AN UPSIDE DOWN WORLD

A Japanese proverb says:
"A left-handed child may grow up to be a genius because of being different"

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0. INTRODUCTION

Most of the people are right-handed and they have never worried about why are they right-handed because they are the majority of the population. But I am not. I am one of the few left-handed in the world and I have wondered it since I was a child.

In spite of being left-handed, I have never felt discriminated or excluded since most of my family is left-handed. Actually my parents are so and what is more, two of my mother sisters are left-handed, as well. My family and I break statistics, don't we? However, my brother is right-handed so at home we tend to say if we are the oddest people of the world and my sibling the oddest member of our family.

For this reason, some months ago, when I had to choose a topic for my research project, I made up my mind focusing my interest on handedness. With this chance, I do want to find out why I am left-handed like most of my relatives. I would also like to discover if there are some differences between left- and right-handed brains or why the word *left* has been associated with death or bad luck. Thanks to my investigation I thought I could support or deny all the myths which have been associated with handedness throughout history, such as left-handed come from alcoholic or drug addict parents or that they are linked to dyslexia or mental problems.

Since then, I have been looking for information and I have to say it has been a difficult work. Although science has advanced so much, this area of knowledge has been stagnant and most of the research still talks about those outdated ideas. Luckily, however, I found a professor called Chris McManus who wrote "Right hand, left hand", winner of the 2003 Aventis General Prize for science books, which has helped me so much. Actually he found out lots of things about this topic and symmetry as well.

Figure 0.1 Professor Chris McManus writer of "Right hand, left hand"

Nonetheless, I am only keen on left- and right-handed so my project has been organised as follows. First of all, I have started my project describing, in general terms, the different meaning of left and right throughout history and the etymology of the term. Then in a more scientific part, I deal with the laterality theory, handedness, and left-handed brain including the differences between left- and right-handed brains. Afterward for curiosity, I talk about left-handed tools, asymmetry and symmetry, left-handed superstitions and left-handed people as well. Finally in a practical part I have recorded some videos comparing skills in daily activities such as how a right-handed manages himself cutting using his left hand and vice versa. I have also done Anett's Test which shows laterality in people.

1.LEFT-RIGHT SYMBOLISM

Handedness is due to genetics, but the symbolism of right and left cannot be only a result of biological differences between hands. Indeed, it's a social phenomenon.

First of all, we should look back through the history. Indo-Europeans, who lived between the 5th to 4th millennia BC, lived far north of the Tropic of Cancer and the heaven was very important for them, specially the phases of the moon or the sun position. For them the sun would rise from the east and set in the west. Then miraculously it would rise again from the east. If they followed the sun movement throughout the day, it was to right. Here, there is a link between the dominant of the right and the movement of the sun.

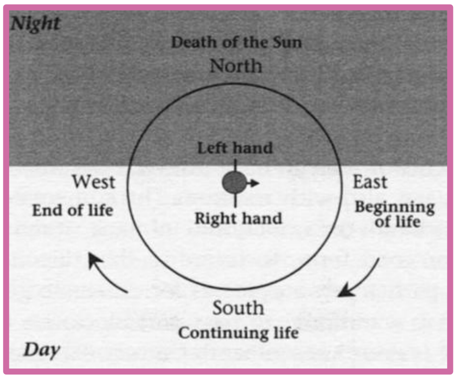

Figure 1.1 Relationship of right and left to the points of compass and the movement of the sun relative to a person.

There is a circle formed by day and night and the four points of the compass, which turns to the right. In a symbolical way, it means the cycle of life: east is the birth of life where the sun rises every morning; south, the warmth and the continuation of it, west the end of life and north, the death of the sun which is reborn the following day from the east.

If the theory seems a little vague, in some Indo-Europeans languages the words from right and south are swappable. For instance, in Sanskrit *dakshina* means "right hand" and "south", and *puras* means "in front" and "east". Moreover, in Old Irish, *deas* and *ders* mean "on the right" and "south", and *jav* mean "behind" and "west". For these reason, in some cultures, bodies are buried facing to the east, which symbolize resurrection or rebirth.

The symbolic of right-left is also present in male-female symbolism. For example, in the Gogo, Tanzania, the right hand is described as *muwokowokulume* "the male hand", whereas the left hand is described as *muwokowokucekulu* "the female hand".

Otherwise, the association of left and right with reproduction and male-female differences is global. Also in Gogo, it is believed that if a woman lies on her right side during coitus she will produce male children. Moreover, before the discovery of chromosomes, it was believed that a child's sex depended on the father's sperm. If the sperm came from the right testicle, the couple would have a boy and vice versa. It was such a believed theory that some men put an elastic band on their left testicle to conceive only male children.

There is also another system known as dual symbolic classification. The world is divided into pairs of opposites which have similarities; one is related to right, and the opposite to left.

