Blakeslee T R, *The Right Brain,* Macmillan Press Ltd, (1980)

Sperry R W, Hemisphere deconnection and unity in conscious awareness. *American Psychologist;* (1968): 23:723-733

Sperry R W, Lateral Specialization in the surgically separated hemispheres, in *Neurosciences*: Third Study Program. Edited by Schmitt F O, Worden F G. Cambridge, MIT Press, (1974).

Springer S P and Deutsch G, *Left Brain, Right Brain: Perspectives from Cognitive Neuroscience* – 5th edition, Freeman, (1998): pp 21, 22, 119, 229-231, 309

Sternberg R J and Lubart T I, Defying the crowd: Cultivating creativity in a culture of conformity. New York: Free Press, (1995)

Teuber H L, The brain and human behaviour. In *Handbook of Sensory Physiology,* (1978): Vol 8 (R Held, H W Leibowitz and H L Teuber eds) Springer-Verlag, Berlin.

Thach W T, On the specific role of the cerebellum in motor learning and cognition: clues from PET activation and lesion studies in man, *Behavioral and Brain Sciences,* (1996), 19 (3), 411-431

Torrance, E P, "The Nature Of Creativity As Manifest In Its Testing," in Sternberg, RJ (ed) *The Nature of Creativity.* Cambridge, England: Cambridge Univ. Press, (1988)

Triggs, W J, Tesar D W, Young M S, Ipsilateral Motor Control in Pathological Left-Handedness, *Neurocase*, (1998): Vol 4, pp 65-69

Tucker DM, Watson RT, Heilman KM. Discrimination and evocation of affectively intoned speech in patients with right parietal disease. Neurology (1977); 27: 947–50

Vinacke, W E, *The Psychology of Thinking.* New York: McGraw Hill, (1953).

Vitale B M, Unicorns Are Real: A Right-Brained Approach to Learning (Creative Parenting/Creative Teaching Series), Jalmar Press, (1982)

Wada J A, Rasmussen T:Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance: experimental and clinical observations. *Journal of Neurosurgery,* (1960); 17:266-282

Wallach M A and Kogan N, *Modes of thinking in young children.* New York: Holt, Rinehart and Winston, (1965).

Wallas G, *The Art of Thought,* cited in Blakeslee T R, *The Right Brain*, 1980, MacMillan Press: London, (1945): p 49-50

Wertheimer, M, *Productive Thinking.* New York: Harper, (1945).

Willis S G, Grayson H W and Owen R M, Cerebral Processing of spatial and verbal-analytic tasks: an EEG study, *Neuropsychologia*, (1979): vol 17, pp 473-484

White N and Kinsbourne M (1980), Does speech output control lateralize over time? Evidence from verbal-manual time-sharing tasks, *Brain and Language*, (1980) 10, 215-223

Wolff P H, Hurwitz I, Moss H, Serial Organization of Motor Skills in Left- and Right-Handed Adults, *Neuropsychologia*, (1977): vol 15, pp 539 – 546.

Young A W, Hay D C and Ellis A W (1985). The faces that launched a thousand slips: Everyday difficulties and errors in recognizing people. *British Journal of Psychology*, (1985): 76, 495-523.

Young A W, Newcombe F, De Haan E H F, Small M, and Hay D C (1993) Face perception after brain injury: selective impairments affecting identity and expression. *Brain*, (1993), 116, 941-59

APPENDICES

Contents

Appendix 1: Taped Sentences For Experiment 1

Date.......... Name......................... Contact ....

Handwriting normally done with ....

Section 1

1.1 the colour lilac is perfect for a room were you want a sense of calm

1.2 in decoration terms it has been much ignored in recent years

1.3 perhaps it has been traditionally seen as a more feminine colour

1.4 happily people are now recognising what a very versatile colour it is

1.5 in a small space a stronger shade such as purple would be too oppressive

1.6 bear in mind that you must have a good light when using shades of lilac

1.7 if the windows are small and the natural light is poor, you need to add light

1.8 introduce extra artificial light such as a circle of spotlights

1.9 without good lighting a pale colour scheme will lose ¾ of its impact

1.10 having created a restful environment don't introduce colours that might disturb it

Appendix 1: Taped Sentences continued......

Date.................Name.......................... Contact ....

Handwriting normally done with..

Section 2

2.1 there is a good way of introducing a touch of visual excitement

2.2 paint one wall a slightly stronger shade than the rest, for example, smokey blue

2.3 it is possible to trick the eye into thinking that a space is wider than it is

2.4 you need to paint a very subtle horizontal line around the room

2.5 in a bigger room with better light you might want to introduce other colours

2.6 a warm orange or a dark blackberry will create different moods

2.7 black is a dynamic ingredient which might seem a surprising choice

2.8 having created the right atmosphere black will give the room more definition

2.9 natural flooring or pale carpet are safe choices but could look too bland

2.10 you could introduce black into the flooring or through the furniture

Appendix 1: Taped Sentences continued....

Date................ Name.......................... Contact ....

Handwriting normally done with..

Section 3

3.1 If you want to be adventurous you could apply some black decoration to the walls

3.2 For highlighting, silver is the perfect choice because it blends in with the lilac.

3.3 The combination of lilac, black and silver is a sophisticated and dynamic one.

3.4 The contribution of the naturals should not be overlooked,

3.5 Naturals create another subtle layer of visual interest without disrupting the harmony

3.6 Natural colours are ideal for accessories or pieces of furniture

3.7 Naturals, woods, whites and creams, work best in rooms with good light

3.8 The idea is to have colours that work in harmony rather than fight for attention

3.9 Naturals are an easy way to decorate as all whites work well together

3.10 Since whites incorporate shades of other colours they change according to what is near

Appendix 1: Taped Sentences continued.........

Date................ Name........................... Contact ....

Handwriting normally done with..

Section 4

4.1 To prevent a grey colour scheme looking too cold an accent shade is needed

4.2 Using hot colours such as oranges or reds can warm up the cool base shade

4.3 Having a theme can help give you direction for choosing accessories

4.4 Grey walls, blue furniture and yellow cushions gives a seaside theme

4.5 By keeping all the colours hazy you accentuate the peaceful nature of the room

4.6 Texture is a key ingredient when using natural colours

4.7 Texture adds visual interest and adds another dimension to the room

4.8 As textural layers are built up the grey will lose its coldness

4.9 It is always important to put all the elements of the room together

4.10 This is the only way you can judge how well a colour is working

Appendix 2: Analysis of Sentences for Experiment 1

Sentence	Words Section 1	Words Section 2	Words Section 3	Words Section 4
1	15	12	15	14
2	11	14	14	15
3	11	17	13	11
4	12	12	9	11
5	14	14	12	14
6	15	11	10	9
7	16	11	12	11
8	10	12	15	12
9	13	13	13	13
10	12	11	14	14
	Total 129	**Total 127**	**Total 127**	**Total 124**
	Average 12.9	**Average 12.7**	**Average 12.7**	**Average 12.4**

Table Appendix 2: showing design of stimulus to provide equal wordage per sentence

Appendix 3: Example of Content Analysis of Text for Experiment 5

◊ How did I get (A) here? (Q) Why am I here? (Q) If (O) I knew somebody (I) would be likely (O) to come (A) in the near future, I would sit (A) down on the chair (I) and make (A) myself more comfortable (E), having turned (A) on the light (I). Otherwise I would consider (E) whether (O) I could attract (A) anybody's (I) attention by knocking (A) on the window (I) . If not (O), and I faced (E) the prospect (O) of being trapped (E) for a long time, I would try to pick (A) the lock (I) . Failing that, (O) I would probably (O) break (A) the window (I) to get (A) out, assuming (O) there was no obstacle to me climbing (A) out. More considered (O) response: it still depends (O) on whether (O) anybody (I) is likely to come (A) past the basement, (Q) or indeed whether (O) somebody (I) is likely to come (A) to open (A)it (I)up. (Q) Why am I here? (Q) Am I trapped for long? (Q) Is there a telephone (I) that I can use to communicate (A) with Security? (I) (Q) The chair (I) can be used for sitting (A) (for comfort) (E) or possibly (O) for standing (A) on. The scissors (I) can be used for cutting (A), or possibly (O) for poking (A) into something. The gap under the door (I) implies (O) I won't suffocate, (E) and could also (O) be used to push (A) something underneath the door (I). The question (Q) then is whether (O) anybody (I) will pass (A) on the other side of the door (I) to see (A) any message (I) pushed (A) underneath. I am allergic to cats! (E) With difficulty (O) the cat (I) could be used to carry (A) a message (I) tied round its leg (I) if (O) egress from the window (I) is impossible for me. The flex (I) could be used to tie (A) the message (I) if (O) necessary, having been cut (A) with the scissors (I). I can't see (O) much use for the block of wood. (I) I don't think (O) I have enough information to formulate (A) a proper response (E), because the circumstances which have led (A) me to be in the basement are relevant to whether (O) I need to get (A) out, (E) and how destructive I am prepared to be (A) to achieve this. I don't suffer from claustrophobia (E) and I am quite patient, (E) so I would be prepared to wait (A) if necessary (O) for release. (PW/LH/M/exp)

Appendix 4

Article Published in Selected Papers: 16th International Conference on Teaching and Learning with note from Editor. The book consists of 12 selected papers from the conference of 300 papers. This paper was the first to appear in the book.