Right	Left	Right	Left
Male	Female	Kin	Affines
Masculine	Feminine	Private	Public
Moon	Sun	Superior	Inferior
Sky	Earth	Above	Below
East	West	Auspicious	Inauspicious
Life	Death	South	North
Good death	Bad death	Sacred	Profane
Odd	Even	Sexual abstinence	Sexual activity
Family	Strangers	Village	Forest
Gods, ancestral spirits	Mortals	Prosperity	Famine
Back	Front	Beneficent spirits	Evil spirits, ghosts

Table 1.1 Purum dual symbolic system.

A system like this is a sort of calculus for assessing symbolic values, with a simple equation of right = good and left = bad. In this kind of systems there are also inversions, for example right is an auspicious for males but it's inauspicious for females.

Besides, Christianity has also symbolic associations with left and right. The Bible is full of expressions involving both, for example in the Last Judgement when people will be divided: *"And he shall set the sheep on his right hand, but the goats on the left. Then shall the king say unto them on his right hand, Come, ye blessed of my Father, inherit the kingdom prepared for you from the foundation of the world... Then shall he say also unto them on the left hand, Depart from me, ye cursed, into everlasting fire..."*[1]

In Christian churches, the altar faces the east. And entering from the west, the left-hand has paints from the Old Testament whereas paints from New Testament are painted on the right-hand. Moreover in some churches, women would sit on the left and men on the right; such in weddings where the bride's family sit on the left and the groom's family on the right.

Christianity is not the only religion with symbolism. In Jewish traditions it is said that "Torah is the right hand and the oral law is the left". What is more the right is the position of honour and it's rude to walk on the right of a more clever or important person. In Islam there is a preference for right hand too. The right is for taking an oath and the left is the bringer of bad omens.

Historically, in Classical Greece there is also right-left symbolism. Pythagoras said that everybody should enter in a sacred place from the right, the origin of even numbers; and leave from the left, the origin of odd numbers. In Classical Greece symbolism involved food as well. They divided the food in two groups *sitos*, such as bread; and *opson*, such as fish, meat or onion. The first ones were eaten with the left hand and the second ones with the right hand.

[1]Matthew 25: 33-34, 41; AV

2.ORIGIN OF THE TERM, ETYMOLOGY

Distinguishing right from left is essential in our society which it means language must have words to describe them. But, where do these words come from? English is part of the Indo-European family of languages, in which there are many similarities between the words for right and left.

	RIGHT	LEFT
Ancient Greek	Δεξιός	άριστερός, εὐώνυμος, σκαιός, λαιός
Modern Greek	Δεξιός	άριστερός, ζερβός
Mycenean	De-ki-si-wo	[not available]
Latin	Dexter	Sinister, laevus, scaevus
Italian	Destroy	Sinistro
French	Droit	Gauche
Spanish	Diestro	Zurdo, siniestro
Portuguese	Direito	Canhoto
Romanian	Drept	Stîng
Old Irish	Dess	Clē, tūath
Modern Irish	Deas	Clē (tūath)
Welsh	De, deheu	Aswy, chwith
Breton (modern)	Dehou	Kleiz
Gothic	Taihswa	Hleiduma
Old Norse (Old Icelandic)	Hœgri	Vinstri
Danish	Højre	Venstre
Swedish	Högre	Vänster
Norwegian	Høgre	Venstre
Old English	Swīþra	Winestra
Middle English	Riht, swither	Lift, luft
Dutch	Recht	Linker
Old High German	Zeso	Winistar, slinc
Middle High German	Zese, reht	Winster, linc
Modern German	Recht-	Link-
Lithuanian	Dešinas	Kairias
Lettic	Labs	Kreiss
Old Church Slavic	Desnŭ	Šujĭ, lěvŭ
Serbo-Croatian	Desni	Lijevi
Czech	Pravý	Levy
Polish	Prawy	Lewy
Russian	Pravyj (desnoj)	Levyj
Sanskrit	Dakşiṇa	Savya-, vāma-
Avestan	Dašina-	Haoya-, vairyastāra-
Tocharian A	Pāci	Śālyās
Tocharian B (Kuchean)	Śwālyai	Saiwai
Luwian	Išarwili-	Ipala-
Hittite	Kunna-	GÙB-la-
Akkadian	Imnu, imittu	Šumēlu
Ugaritic	Ymn	(u)sm'al
Hebrew	Yamin	Semo'l

	RIGHT	LEFT
Arabic	Yamîne	Šimâl
Albanian	Djathtë	Majtë
Amenian	Aĵ	Jax

Table 2.1 Indo-European and other words for right and left.

Some of these words are very similar - *pravý* in Czech and *prawy* in Polish or *sinister* in Latin, *sinistro* in Italian and *siniestro* in Spanish – because they come from a common source. The closer the speaker's countries are, the more similar the words are such as Russian and Polish or Dutch and German. We can also see that sounds in one language are systematically modified in other languages for example in Latin /p/ is modified into /f/ in German languages

Latin /p/	German languages (English) /f/
Pater	Father
Piscis	Fish

Table 2.2 sounds modified systematically in languages.