A STEP TOO FAR? - ARE WE ABUSING THE CONCEPT OF LEFT BRAIN/ RIGHT BRAIN IN LEARNING AND DEVELOPMENT?

Julia Claxton
York St John College

INTRODUCTION

The purpose of this paper is to highlight the dangers of the concept of being 'right brained or left brained' in learning and teaching. It takes a multidisciplinary approach drawing from literature in neuroscience and psychology and relates this to learning and teaching. It seeks to identify the false assumptions that comprise a paradigm leap (illustrated in Figure 1) that is being used today in tools used for learning development which communicate the 'right brained or left brained' concept to learners. This paper aims to illustrate the types of errors made and what their effect can be to the learner. It seems to suggest a more positive way forward for exploring diversity of thinking amongst learners.

Learning styles, thinking styles, personality indicators etc are there to help people to understand themselves and to understand others, and in particular, to appreciate the 'richness' that comes from diversity. However, there is a darker side to this type of categoratization.

One of the widely promulgated ideas recently is the 'right brained', 'left brained' *concept.* It is used in numerous development programmes and more recently in the school and college classroom. This is interesting but on examination of some of the assumptions, explanations and techniques being used and in particular on examination of some of the tools which seek to determine whether individuals are so-called 'right brained' or left-brained', the picture becomes somewhat worrying. The reason for concern is that when compared to the actual literature and research that has been carried out, many of the materials that are being used in the learning and development programmes often evidence a massive paradigm leap from fact into fantasy. This can lead to individuals being given unreliable information and therefore being misled.

The brain is made of two hemispheres which are joined together by a communicating fibre. In a normal person the two sides communicate with each other.

However, the two sides have been shown to support particular thinking processes in different ways. This has been shown particularly in people where the communicating fibre has been cut or where there has been brain damage on one side of the brain. In such cases individuals find they cannot complete certain physical or mental tasks. Concerning physical motor tasks this is shown clearly in tests where one side of the brain is anaesthetised. Shortly after the anaesthetic is administered to one side of the brain the individual loses the use of the opposite side of their body to that which was given the anaesthetic. Concerning mental tasks, experiments on split-brain patients (Springer & Deutsch1981) (that is patients who have had the communication fibre cut so that the two sides of the brain cannot communicate with each other) have shown that whilst an individual recognises an object which has been shown to the right hemisphere only, the individual cannot find the word to describe what it is because the right brain cannot tell the left brain what it is.

Experiments of this kind led to the theory of 'specialisation' of tasks of each side of the brain ie that there are some tasks that one side of the brain specialises in. EEG scans also confirm that difference activities cause activity in different parts of the brain, However, and it is an important however, it is not possible to talk about specialisation is this sense because thought processes are so complex. Hellige (1993) points this out very clearly in his writings. Even when it has been ascertained biologically that one hemisphere supports a particular thinking process, because that process is lost or impaired when damage occurs to that hemisphere, it does not mean that the hemisphere 'specialises' in that thinking process. Vitally supporting a thinking process, somewhere along its path, does not mean that the hemisphere completes the process on its own or even that it completes most of the process – a small chink can break the chain. Herein lies the unstable foundation of many of the assumptions of the right brain/left brain concept – the unstable foundation of 'specialisation'.

If the foundation of 'specialisation' is accepted then the following assumptions follow:

- The *first* assumption here is that there is indeed an associated list of thinking skills for each hemisphere. That is, that one hemisphere has one set of complete thinking processes and the other has a different set and that these can be identified for each. Many people can identify with these and many will talk in the left brain/right brain language. Thinking processes such as logical, sequential and linear are often attributed to the left brain whilst creativity, intuition and perception are often attributed to the right hemisphere. As research progresses it is showing this attribution is not accurate and that thinking processes are so complex that to break them down into their parts for testing becomes almost meaningless – as I have found to my frustration in my research.

- The *second* assumption is that if an individual has some of the thinking skills associated with that hemisphere that they should <u>also have</u> a natural tendency for the others attributed to that same hemisphere. Therefore, if someone is shown to be logical they are probably good sequential thinkers too because both these are often associated to the left brain. Conversely, if someone is shown to be intuitive there may be the assumption that they must be creative too as both these are associated with the right brain.

- The *third* assumption is that if they show a tendency for a number of the processes in *one* hemisphere that they are <u>unlikely to be strong</u> in those associated with the *other* hemisphere. That is, if someone is logical then they are probably 'not' intuitive which is attributed to the right hemisphere. These three assumptions alone, if accepted, could be very damaging to learning and teaching.

Along with the above there is a need to consider the 'origin' of the concept as this alone highlights a problem with the use of it. The discovery that the two hemispheres of the brain work in a different way came about through observing people who had had the connecting tissue (corpus collusum) of these two hemispheres severed so that the brain had effectively become two separate processors rather than one whole processor as in 'normal' brains. Numerous experiments showed that in these patients there were differences in the processing abilities of the left and right hemisphere. Although comparisons of each hemisphere separately can be made between split-brains and normal brains, normal brains have no restriction on the communication between each hemisphere. Additionally the speed of communication has been shown to be extremely fast. Is the concept of two different sides therefore just an unhelpful illusion?

If the concept merely becomes a 'metaphor', as many in learning and teaching use it now – is the metaphor itself harmful? It still establishes the grouping and separation that can be so misleading. It still talks of dominance and still talks about linking certain processes together and still talks about separating those two groups from one another. It still promulgates the idea that a left brained person is logical, sequential, numeric, detailed, vertical, and a right brained person intuitive, holistic, creative, musical, lateral, and spatial. The judgement as to whether someone is classified 'left brained' or 'right brained' is determined by which category their thinking strengths, or rather those most easily measured or observed, tend to fall into.

One of the main factors that decides whether the grouping can be used positively or negatively is where there is a different value attributed to one group of thinking. Different types of thinking give different approaches to problem solving, decision making, planning etc and if these are viewed as left brain or right brain tasks then an individual could find themselves being valued in a particular way if they have been categorised as a left brain or right brain thinker. In an enlightened context the value given to particular thinking styles can be challenged but if you are the only person with strong intuitive thinking and all the others do not have this ability then your strength could be devalued. On the other hand if others are aware of all the different types of thinking and know they have a need for diversity they may welcome, in their mind, a more 'right brained' approach. It can also highlight the sheer number of different approaches available and also indicate whether some approaches are lacking or over-empowering some less populated approaches. It can help those who feel they are in minority to label their thinking approach and see it appear in black and white as an identified way of thinking. It can be helpful to reflect on the fact that the value of a person's thinking is not determined by whether they are in line with the thinking of the majority of people in their group but in the fact that if they are in the minority then they are needed all the more to bring a balance. The notion of a 'balance' then brings us back to the idea of two different approaches, that is, left brain and right brain. Therefore this may be a positive feature of the notion as without it there may not be the desire to have a 'balance'.

This point also leads into discussions concerning whether certain organisations actually recruit only a proportion of the diversity of thinking approaches. In higher education I there is more and more emphasis on form filling and procedures which could lead to valuing sequential thinking higher than creative thinking. In appointing and promoting faculty is there a danger of screening out the more creative thinkers?

What about students? Do recruitment strategies filter out students who do not appear at interview and on application form to have those thinking processes the academics can identify as helpful. Could students accuse academics of selecting people on the basis of evidence of certain thinking strengths over others. Are assumptions made concerning the thinking strengths on an individual which is related to grouping certain thinking processes together. Do academics know which thinking skills are most valued in their institution?

If a student shows a strong aptitude for creative thinking does this mean they may not be logical? There is no evidence to suggest this yet this quantum leap is promulgated in numerous learning and development arenas around the world today. On an even more dangerous level, if this attitude is exposed to others, and in particular influential others, this can have a profound effect on how a person is viewed. If a student hopes to work with particular professors on some research but have been exposed as being creative and therefore not logical this may affect their chances of being selected for the research. Does an academic's own personal biases of how they value certain thinking processes make the student a victim of discrimination? This was exactly the problem caused within one organisation who sought to improve understanding of diversity by running a seminar on differences in learning styles and looking at four different styles to see which one you were. Months later one attendee reported 'I felt as if I had been pigeon-holed and what was most upsetting was that I noticed that since that day people have talked to me differently from what they had been doing before and not asking me to be involved in certain projects anymore. I feel as if I'm now in a certain zone that I've been put in and it's going to take effort for me to get people to see that I'm not in that zone or any zone and that I'm not that limited". Sometimes the best intentions do not work and in this case the seminar did not have the benefit of showing strength in diversity as had been planned. Also, another important question is that if others recognise our strengths and then try to play to them is this manipulation? The *context* in which these ideas are explored is essential. It is easier to abuse the concept if people are not being sufficiently aware of the dangers. People should be told about the possible downside of such exploration and in that knowledge can make their own decision as to whether to attend such seminars. Understanding the *context* means identifying the present culture and the readiness of individuals to be able to get positive results from such a seminar. It can be a powerful tool to identify strengths and diversity and understanding of different approaches but in the wrong *context* it can be a manipulative tool to fast track getting to know people in order to get the best performance out of them. People within organisations need to be really honest and ask some hard questions about motives for these kinds of initiatives. If the culture is already one of 'allowing' and 'enabling' and 'learning' and is genuinely using coaching, mentoring and listening then it may well be the right environment to introduce the concepts and they will be 'useful'. However, in a blame culture with a definite preference for certain thinking styles and a greater value put on some of them then it can be divisive and destructive. Educators and academics have to be so careful to consider the *context* in which they are introducing concepts such as this.

It is also essential to know what is meant by the term 'thinking'? Thinking is complex and to break it down into small enough parts to test out it can become meaningless. For instance, the literature to date broadly supports the notion that 'recognising unfamiliar blurred faces' is something which the right hemisphere can do better than the left hemisphere. Note the exactness of each word here: 'recognising' not 'remembering', 'unfamiliar' not 'familiar', 'blurred' not 'clear', 'faces' not 'pictures' or 'words'. This cannot be generalised into 'remembering faces'. Even if it is accepted that the right hemisphere, rather than the right, is better at doing this specific task, it does not conclude that the right it is *completely* responsible for this task. All that can be said is that some vital part of that process resides in the right hemisphere so much so that when it is not involved the left hemisphere struggles to complete the task well. It may be that by not using the right hemisphere there is a 'chink in the armour' but that some of the armour is still functioning fine and some of it may reside in the left hemisphere. So one cannot attribute a whole thinking process or task even for such a carefully 'boiled down' or dissected process as the one in this example purely to the right hemisphere. It can only be said that the right hemisphere does contribute and/or support a vital part of that process. (Hellige 1993)

An example of misuse of generalisation is found in the following question which appears in a learning tool for a management development programme used in a large British company: 'Do you remember faces easily?' for which a 'yes' is attributed to right brain and a 'no' to left brain. The early research showed that patients with right brain lesions or split-brained patients could not recognise faces (Hecaen and Angelergues 1962, Milner 1968) and that in normal brains the faces were perceived more clearly by the right hemisphere (Levy et al 1972, Milner & Dunne 1977, Schwartz

& Smith 1980). However as more and more research has been carried out (Bruce 1982, Hellige et al 1984, Sergent 1985, Freeman 1980) and the only thing we can really say now is that the right brain does seem to have the process for recognising *unfamiliar* faces. Familiar faces, however, are a different matter and these have been shown to have different neural pathways than unfamiliar faces and also expression of face is a different pathway (Bruce & Young 1986). For faces of people personally known there is the complexity of knowing a personality and having a relationship with the person. With a familiar face but unknown person there will be information as to why the face is familiar – perhaps an actor or a famous person or perhaps a name or occupation is known which the left hemisphere can use to help it remember a face. It also depends on what type of face and whether more than just a face is considered. This is because the left hemisphere can process and store faces but it does it in a different way. It remembers the more local information of nose, eyes, eyebrows and in particular noticeable features like hair, beard and glasses whereas the right brain will process the more holistic overall image and is therefore much better at recognising a blurred image than the left hemisphere which requires more of the detail to be in focus. Teuber (1978) even states that face recognition was possible without a right brain at all. Therefore, the question as 'do you remember faces' is far too general to determine anything and this serves as an example of the many generalisations that occur in such learning tools.

So who is responsible for ensuring that in learning and development we do not fall into the pitfall of generalisation? There is a need to consider the power that a presenter has in any learning setting because students will receive the information with a sense of authority. Therefore, the responsibility must fall mainly to the presenter. Part of that responsibility is to make sure that all materials are accurate and backed-up by research but also to encourage dialogue around the benefits and possible problems with using any tool well before their intended use. The *context* needs to be understood and taken account of.

Another illustration from a learning tool, designed to ascertain whether a person is left brained or right brained, brings to the attention the important of 'accuracy' and 'wording' which are used when this concept is tested. The following is a question where respondents are asked to select which of the following best describes them 'concerning hunches'. The options are:

A I frequently have strong ones and follow them

B I have strong hunches but don't place much faith in them

C I occasionally have hunches but don't place much faith in them

D I would not rely on hunches to help me make important decisions

The word 'hunches' is being used to mean 'intuition' which is one of the most difficult thinking processes to research but is frequently reported as relating to the right hemisphere. Therefore this question does seem to have some research back-up in terms of a strong sense of 'intuition' could suggest dominance of the right brain. However, the structure of the questions do not ask whether the person has 'hunches' but whether they follow them or not. This brings in a multitude of other factors such as self-esteem, self-confidence, social norms and occupational freedom. Answer d) would in fact cover the person with strong intuition but who feels they cannot rely on it for important decisions due to low self-confidence and non-acceptance of this thinking process in their work environment. If they were to choose d) the scoring would classify them as left brain dominant.

Another question asks about handwriting position and this is an interesting attempt to consider handedness which to be fair most questionnaires do not include at all. Again however, it is flawed because it is too simplistic. If there is to be a link made between thinking and handedness then it is important to be more exact about determining someone's handedness. For instance, there are many reasons why people are left handed, some due to hereditary factors, some pathological factors and some chemicals in the mother's blood or womb. It is essential to find out which before a classification of the type of left handedness can even be made. Also, asking people whether they are left handed or not assumes that they actually know. It also assumes they are basing this diagnosis on a particular skill for which they use that hand. Many people use both hands for different tasks and accurate classification in itself is a major task.

So should academics be using the concept of right brain/left brain to help their students to learn? And, how aware are academics of the value they place on particular learning skills of students. Is there some intrinsic assumed hierarchy?
There are companies who are putting their staff through so called 'right brain left brain' training. The information they are receiving is not backed-up by research and individuals genuinely believed that they now know whether they were 'right brained' or

'left brained'. They now know they should be good at certain things and not good at others. This is turn has affected their self-perception on their abilities to carry out certain tasks. Clearly this could limiting their development rather than enhancing it.

So is there a better way forward? Figure 2 illustrates the components needed to ensure a responsible use of the concept. Certainly research shows us that there are differences in the processing abilities of right and left brains. There are also indicators related to handedness, gender and medical conditions etc. To deny this is contrary to the evidence and would not be helpful. However, we have to acknowledge that most people have 'normal' brains where the interconnecting communication tissues are fully intact and so in 'normal' situations (where we are not deliberately trying to arouse one side of the brain more than the other) we can access the thinking processes of both sides of the brain. Of course, we have individual strengths but these can relate to a myriad of factors eg personality, upbringing, social conditioning, some which we can explore and some which are almost impossible to investigate.