Of course we do not only take care about its sounds but also its morphology, the predecessors of the modern languages: English coming from Middle English, which is related to Anglo-Frisian, which is related to Gothic, and so to East Germanic, and to Germanic and proto-Indo-European which was spoken 3'000BC by half people on Earth.

Despite being so old, Proto-Indo-European had rich vocabulary. Therefore, words like "left" and "right" which show some similarities in modern languages should have had a common ancestor. Proto-Indo-European had some words for right such as desk, deksinos/deksiwos/deksiteros[2] but there is a lack of a word for left. The lack of a word of left is so strange, because they should need a word which means the opposite of right. How can the word for left be missing? The reason must lie in symbolism, as I had said in "Left-Right symbolism" left has always been linked to death so it had become taboo.

If we look back to the table, we can see that more languages have multiple terms for left than for right. This fact is due to left words comes from different languages or new invented words so there is not any similarity between left and right words. As we can see there is not any commonality between the Old English *winestra* and the Modern English *right.*

In short, we can say that words are more similar as the speaker's countries are closer and they come from a common source, proto-Indo-European. However, left has not had a common source because of the symbolism of the term. It comes from other languages and has been modified from one language to other.

[2]These words have been reconstructed by linguistics, they are hypothesized words.

3.LEFT AND RIGHT, OR RIGHT AND LEFT?

Since we are children we have difficulty differentiating left and right and we sort out these problems with some tricks such as doing a writing movement or linking right and write –they are homophones- but this only works if you are right-handed.

Piagel’s research has revealed that children take about ten years to learn about left and right. It involves the coordination of three separate skills: understanding left and right, carrying out a mental rotation and seeing the world from a different perspective. We can recognise three stages in children’s understanding of left and right.

In the first stage, children at about the age of five, see left and right in relation to themselves. This is also called egocentrism – seeing the world from their own perspective. The terms are seen by the child to their left and right and then projected to the world. They can point their own left and right hand properly but not the others, since they would say that the other left hand is in front of their left hand instead of knowing they are crossed. In the second, about seven-years-old-children understand that other people do not see left and right as they see them. Now they can distinguish “their” left from “my” left side of the body. Finally, left and right are seen as properties of relationship between objects and not of objects themselves by ten-years-old-children. As we can see in Figure 3.1, in this stage children will be able to say that the glass is in the right side of the teapot and in the left side of the bowl. In this stage also called complete objectivity the understanding has been achieved.

Figure 3.1 In the third stage, children see left and right as properties of relationship between objets

Although the majority of the children solve left-right problems by the age of twelve, left and right might carry on providing problems throughout their life. Before going on, answer this simple question which was answered by three hundred and sixty four professors at Michigan State University:

As an adult, I have noted difficulty when I quickly have to identify right versus left:

- All the time
- Frequently
- Occasionally
- Rarely
- Never

Figure 3.2 Question for adults to know how often they have problems to distinguish left and right.

The research has showed that 2% have the problem all the time, 6% frequently, 11% occasionally, 36% rarely and 45% never. It is stinking that 1 in 5 has troubles occasionally, frequently or all the time.

Even adults who say they are not confused show problems when they are tested precisely. The tests were Figures 3.3 and 3.4. In the first one you have to say as quickly as possible whether the hands are pointing up or down. And in the second one you have to say loud whether the hands are pointing left or right. Most of the people take half longer to do the second task. Finally the most difficult, look again at the second figure and say loud whether each one is a left hand or a right hand. This task usually takes about two and a half times longer than saying if the hand points to the left or to the right.

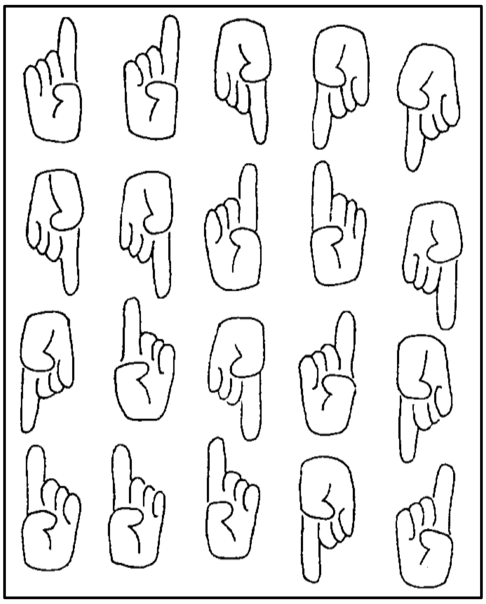

Figure 3.3 The hands tested of Left-Right Confusion. This is the control condition, in which one has to say whether hand is pointing up or down.