In order to keep the benefits, of showing a full array of differences and holding up each in equal value and then allowing individuals to explore which they may prefer, and in order to, lose the misuse of categorising people, often erroneously due to inaccurate or incomplete questions, perhaps we need to take a more open approach.

A practical suggestion would be to ask a group of students to list all the types of thinking that they can generate. Students therefore focus on 'thinking about thinking' and the richness of diversity that exists. This alone is important learning. This brings about an array of thinking types such as logical thinking, sequential thinking, metaphorical thinking, synthesizing, creative thinking, emotional thinking, holistic thinking, detailed thinking aswell as general debate as to what is thinking anyway. Depending on the culture and whether people are likely to value different thinking processes more highly that others (which can become destructive) individuals could select processes that they feel are real strengths for them and then talk about whether they use these in their studies fully and if not how this might be facilitated or resourced. They can talk about thinking approaches they do not tend to use and whether they might want to explore using them more. This approach whilst giving labels to thinking processes does not have any assumptions of linkage and assumed groupings within it. It is also important to inform students as to the pitfalls of assuming linkages in thinking and to give them as much responsibility as possible over the exercises they are carrying out. The extent to which the discussions should be shared and open depends on the context of the group and whether stereotyping is likely or not. It is essential that the academic knows the context of the group.

In summary, the metaphor of left brain/right brain thinking has many pitfalls which the academic and student alike need to be aware of. The paradigm leap that is so commonly represented in education today needs to be strongly challenged lest we rob individuals of their perceived ability to develop in every area of their thinking.