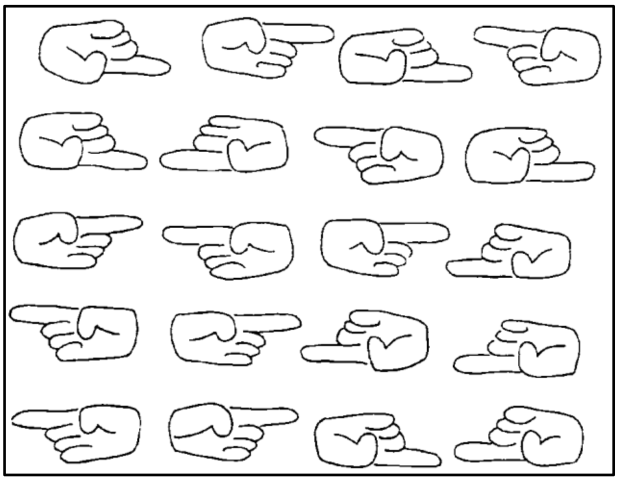

Figure 3.4 The hands Test of Left-Right Confusion. This is the main condition, in which one has to say whether each hand is pointing “to the right” or “to the left”.

There is something more difficult identifying right or left rather than up or down. To understand why this happens psychologists have developed two sorts of explanations called perceptual encoding and verbal labelling. When we distinguish two objects, first we have to see the difference – the perceptual stage – and then we have to describe that difference – labelling stage. As a result from another survey, it has been revealed that the problem with left and right must be from verbal labelling, it means people see that the hands are different but they have difficulty saying which hand is that.

Besides, there is the marked word; the brain takes extra time to process this word. Another experiment can be carried out to test which of right and left is marked. This time it is shown a box with the word right or left on it and a spot painted on one side of the box – left or right. The subject has to say if the relationship between the box, the spot and the word are true or false. There's an example below:

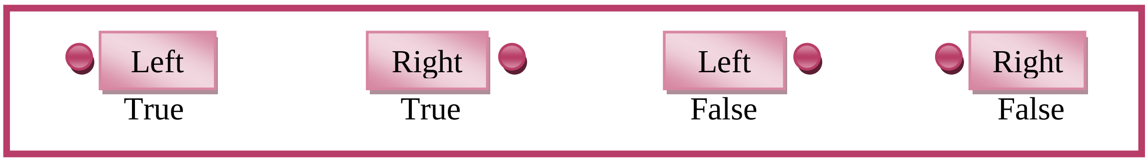

Figure 3.5 Experiment that has been carried out to know the marked word.

The answer in the test are given faster when the word in the box was right than when was left. As a result, right is unmarked being remarked as the norm and left is marked being remarked as the abnormal. But the test was only carried out with right-handed so we do not know if the marked word for left-handers is also left or if it is right.

Left and right are difficult to distinguish for humans but, can animals distinguish them as well? Some experiments have been done with octopus, goldfish, pigeons, rats, rabbits, cats… And most can't distinguish them. It is because their brain is symmetric so they cannot differentiate something asymmetric such as left and right – they are not equals, you cannot wear you right glove in your left hand – like humans, whose brains are asymmetric. This theory explains why some people have more troubles distinguishing left and right. People with more asymmetric brain have less trouble than people with a more symmetric brain. Left-handers have less lateralised brains than right-handers and men have more lateralised brains than women as well.

4. LATERALITY

Darwin, also known as who conceived the ideas on natural selection and evolution, was really interested in his children's handedness. He wrote a diary about child development throughout his son childhood.

When his son was only 11 weeks old, Darwin was studying his handedness. His comments such as his son had a tendency taking the sucking bottle easier with the right than with the left, Darwin supposed he would be right-handed. However, he was not. As he commented, his son inherited the tendency of being left-handed from his grandfather, mother and a brother. In spite of being right-handed himself, his wife and one of his son's grandfathers were left-handed so it was a strong family history of left-handed – taking into account that in the time, there were a few left-handed. Thus, it is not a surprise that two out of eight Darwin's children two of them were left-handed.

Darwin's interest in handedness would not be seen as unusual nowadays. Since 1970s one of the most frequent questions some parents have been asking themselves is "How common is left-handedness?" Let's focus on this question completing this questionnaire below which was taken by nearly three hundred students in Waltham Forest in North London.

With which hand do you mainly carry out the following tasks?
Ring left or right, not both.

Write	Left	Right
Draw	Left	Right
Throw a ball	Left	Right
Brush your teeth	Left	Right
Hold scissors	Left	Right
Hold a knife (without fork)	Left	Right
Hold a spoon	Left	Right
Hold a cup	Left	Right
Use a TV remote control	Left	Right
Open a can of drink	Left	Right

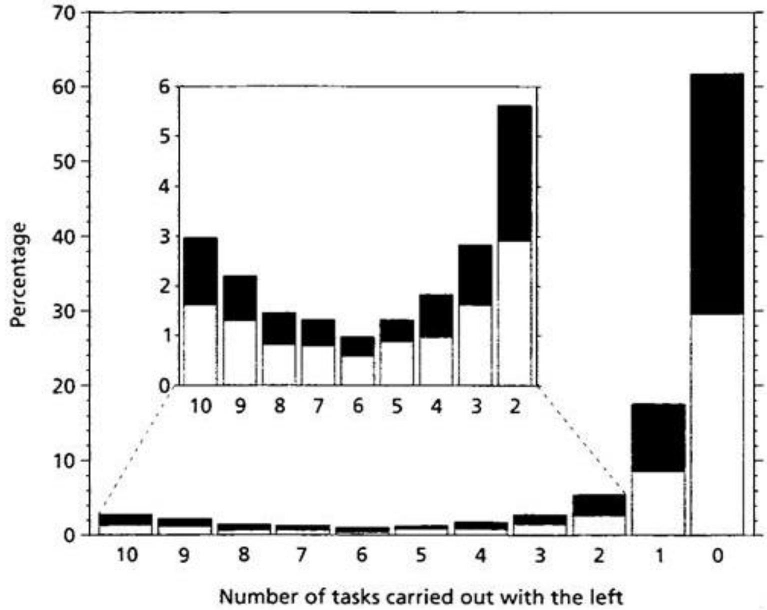

Figure 4.1 A study of handedness. The proportional results of males and females are highlighted through shading: black for females and white for males.

First of all, count the number of times you have answered “Left” which will be none – if you are a strong right-handed – and ten – if you are a strong left-handed. To compare your result with other people look at the graphic. The horizontal axis of the main graph which goes from ten to zero shows the number of “Left” answers and on the vertical axis it is shown the percentage of people with each score.

At first sight, several things are apparent. The results show a curve – high at the right side descending until almost zero and the rising again at the left side. Most people do not carry out any task with their left hand which means they are strong right-handers. To make clearer what is going on in the rest of the graph the smaller one is a magnification of the left-hand and central area of the main graph.

Between both sides – strong left and right – there are few people called weak left-handers if they use their left for six to nine tasks or weak right-handers if they use their left for one and five tasks. But what about people who use their left hand for five tasks and their right hand for other five tasks? Are they ambidextrous? Probably not, when they take more detailed tests, it is shown that these people still have predisposition for one hand. Although there are people who claim being ambidextrous they are not unless they have practised very hard.

The graph also shows that 11.6% of the males are left-handed and only 8.6% of females are, being 10% of the population in Europe left-handed; so left-handedness is more common in men than women. Another study reveals there are five left-handed men for every left-handed woman. In spite of not being a very large difference, it shows somehow there is something biological in left-handedness. The idea that sex and handedness are related has been shown throughout history. Freud noted down that bisexuality and laterality are related and that left-handedness is associated with homosexuality. Furthermore, it is said that male homosexual are likely to be left-handed and left-handedness also seems more common in transsexuals. Likewise, American children who present signs of gender identity disorder[3] are likely to be left-handed.

Finally the graph shows something else. Look carefully at the right side of the graph, most of the right-handed score zero than one, two, three or four; that means right-handers tend to be strong right-handers whereas left-handers are not as extreme. Compare the ones who score ten with those scoring nine, eight, seven or six; there is only a slight difference between these scores.

To summarise, right-handers tend to be more strongly handed than left-handers. This is partly because they live in a “right-handed world” in which most of the tools are built and designed for right-handers. As a result, left-handers have adapted to the right-handed world and use their right hand although their preference is using their left. This may explain the fact superficially.

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[3] Gender Identity Disorder (GID): is the normal diagnosis used by psychologists to describe people who experience significant gender dysphoria (discontent with their biological sex and/or the gender they were assigned at birth). It describes the symptoms related to transsexualism.

Nevertheless, a further explanation is more interesting, and reflects that many left-handers and some right-handers, as well, are inconsistent handers, and carry out some activities with one hand and some with the other. I am aware of this myself when I was doing the Annett's Test, which tests your laterality. I always thought I deal cards with my left hand but when I tried it again I found out I was doing it with my right hand! And I feel unnatural to do it with my left hand. The many right- and left-handed who scored between one and nine exhibit a similar inconsistency.

In spite of talking about handedness some people prefer to talk of "sidedness", because many aspects of behaviour seem to occur in one side of the body involving not only hands but also arms, legs, eyes, ears and even feet.

Footedness is related to handedness, right-handers mostly being right-footed and left-handers being left-footed. Testing footedness is straightforward: ask someone to kick a ball at a goal or for football players ask them to count how often they touch the ball with each foot during a football match. The results are 85% of the time, people use their preferred foot and almost none use both feet the same number of times. Besides, despite of 10% of left-handed, 20% of the population is left-footed.

Ear dominance is another laterality seen when people hold a telephone. This one has been rarely studied since few people got telephones. However, studies reveal about 60% prefer listening with the right ear and the other 40% with the left ear. What is more, right-handers tend to the first and left-hander the latter.