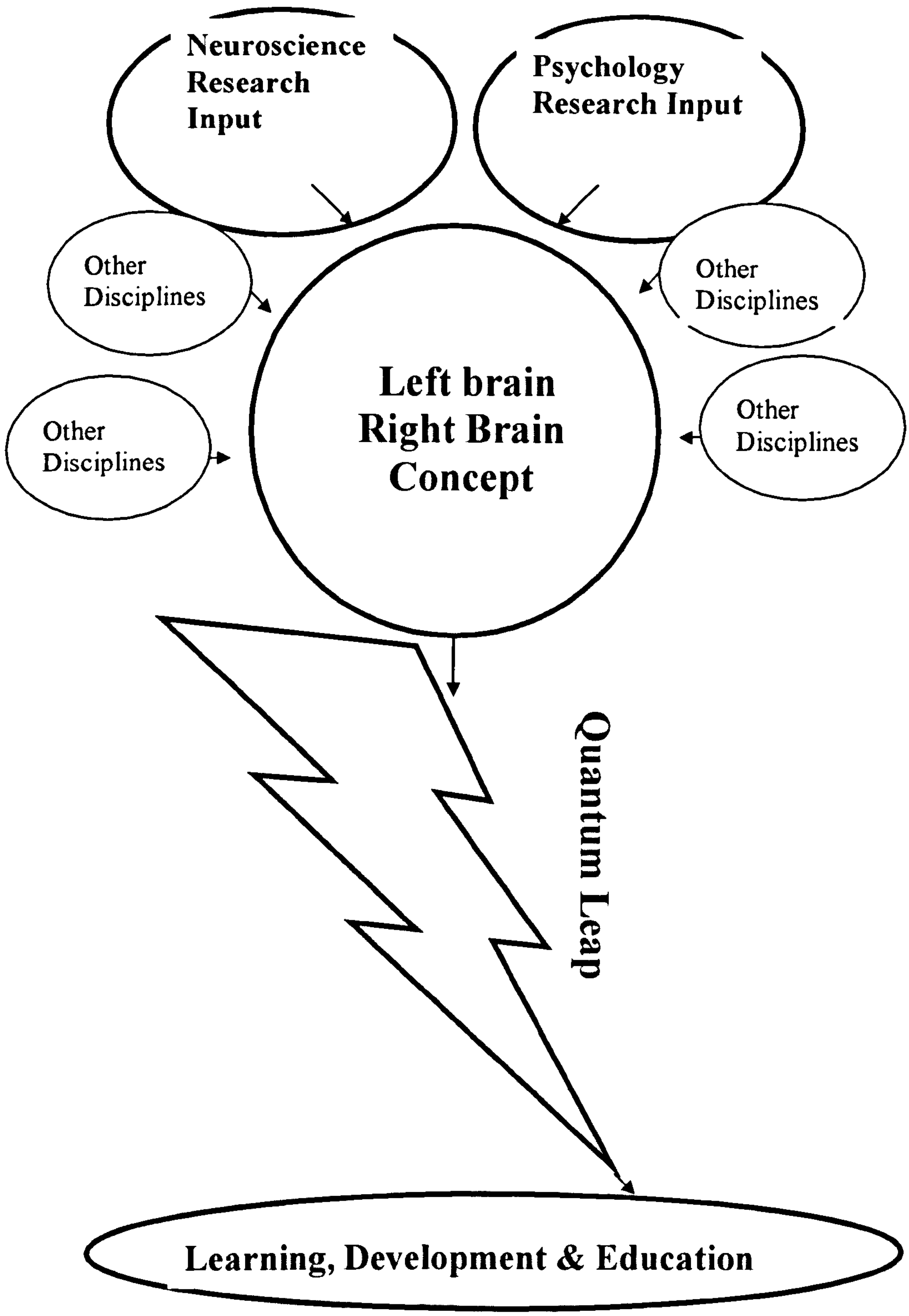


Figure 1: Quantum Leap in use of 'Right Brained or Left Brained' Concept

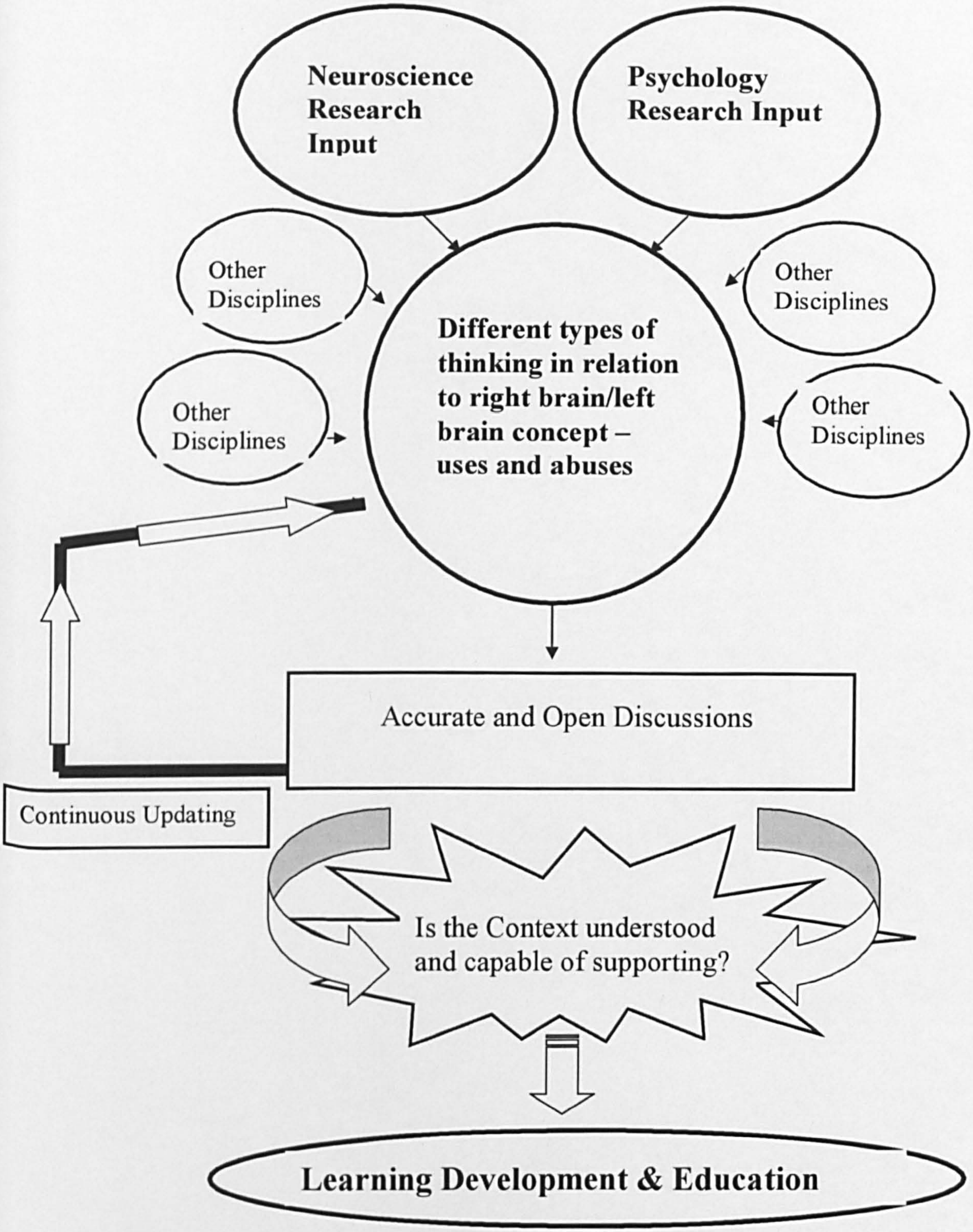


Figure 2: Suggested Model for Use of 'Right Brained or Left Brained' Concept

REFERENCES

BRUCE V (1982) Changing faces: Visual and non-visual coding processes in face recognition. *British Journal of Psychology* **73,** 105-116

BRUCE V, YOUNG A (1986) Understanding face recognition. British Journal of Psychology, **77,** 305-327.

FREEMAN J (1980). Cerebral asymmetries in the processing of faces. PhD Thesis, University of Aberdeen.

HECAEN H and ANGELERGUES R (1962). Agnosia for faces (prosopagnosia). *Archives of Neurology* 7, 92-100.

HELLIGE JB (1993). *Hemispheric Asymmetry: What's Right and What's Left?* Harvard University Press: Cambridge, Massachussets. P 45-53

HELLIGE JB, CORWIN WH and JONSSEN JE (1984). Effects of perceptual quality on the processing of human faces presented to the left and right cerebral hemispheres. *Journal of Experimental Psychology: Human Perception and Performance,* **10**, 90-107

HOCHBERG J and GALPER RE (1967). Recognition of faces: 1. An Exploratory Study. *Psychon. Sci.,* **9 (12)**, 619-620.

LEVY J, TREVARTHEN C and SPERRY RW (1972). Perception of bilateral chimeric figures following hemispheric deconnection. *Brain* **95**, 61-78.

MILNER AD and DUNNE JJ (1977). Lateralised perception of bilateral chimaeric faces by normal subjects. *Nature,* London **268**, No 5616, 175-176.

MILNER B (1968). Visual recognition and recall after right temporal lobe excision in man. *Neuropsychologia* **6**, 191-209.

SCHWARTZ M AND SMITH ML (1980). Visual asymmetries with chimeric stimuli. *Neuropsychologia **18**, 103-106.*

SERGENT J (1985). Influence of task and input factors on hemispheric involvement in face processing. *Journal of Experimental Psychology: Human Perception and Performance,* **11**, 846-861

SERGENT J and BINDRA D (1981). Differential hemisphere processing of faces: Methodological considerations and reinterpretation. *Psychological Bulletin* **89,** 541-554.

SPRINGER SP and DEUTSCH G (1981). *Left Brain: Right Brain, Perspectives from Cognitive Neuroscience (5th)* WH Freeman: New York.

TEUBER HL (1978). The brain and human behaviour. In *Handbook of Sensory Physiology* Vol **8** (R Held, HW Leibowitz and HL Teuber eds) Springer-Verlag, Berlin.

Appendix 5

Paper given at 12th International Conference on Learning: Designs for Learning, Universidad de Granada, Spain, Wednesday 13th July 2005-12-13

The Dangers of Left Brain Right Brain Thinking: How to get the Balance in Learning

Julia Claxton
Senior Lecturer
York St John College
York
England
YO31 7EX
j.claxton@yorksj.ac.uk

Paper Presented at the
Twelfth International Conference on Learning
Granada, Spain, July 2005

Abstract

This paper strives to find the balance between the misuse of the right brain/left brain concept and the use of looking at different ways of thinking.

In learning and teaching, more and more, we are exposed to the notion of left brain or right brain thinking. People are encouraged to find out where their strengths lie and often fill out questionnaires to help them establish this. This can be useful but there are grave dangers and the rapidity of exposure to these kinds of notions can be dangerous to learning and development. This workshop sets out what is fact and what is fiction and suggests practical ways forward for those who are interested in developing people's thinking without falling into the left brain/right brain trap.

Keywords: Left Brain Right Brain, Thinking Styles, Learning and Development, Meta Cognition
Stream: Learner Diversity

As a university lecturer and learning facilitator for 15 years, like many others, I have used learning styles, thinking styles, personality indicators etc to help people to understand themselves and to understand others, and in particular, to appreciate the 'richness' that comes from diversity.

More recently I have been researching hemispheric asymmetry which in general terms is about the differences between the right half of the brain and the left half of the brain. I have researched this from a multidisciplinary approach with the two main perspectives being 'neuroscience' and 'psychology'.

A large part of the research has been looking at exactly what neurologists and psychologists have established to be valid in this area and I have also conducted experiments to add to the established data.

There is much research in both disciplines and much of it is confusing and some contradictory and it is difficult to ascertain exactly what is accepted as factual. Also since the disciplines differ in their approach to collecting data and analysing the data this gives differing perspectives.

One of the things that has struck me most as an academic is the development of a 'right brained', 'left brained' *concept* which has become widely accepted in numerous learning development programmes and more recently in the school classroom.

This is interesting but on examination of some of the assumptions, explanations and techniques being used and in particular tools which seek to determine whether individuals are so-called 'right brained' or left-brained' the picture becomes worrying.

The reason for concern is that when compared to the actual literature and research that has been carried out, many of the materials that are being used in the learning development programmes and classrooms often evidence a massive paradigm leap from fact into fantasy. This can lead to individuals being given unreliable information and therefore misled.

In this paper I do not wish to discredit any particular tools in use, as they have no doubt been developed with the genuine desire to be helpful for learning and development.

What I will do is use examples of questions I have found which evidence the quantum leap from fact to fiction.

Firstly to establish some facts. It is fact that the brain is made of two hemispheres which are joined together by a communicating fibre. In a normal person the two sides communicate with each other. However, the two sides have been shown to support particular thinking processes in different ways. This has been shown particularly in people where the communicating fibre has been cut or where there has been brain damage on one side of the brain. In such cases individuals find they cannot complete certain physical or mental tasks. Concerning physical motor tasks this is shown clearly in the WADA tests (1960) when one side of the brain is aneasthetised the individual loses the use of the opposite side of their body. Concerning mental tasks, experiments on split-brain patients (Sperry), that is patients who have had the communication fibre cut so that the two sides of the brain cannot communicate with each other, have shown that whilst an individual recognises an object which has been shown to the right hemisphere only the individual cannot find the word to say what it is because the right brain cannot tell the left brain what it is.

Experiments of this kind led to the theory of 'specialisation' of tasks of each side of the brain. EEG scans also confirm that difference activities cause activity in different parts of the brain, However, and it is an important however, we cannot really talk about specialisation is this sense because thought processes are so complex. Hellige (2001) points this out very clearly in his writings. Yes it is a biological fact that one hemisphere supports a particular thinking process so that when damage occurs that support is lost and that thinking process is impaired. However, it does not mean that that hemisphere 'specialises' in that thinking process but that is does support it somewhere along its path and to lose that support means that thinking process does not complete. Herein lies one of the major problems with the concept of right brained and left brained as it is often based on this idea of specialisation.

Using the concept of right brained or left brained is suggesting to individuals that they may have a natural propensity to favour the thinking skills more associated with one hemisphere over the other ie have a dominance in one hemisphere.

The *first* assumption here is that there is indeed an associated list of thinking skills for each hemisphere. That is, that one hemisphere has one set of complete thinking processes and the other has a different set and that these can be identified for each. As research progresses it is showing this is less obvious than originally thought.