Eye dominance, however, has been much more studied. To find out your dominant eye you have to stretch out your arm pointing some small object in the distance. Now close one eye, if the finger is still pointing the object then the open eye is the dominant one. And if you now look with the other eye – the non-dominant eye – then the finger should not be pointing the object. That is called sighting dominance: an object is preferentially sighted with one eye rather than the other. Eyedness can also be tested by asking which eye is used for looking through a telescope or a microscope. The test shows that about 70% of the people prefer the right eye and 30% the left. Despite handedness, some people are cross-lateral - writing with one hand and sighting with the other – that fact explains why the percentages are so different such as in footedness.

People have lots of lateralities, some being silly and unimportant such as hand-clasping and arm-folding. To evaluate hand-clasping, clasp your hands together with the fingers and thumbs interlaced. Now try it on the other way and you will feel the fingers don't fit together properly. Your first clasp was easier and more natural.

In Britain about 60% of people clasp with the left thumb on top and the proportion is the same in left- and right-handers. Surprisingly, this proportion decreases gradually across Europe, Asia and Oceania until in New Guinea and Salomon Islands only 30% of the population clasp their hands with the left thumb on top.

Arm-folding can also be assed by yourself. You only have to fold your arms one over the other, which wrist in the top? Now try to do it the other way, it has been demonstrated that most people end up where they begun, with the same wrist on the top. In the UK about 60% of the people put the left wrist on the top, the proportion being the same in right- and left-handers.

Figure 4.2 This picture shows the wrist in the top surrounded.

The list of minor asymmetries could continue throughout pages and pages; for instance, more people chew on the right side than the left.

Many psychological processes are lateralised as well. For example smell and flavours are rated more highly when inhaled into the right nostril and processed by the right hemisphere rather than the left. However, the left hemisphere is more accurate at identifying and naming smells.

4.1 LATERALITY IN HUMANS

Handedness, though, has been the laterality which scientists have more looked into because it is the most extreme laterality and it is very easy to measure, either through questionnaires or by observing them. Even today, scientists are arguing whether handedness is inherited or not. Although it is not disputed, handedness runs in families somehow. A while ago, 70,000 children whose parents were both right-handed, both left-handed or one of them left- and the other right-handed were studied. The results indicated that where both parents are right-handed there is 9.5% of the chance of having a left-handed child; where one is right- and the other is left-handed there is 19.5% of the chance and where both are left-handed the chance rises to 26,1%. Even so, there is not any pattern how handedness runs in families.

Does it mean it has to be genetic? Not necessary. In fact, one of the oldest ideas in psychology is that handedness is acquired culturally, through the social pressure of teachers or through imitation of parents and nursemaids; this idea was developed in the 4th century BC by the philosopher Plato.

After all, we learn so many things by imitating our parents that it would seem hardly surprising if children with left-handed parent copied that parent and used their left hand; and if both parents were left-handed this would be more likely. The fact that most children with two left-handed parents is right-handed might reflect the strength of the right-handed world.

The difficulty in terms of data comes from families in which both parents are right-handed but one grandparent is left-handed. The children in that family are more likely to be left-handed. The left-handedness of the children cannot be due to imitating the parents since both are right-handed, and it's doubtful grandparents have such influence over their grandchildren. It is more likely that the left-handed grandparent carries a gene for left-handedness that has lain dormant in the parent but then manifested in the grandchild.

Although the environment can act in a rich variety of ways, there may be other factors increasing the likelihood of left-handers having left-handed offspring without genes being involved. A theory in vogue a while ago was that left-handedness results from brain damage due to physical traumas associated with birth. The human head has been subject to two evolutionary pressures; on the one hand, to be as large as possible in order to contain the much-expanded brain, and, on the other, to be small enough to fit through the female pelvis. As a result, the soft and vulnerable brain can be sometimes damaged.

Imagine everyone is meant to be right-handed, with the left-side of the brain leading hand movements in the right hand. What happens if the brain is damaged as it is squeezed through the pelvis? If the right side is damaged, then there is no effect on handedness since the left-side of the brain is still controlling the right hand. But if the left side is damaged, then the right-hand doesn't work properly anymore and the right side of the brain assumes complex movements being conducted by the left hand. Therefore, that person will become left-handed.

Brain damage in birth can explain left-handedness, but how does it run in families? The answer is if a woman is left-handed because her mother's small pelvis has damaged her left-side of the brain, then she could have inherited the gene to produce a small pelvis, and her children will also have the risk of damage in the left-side of the brain at birth, therefore, being left-handed. Many years later, it was shown that left handedness is not due to birth complications.

Anyway, any acceptable model of the inheritance must explain why two right-handed parents can have left-handed children, or why most of the children of two left-handed parents are right-handed. Therefore, I've played with a gene[4] (technically an allele[5]) called *C* for chance, which gives 50% of being right-handed or left-handed. As well as the *C* genes, the model included a second gene called *D* which always results in a person being right-handed.