The *second* assumption is that if an individual has some of the thinking skills associated with that hemisphere that they should also have a natural tendency for the others attributed to that same hemisphere. Therefore, if someone is shown to be logical they are probably good sequential thinkers too because both these are often associated to the left brain. Conversely, if someone is shown to be intuitive there may be the assumption that they must be creative too as both these are associated with the right brain.

The *third* assumption is that if they show a tendency for a number of the processes in *one* hemisphere that they are unlikely to be strong in those associated with the *other* hemisphere. That is, if someone is logical then they are probably 'not' intuitive which is attributed to the right hemisphere. These three assumptions alone, if accepted, could be damaging to learning.

Along with the above we need to consider the 'origin' of the concept as this alone highlights a problem with the use of it. The discovery that the two hemispheres of the brain work in a different way came about through observing people who had had the connecting tissue (corpus collusum) of these two hemispheres severed so that the brain had effectively become two separate processors rather than one whole processor. Numerous experiments then went on to show that the differences in processing abilities of the left and right hemisphere. Although it is therefore likely that in 'normal' brains there will be similar differences in the preferred processes as in split-brained patients, normal brains have no restriction on the communication between each side. Additionally the speed of communication has been shown to be extremely fast. Is the concept of two different sides therefore just an illusion?

If we do accept that the hemispheres vitally support different thinking processes and we accept that normal brains are included in this then what about other factors which affect our thinking strengths. For instance, there is also a good deal of research which suggests that gender difference has implications for strengths in certain areas eg verbal skills are a strength for females and spatial skills for males. However, more and more in the literature these ideas are being challenged and other factors being investigated. For example, there is research that shows that males read directions differently from females with males preferring maps and directions of left and right whilst women prefer landmarks and that women get lost more easily. However, some research on school children showed that both sexes were just as successful at following the directions but the females showed more anxiety than the males.

Handedness is also an area where differences are explored and much research has been done concerning occupations and handedness with music and the creative arts usually attributed to left handedness. Again however, more current research is challenging some of these findings and it is becoming less clear as a factor. Some statistics still show that dyslexia is more common in males. However, we must still be careful because until recently 'attention deficit disorder' was presumed to be more of a problem for boys. Some research is now showing that it is also a problem for girls but because the behavioural symptoms are different (boys tend to get noisier while girls may withdraw and get quieter both being equally inattentive) the disorder may not so easily be noticed.

So there is biological and psychological research to show that the right hemisphere and the left hemisphere do have different strengths and that gender and handedness and some disorders have an influence on the strengths of these hemispheres. This is not in dispute at all and to deny these facts could also be a misuse of research and would not be helpful for learning.

So there is acceptance that there are differences in some of the processing abilities of the left brain and the right brain. It is also accepted that recent research is showing these differences to be more within sub processes of thinking rather than in full processes. So from a biological point of view is there really a left brain and a right brain or is it just that the brain is made of a many sections? In creating a concept of grouping and separation are we just misusing the physical makeup of the brain. If we accept that it is just a 'metaphor' as many in development do now – which incidentally can deny some of the biology – the is the metaphor itself not just as harmful because the metaphor still establishes the grouping and separation that can be so misleading? It still talks of dominance and still talks about linking certain processes together and still talks about separating those two groups from one another. For instance, popular psychology would roughly divide thinking into;

left brain: logical, sequential, numeric, detailed, vertical,
right brain: intuition, holistic, creativity, musical, lateral, spatial,

and the judgement as to whether someone is classified 'left brained' or 'right brained' is determined by which category their thinking strengths or at least those most easily measured or observed tend to fall into.

So how can the concept or metaphor be useful in learning? It can bring understanding as to why they do things the way they do. It can also bring understanding that others do things differently and why that may be perfectly normal for them. It can also give an understanding that there is equal value in different approaches to problem solving, decision making, future planning etc It can also highlight the sheer number of different approaches available and also indicate whether some approaches are lacking or over-empowering some less populated approaches. It can help those who feel they are in minority to feel that their approach is validated when they see it appear in black and white as a bone fide approach and fully acceptable. In one very emotional conversation with a lady she described how her son was continually bullied and struggling at school and as she talked I got an understanding of his thinking preferences and strengths and when I asked if he was left-handed she was amazed that I would know that. When I told her that these were not uncommon problems and that it may also be worth checking he was not dyslexic she felt relieved that someone was saying 'this is known about – he is not on his own'. Sometimes we feel we are not well understood and that at meetings our view always seems rather different from others and we need to know that it is in fact a strength and not a weakness and just because we are in the minority in that particular grouping we could be in the majority in another grouping. This also brings about discussion concerning whether certain organisations actually recruit only a proportion of the diversity of thinking approaches. Being employed in an institute of higher education I find that the copious form filling certainly leans towards those who find sequential thinking easy and leans against those who find creative thinking easy. Are we therefore automatically screening out creative thinkers when we put more and more emphasis on conforming to form layouts. So, having this concept of right brained and left brained has brought about a dialogue which has been very useful. The dialogue has been developed into types of thinking and this has also been useful. This can all be very useful developmental teaching and I would not want us to lose these benefits.

However, it is when these things are stretched too far that we see problems. For instance, I may know I am good at creative thinking and I am left handed – does that mean that I am right brained and therefore not good at logical thinking? Of course not and yet that could be the impression I would be given in a learning forum where the details are not fully understood. And if my results were shared with others in the room would they then assume I was not a logical thinker and what effect would that have on the way they approached me. This was exactly the problem caused within one organisation who sought to improve understanding of diversity by running a seminar. Months later one person reported to me 'I felt as if I had been pigeon-holed and what was most upsetting was that I noticed that after that day people talked to me differently from what they had been doing before and I feel as if I'm now in a certain zone that I've been put in and it's going to take effort for me to get people to see I'm not that limited". Sometimes our best intentions don't work and in this case it didn't have the benefit of showing strength in diversity as had been planned. However, is it not also a benefit if people recognise our strengths and try to play to them or is this manipulation? So one of the ways in which we can abuse this concept is by not being sufficiently aware of the *context* in which we are exploring these issues. Perhaps people should be told about the possible downside of such exploration and in that knowledge can make their own decision as to whether to attend such seminars. Understanding the *context* means identifying the present culture and the readiness of individuals to be able to get positive results from such a seminar. It can be a powerful tool to identify strengths and diversity and understanding of different approaches but in the wrong *context* it can be a manipulative tool to fast track getting to know people in order to get the best performance out of them. As organisations we need to be really honest and ask some hard questions about our motives for these kinds of initiatives. If the culture is already one of 'allowing' and 'enabling' and 'learning' and is genuinely using coaching, mentoring and listening then it may well be the right environment to introduce the concepts and they will be 'useful'. However, in a blame culture with a definite preference for certain thinking styles and a greater value put on some of them then it can be divisive and destructive. Educators have to be so careful to consider the *context* in which they are introducing concepts such as this. If such tools are used for team development with a good understanding that is a means of exploring 'preferences', not 'skills' or 'competencies', but 'preferences', and as long as the concepts are backed up by research then they can be helpful in learning.

If we are considering the idea of left brain thinking and right brain thinking then what do we actually mean by thinking? It's a very broad term and yet it is very difficult to break down any thinking processes into definite parts. This is where it becomes difficult to make generalisations. I have found that in my experiments in order to measure anything definite I have had to break down tasks in a minute fashion and therefore the conclusions are very limited. This frustration is perhaps the reason why generalisations are made. After all, if we are trying to attribute certain thinking processes to one hemisphere then the process has to be a complete one that has meaning and this is where research does not back-up much of the popular learning development tools used today. For instance, we can say that literature to date broadly supports the notion that recognising unfamiliar blurred faces is something which the right hemisphere can do far better than the left hemisphere. Note the limitation here; unfamiliar blurred faces – this is very limited and cannot be generalised into 'faces'. Even if we accept that the right hemisphere is better at doing this than the left, we cannot say the right it is *completely* responsible for this task. All we can really say is that some vital part of that process resides in the right hemisphere so much so that when it is not involved the left hemisphere struggles to complete the task well. It may be that by not using the right hemisphere there is a chink in the armour but that some of the armour is still functioning fine and some of it may reside in the left hemisphere. So we cannot attribute a whole thinking process or task even for such a carefully 'boiled down' or dissected process as the one in this example purely to the right hemisphere. We can only say that the right hemisphere does contribute and/or support a vital part of that process. (Hellige 2003)