That still left the question of what happened in individuals who had one *D* and one *C*. Some mathematical modelling soon showed that if the *C* gene was recessive, then the model did not fit, and it was no better if the model was dominant. The model, however, did fit if the two genes, *D* and *C*, were additive or co-dominant, meaning that individuals with one of each gene were midway between those with two *D* genes or two *C* genes. In this model people with the *DD* pattern had always been right-handed; those

[4] This model has been done by Chris McManus and it isn't scientifically demonstrated.

[5] An allele is one of two or more forms of genes (generally a group of genes). Sometimes, different alleles can result in different traits, such as colour. At other times, different alleles give rise to the same trait, since some variations at the genetic level result in little or no variation of a trait.

with the *CC* genotype had a 50% chance, and those being *DC* had a 25% chance of being left-handed and 75% of being right-handed.

The next thing is to see how the model explains the pattern of handedness in families. As far as two right-handed parents, if both have a *DD* genotype their children can only have *D* genes, and so must be *DD* being right-handed. But those both right-handed parents being *DC* or *CC* – which must be a minority - their children can be *DC* or even *CC*; so they can be left-handed.

The only certain fact in left-handers is they are not *DD*; they can thought be *DC* or *CC*. It's easier thinking if both are *CC*, each parent carries only *C* genes so the children must be *CC* as well, giving them a 50% of chance of being left-handed. However, *CC* is less common than *DC*. Most left-handed parents should be *DC*, so their children will have a *D* gene giving them a higher chance of being right-handed rather than left-handed.

DD → 100% chance of being right-handed.
DC → 75% chance of being right-handed and 25% chance of being left-handed.
CC → 50% chance of being left- or right-handed.

- If both parents were *DD*, their children would be all right-handed.

P: DD x DD
↓
C: DD

- If both parents were *DC*, their children would have more chance of being left-handed (25%)

P: DC x DC

C: DD DC DC CC

- If both parents were *CC*, they children would have 50% chance of being left-handed.

P: CC x CC
↓
C: CC

- If one parent is *DD* and the other is *DC*, they children would have 87,5% chance of being right-handed and 12,5% chance of being left-handed.

P: DD x DC

C: DC DC DD DD

- If one parent is *DD* and the other is *CC*, they children would have 75% chance of being right-handed and 25% chance of being left-handed.

P: DD x CC
↓
C: DC

- If one parent is *DC* and the other is *CC*, they children would have 62,5% chance of being right-handed and 37,5% chance being left-handed.

P: DC x CC

C: DC DC CC CC

By now it should be clear that this model fits perfectly, but it does not mean it is necessary correct. In the modern world, the real proof that handedness is due to a gene has not been proved since only a few people seem to be serious about carrying out such a search.

However, we might ask what happened two or three million years ago that made the right and the left hemispheres different. Which gene could be involved in this? Genes don't come from nowhere. New genes are sequences of DNA, copies of chromosomes are made being identical. Sometimes these copies aren't equal, one sequence becoming slightly different because of mutation. Sometimes mutation produces a slight change in the way that the chromosome works. There is no evidence at the moment as to where this might have been, but the most likely explanation is that sometime in the past two million years the *C* gene mutated from the *D* gene. From then until now the *D* and *C* genes are both present in the population.

5. THE ASYMMETRY OF THE BRAIN

5.1 LEFT HEMISPHERE

The first ability which was involved in studies was the speech. Some people who had had brain damage were analysed and it was known by intuition that language was associated with only one half of the brain.

Results were not as useful as they had expected. Altogether, forty-six patients were studied who had damage to only one half of the brain, but only some showed “speechlessness”. The table below shows the results:

	SPEECH LOSS	NO SPEECH LOSS	% WITH SPEECH LOSS
Left-sided brain damage	15	6	71% (15/21)
Right- sided brain damage	5	20	20% (5/25)

Table 5.1.1 Experiment carried oit by Morgani, Bouillaud and Andral published in 1761.

The pattern appears to be clear enough. Most patients with left-sided brain damage had speech loss – 71% - only few patients with right-sided damage had speech loss – 20%. Unfortunately, it was not so obvious to the scientists.

Part of the problem, even today, is that speech loss somehow is related with some conditions many of which are unrelated to the fact that language is originated in the left hemisphere of the brain. But there are some diseases that are related with this part of the brain.

For example there is the Broca’s aphasia[6] which shows a tiny area of damage, restricted to the frontal lobe of the left hemisphere. The patient is incapable of speaking; he can only pronounce isolated syllables without meaning. It was soon recognised that not all aphasia is Broca’s aphasia, other symptoms also occurring after left hemisphere damage. There is also the Wernicke’s aphasia or “jargon” aphasia. It consists of being able to speak but only syllables being quite intelligible.