An example of misuse of generalisation is found in the following question which appears in a learning tool, 'Do you remember faces easily?' for which a 'yes' is attributed to right brain and a 'no' to left brain. Again, I have the advantage of having looked into this in detail as I wanted to find a thinking process that only the right brain supported and I had thought that this was it. Of course, the research shows something different. Yes, the early research showed that patients with right brain lesions or split-brained patients could not recognise faces (Hecaen and Angelergues 1962, Milner 1968) and that in normal brains the faces were perceived more clearly by the right hemisphere (Levy et al 1972, Milner & Dunne 1977, Schwartz & Smith 1980). However as more and more research has been carried out (Bruce 1982, Hellige et al 1984, Sergent 1985, Freeman 1980) and the only thing we can really say now is that the right brain does seem to have the process for recognising *unfamiliar* faces. Familiar faces, however, are a different matter and these have been shown to have different neural pathways than unfamiliar faces and also expression of face is a different pathway (Bruce & Young 1986). For faces of people personally known there is the complexity of knowing a personality and having a relationship with the person. With a familiar face but unknown person there will be information as to why the face is familiar – perhaps an actor or a famous person or perhaps a name or occupation is known which the left hemisphere can use to help it remember a face. It also depends on what type of face and whether more than just a face is considered. This is because the left hemisphere can process and store faces but it does it in a different way. It remembers the more local information of nose, eyes, eyebrows and in particular noticeable features like hair, beard and glasses whereas the right brain will process the more holistic overall image and is therefore much better at recognising a blurred image than the left hemisphere which requires more of the detail to be in focus. Teuber (1978) even states that face recognition was possible without a right brain at all. Therefore, the question as 'do you remember faces' is far too general to determine anything.

So when exactly do we pass the line of 'use' to 'misuse'? And who takes the responsibility for crossing the line – is it the person who is giving the information or the person receiving it? I have the assuming that the 'power' is with the person giving the information so I would firmly put the responsibility there. Why? Simply because in learning development seminars, even if we try to attribute power to the participants, the power still remains with the person giving the information because 'even when the power is supposed to be with the receiver it is seldom the case in reality '(Wray-Bliss 2003).
Part of that responsibility is to make sure that all materials are accurate and backed-up by research but also to encourage dialogue around the benefits and possible problems with using any tool well before their intended use. The *context* needs to be understood and taken account of.

As an illustration of the design of tools to ascertain whether a person is left brained or right brained I have taken extracts from some such tools. There are two issues to consider here. One is the accuracy of the notion which is being questioned and the other is the actual wording of the question. For instance, this is one extract where the participant has to choose one of the options:

Concerning hunches:

A I frequently have strong ones and follow them

B I have strong hunches but don't place much faith in them

C I occasionally have hunches but don't place much faith in them

D I would not rely on hunches to help me make important decisions

The word 'hunches' is probably used to mean 'intuition' which is one of the most difficult thinking processes to research but is frequently reported as relating to the right hemisphere. Therefore this question does seem to have some research back-up in terms of a strong sense of 'intuition' could suggest dominance of the right brain. However, the structure of the questions do not ask whether the person has 'hunches' but whether they follow them or not. This brings in a multitude of other factors such as self-esteem, self-confidence, social norms and occupational freedom. Answer d) would in fact cover the person with strong intuition but who feels they cannot rely on it for important decisions due to low self-confidence and non-acceptance of this thinking process in their work environment. If they were to choose d) the scoring would classify them as left brain dominant.

Another question relates to hobbies and activities that the person should tick to say which they enjoy and again the research in this area has now shown that it is difficult to link these activities to the dominance of one hemisphere or another. It is difficult to say because some literature does support some activities. The danger here is that not all other reasons are included. For instance, the specialists schools for dyslexia are predominantly for boys and one of their main activities that they report the children enjoy is 'fishing'. If activities are to be used as a guide then the difficulty is that all factors that reflect this should be included and asked of the questionnee. Also some terms are very vague eg home improvements – this would be a variety of tasks – some very sequential, some spatial, some intuitive and some logical and yet here it is assumed that it is a left brain task. I daren't get into the 'hugging' and 'kissing' arena which for some reason are given high right brain scores but it is interesting that the 'chatting' item is given more of a left brain score and yet the questionee is not asked whether they are male or female for which there is a vast amount of research covering verbal skills. In fact on the latter point there is a question which asks 'Do you express yourself well verbally?' and apparently a 'yes' means a left brain dominance and right means a right brain dominance. Again, I can see where this comes from as for part of my Phd I searched for a left-brain task which I could test. I could find only one task which the majority of research has shown to be accepted as a left brain task and that is verbal recall. Expression of new ideas, repeating something from memory and host of other verbal skills are not identified as left brained – only the verbal recall of something that has been said. Of course, the whole aspect of gender which has already been mentioned and for which there is much research supporting the notion that females are more articulate is not taken into account at all. Also, again self-confidence and self-judgement is a factor here.

One of the questions asked about handwriting position and this is an interesting attempt to consider handedness which to be fair most questionnaires don't ever bother to ask. Again however, it is flawed because it is too simplistic. The hooked position refers to research on inverted handwriting position which some research says gives an indication of ipsilateral (same sided) control instead of the normal contralateral (opposite sided) control. Basically the biology says that your left brain controls your right hand and right brain controls your left hand and this does stand the rigours of research and in particular with handwriting which is a controlled precise (fine motor control) task of the fingers (rather than wrist or arm) which makes the contralateral control more acute. My main concern with this type of question is that the association between left handed and right brained is not proven. This is partly because there are at least 3 different reasons why someone could be left handed and research is not valid unless the left handers are first separated into these three categories. The scores show that if you are left handed then you are right brained and if right handed then left brained but right and left handed in what? Handwriting is a good indication of handedness but there are many people around who write with the hand they do because of social reasons (left handed was frowned on socially in the UK and still is in many countries), an accident with their dominant hand or they may be ambidextrous of mixed handed none of which are included. Also although handwriting is the strongest indicator of handedness there are right handed people who may play all sports with their left hand and would be classified as mixed handed – not an option on this questionnaire.

A question relating to mood changes is very intriguing. I have found that most research attributes emotions to the right hemisphere but some more recent research gives indications of positive emotions from left hemisphere and negative from the right hemisphere. It may be that this question is related to that research but again it is such a general question that it could cover a multitude of factors. Frequent mood changes are attributed here to the right brain and this may be loosely linked to the logical assumption of the left brain where logical means less emotional – who knows?

I think one of the most common errors I have come across is displayed in the dominance of the eye. It is clear from research in neurobiology that the left visual field is controlled by the right hemisphere and the right visual field is controlled by the left hemisphere. And this is usually where it goes wrong – 'visual field' does not mean 'eye'. Very quickly we find that the there is a leaping assumption that the left eye is controlled by the right hemisphere and the right eye is controlled by the left hemisphere and that is just not the case. Exercises where you close one eye or another and carry out a task is still using both hemispheres. The idea that the direction in which the eyes go when someone is thinking links to their dominance is often quoted and yet the evidence in the research is very mixed. Also, exercises that are supposed to improve the communication between the right brain and the left brain have been developed which are rather like the childhood notion of 'can you pat your head and rub your tummy at the same time.....now do it the other way round'.

So what is the conclusion to all this. It is 'use' or 'misuse'?
I think the thing that concerns me most which is what has led me to write this paper is that I speak to people who tell me they have been finding out whether they are left brained or right brained. Yes the information they are receiving is not backed-up by research and some of the extracts highlighted here have been used. The problem is more worrying because the individuals I spoke to genuinely believed that they now knew whether they were 'right brained' or 'left brained' and that this meant they would be good at certain things and not good at others. This is turn affected their self-perception on their abilities to carry out certain tasks.

So is there a better way forward? Certainly research shows us that there are differences in the processing abilities of right and left brains. There are also indicators related to handedness, gender and medical conditions etc. To deny this is contrary to the evidence and would not be helpful. However, we have to acknowledge that most people have 'normal' brains where the interconnecting communication tissues are fully intact and so in 'normal' situations (where we are not deliberately trying to arouse one side of the brain more than the other) we can access the thinking processes of both sides of the brain. Of course, we have individual strengths but these can relate to a myriad of factors eg personality, upbringing, social conditioning, some which we can explore and some which are almost impossible to investigate.

In order to keep the benefits, of showing a full array of differences and holding up each in equal value and then allowing individuals to explore which they may prefer, and in order to, lose the misuse of categorising people, often erroneously due to inaccurate or incomplete questions, perhaps we need to take a more open approach.

A suggestion would be to ask a group of managers to list all the types of thinking that they can generate – this alone is an interesting exercise. Just getting managers to think about thinking can be fruitful in itself. This will bring about an array of types such as logical thinking, sequential thinking, metaphorical thinking, sythensizing, creative thinking, emotional thinking, holistic thinking, detailed thinking. Depending on the culture and whether people are likely to value different thinking processes more highly that others (which can become destructive) individuals could select processes that they feel are real strengths for them and then talk about whether they can use these in their present roles fully and if not how this might be facilitated or resourced. This may be an approach which can avoid categorising people and also avoid the assumption that because some skills are identified as residing in one side of the brain then that person is expected to exhibit the other skills associated with that side as is also expected to have a weakness in the skills associated with the other side of the brain.

References

BAHRICK HP, BAHRICK PO and WITTLINGER RP (1975). Fifty years of memory for names and faces: A cross-sectional approach. *Journal of Experimental Psychology: General* **104,** 54-75

BENTON A L, HAMSHER K de S, VARNEY N ET AL (1983). *Contributions to neuropsychological assessment: A clinical manual.* Oxford University Press, Oxford.

BLAKESLEE Thomas R (1980). *The Right Brain.* MacMillan Press, London Pp 164-173

BRADSHAW John L and NETTLETON Norman C (1983). *Human Cerebral Asymmetry.* Prentice Hall, New Jersey, 92-95.

BRUCE V (1982) Changing faces: Visual and non-visual coding processes in face recognition. *British Journal of Psychology* **73,** 105-116

BRUCE V, YOUNG A (1986) Understanding face recognition. British Journal of Psychology, **77,** 305-327.

CAREY S (1981). The Development of Face Perception. In *Perceiving and Remembering Faces* (Editors: G Davies, H Ellis, J Shepherd). Academic Press: London.

ELLIS HD (1981). Theoretical Aspects of face recognition. In *Perceiving and Remembering Faces* (Editors: GM Davies, HD Ellis, JW Shepherd eds). Academic Press, London and New York

ELLIS HD (1983). The role of the right hemisphere in face perception. In *Functions of the Right Cerebral Hemisphere* (Editor: AW Young). Academic Press, London and New York.

ELLIS HD, SHEPHERD JW and DAVIES GM (1979). Identification of famililar and unfamiliar faces from internal and external features: some implications for theories of face recognition. *Perception* **8,** 431-439

ERNEST CH (1997). Spatial ability and laterality effects on a face recognition task. *Personal Individual Differences* **23**(5), 839-848.

FINLAY DC AND FRENCH J (1978). Visual field differences in a facial recognition task using signal detection theory. *Neuropsychologia* **16**, 103-107.

FREEMAN J (1980). Cerebral asymmetries in the processing of faces. PhD Thesis, University of Aberdeen.

GALPER RE and HOCHBERG J (1971). Recognition memory for photographs of faces. *American Journal of Psychology* **84(3)**, 351-354
GAZZANIGA Michael S and LEDOUX Joseph E (1978). *The Integrated Mind.* Plenum Press, New York Pp 70-71

GOLDSTEIN AG (1977). The fallibility of the eye witness. Psychological Evidence. In *Psychology in the Legal Process* (Editor: BD Sales). Spectrum: New York.

HAY DC AND ELLIS HD (1981). Asymmetries in facial recognition: Evidence for a memory component. *Cortex* **17**, 357-368

HECAEN H and ANGELERGUES R (1962). Agnosia for faces (prosopagnosia). *Archives of Neurology* 7, 92-100.

HELLIGE JB (1993). *Hemispheric Asymmetry: What's Right and What's Left?* Harvard University Press: Cambridge, Massachussets. P 45-53

HELLIGE JB, CORWIN WH and JONSSEN JE (1984). Effects of perceptual quality on the processing of human faces presented to the left and right cerebral hemispheres. *Journal of Experimental Psychology: Human Perception and Performance,* **10**, 90-107

HILLIARD RD (1973). Hemispherice laterality effects on a facial recognition task in normal subjects. *Cortex* 9, 246-258

HISCOCK M (1988). Behavioural Asymmetries in Normal Children. In *Brain Lateralization in Children* (Editors: DL Molfese, J Segalowitz). Guildford Press: New York.

HOCHBERG J and GALPER RE (1967). Recognition of faces: 1. An Exploratory Study. *Psychon. Sci.*, **9** (**12**), 619-620.

IVRY Richard B and ROBERTSON Lynn C (1988). *The Two Sides of Perception.* MIT Press, Cambridge, Massachussets Pp 116-120

JONES B (1979). Lateral symmetry in testing long-term memory for faces. *Cortex* **15**, 183-186.

LEVY J, TREVARTHEN C and SPERRY RW (1972). Perception of bilateral chimeric figures following hemispheric deconnection. *Brain* **95**, 61-78.

KATANODA , YOSHIKAWA K, and SUGISHITA M (2000). Neural substrates for the recognition of newly learned faces: a functional MRI study. *Neuropsychologia* **38**, 1616-1625.

KEENAN JP, McCUTCHEON, FREUND S, GALLUP GG, SANDERS G and PASCUAL-LEONNE A (1999). Left hand advantage in a self-face recognition task. *Neuropsychologia.* **37** 1421-1425

PHILLIPS ML and DAVID AS (1997). Viewing Strategies for Simple and Chimeric Faces: An Investigation of Perceptual Bias in Normals and Schizophrenic Patients Using Visual Scan Paths. *Brain and Cognition* **35**, 225-238.

McGLONE J (1980). Sex differences in human brain asymmetry. A critical review. *The behavioral and Brain Sciences 3, 215-227.*

MILNER AD and DUNNE JJ (1977). Lateralised perception of bilateral chimaeric faces by normal subjects. *Nature*, London **268**, No 5616, 175-176.

MILNER B (1968). Visual recognition and recall after right temporal lobe excision in man. *Neuropsychologia* **6**, 191-209.

MOHR B, LANDGREBE A and SCHWEINBERGER ST (2002). Interhemispheric cooperation for familiar but not unfamiliar face processing. *Neuropsychologia* **40** (11), 1841-1848

MOSCOVITCH M, SCULLION D AND CHRISTIE D (1976). Early versus late stages of processing and their relation to functional hemispheric asymmetries in face recognition. *Journal of Experimental Psychology (Human Perception and Performance)* **2**, 401-406

SCHWARTZ M AND SMITH ML (1980). Visual asymmetries with chimeric stimuli. *Neuropsychologia 18, 103-106.*

SERGENT J (1985). Influence of task and input factors on hemispheric involvement in face processing. *Journal of Experimental Psychology: Human Perception and Performance*, **11**, 846-861

SERGENT J and BINDRA D (1981). Differential hemisphere processing of faces: Methodological considerations and reinterpretation. *Psychological Bulletin* **89**, 541-554.

SHEPHERD JW and ELLIS HD (1973). The effect of attractiveness on recognition memory for faces. *American Journal of Psychology* **86**, 627-634.

SPRINGER SP and DEUTSCH G (1981). *Left Brain: Right Brain, Perspectives from Cognitive Neuroscience (5th* . WH Freeman: New York.

TEUBER HL (1978). The brain and human behaviour. In *Handbook of Sensory Physiology* Vol **8** (R Held, HW Leibowitz and HL Teuber eds) Springer-Verlag, Berlin.

WADA J A and RASMUSSEN T, (1960), Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance: experimental and clinical observations. Journal of Neurosurgery 17, 266-282

YOUNG AW, HAY DC and ELLIS AW (1985). The faces that launched a thousand slips: Everyday difficulties and errors in recognizing people. *British Journal of Psychology*, **76**, 495-523.

YOUNG AW, NEWCOMBE F, DE HAAN EHF, SMALL M, and HAY D C (1993) Face perception after brain injury: selective impairments affecting identity and expression. *Brain*, **116**, 941-59