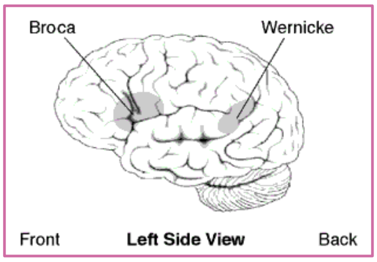

Figure 5.1.1. It is shown both areas of damage in Broca’s aphasia and Wernicke’s aphasia.

Although there are various types of language problems and aphasias, most of them are due to left-hemisphere damage. A key problem has been to define what the left hemisphere does and what the left hemisphere does not.

[6] Aphasia: loss of language ability.

Researchers have used brain scanners to find out tasks that are only carried out in the left hemisphere. A part of language depends only on the left-hemisphere but is syntax or grammar? Look at the following sentences:

The boy is watching TV
The boy are watching TV

It is obvious that the second is grammatically wrong, the plural "are" not agreeing with the singular "boy". People who took the test were lying in a brain scanner. Activity occurred only in the left-side of the brain, so we can say grammar depends on the left-side hemisphere.

The left hemisphere also involves other activities unrelated to language. In the condition called apraxia patients have difficulty producing skilled and complicated movements. This fact is due to an impaired control of some parts of the body. Consider an everyday action such as striking a match. The box is held in one hand and the match in the other. The match must be pushed against the box at a certain pressure: not too hard or the match will break and not too gently or the match will not strike. Patients with apraxia have trouble with such tasks, either because they can't conceptualise the idea of movement or because they cannot put the idea into practise. Although apraxia is due to damage to the left half of the brain problems usually occur with both hands.

Since speech and writing also involve fast, intricate, carefully co-ordinated movements, this may indicate a link between movement and language both being originated in the left hemisphere because both have grammatical rules: independent movements in motor actions only make sense in the correct order like words in sentences; if you put them in the wrong order the result is meaningless.

5.2 RIGHT HEMISPHERE

Hughlings Tackson, one of the greatest English neurologists, suggested that "the right side is the chief seat of the revival of images in the recognition of objects, places, persons..." What we would call "non-verbal" processing. People usually forget that thought doesn't always involve only language but also is concerned with processing pictures, images and three-dimensional space.

Think about a cube. How many sides has it got? How many corners? If one side is painted black and all the others white, how many white sides will the black side touch? Such problems are not solved with words although they are involved in asking the question and giving the answer. They are solved by generating in the mind a picture of a cube which is turned to "see" the answers. These kinds of tasks are carried out in the right hemisphere.

The right hemisphere is involved in the process called perception of the sensory world. It involves not only sight but also touch, sound and so on. Right hemisphere damage can cause visual agnosia[7] in which patients cannot understand what they are seeing. Their eyes work normally since they are aware of light and shade, lines and blobs but they are not able to combine these components into something coherent and meaningful. Figure 5.2.1 might give you an example how agnostics feel like.

Figure 5.2.1. A demonstration of what it feels like to be agnostic.

You should not have trouble seeing areas of black and white but can you see something else in this picture? What is on the picture? If you cannot see the face of the very famous person it is because it is printed upside down. Turn the page and try again. A few clues may help. The person is a man... with white hair... looking straight at the camera... a scientist... the most famous scientific of the twentieth century... the word relativity will probably give you the answer. At some point the meaningless blobs become organised, make sense as you see a picture of Albert Einstein. While you were not able to recognise this picture you understood the experience and the frustration of patients with agnosia.

Agnosic patients sometimes recognise objects by tracing the outline of the shape but when images are overlain one another they confuse the outline as for instance in the Figure 5.2.2. It is almost impossible for agnostic to recognise them. Agnosic patients also have problems if objects are shown in a different point of view such as in Figure 5.2.3. The first picture is easy to recognise even for patients with right-hemisphere damage but the other one is far more difficult.

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[7] Agnosia: is a loss of ability to recognize objects, persons, sounds, shapes, or smells while the specific sense is not defective nor is there any significant memory loss.

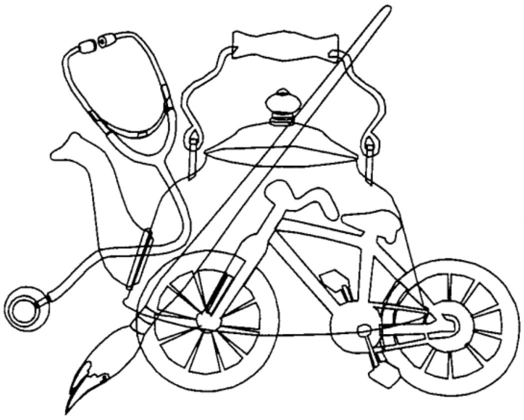

Figure 5.2.2 Patients with agnosia have great difficulty in identifying objects which the outlines have been confused because they are overlap.

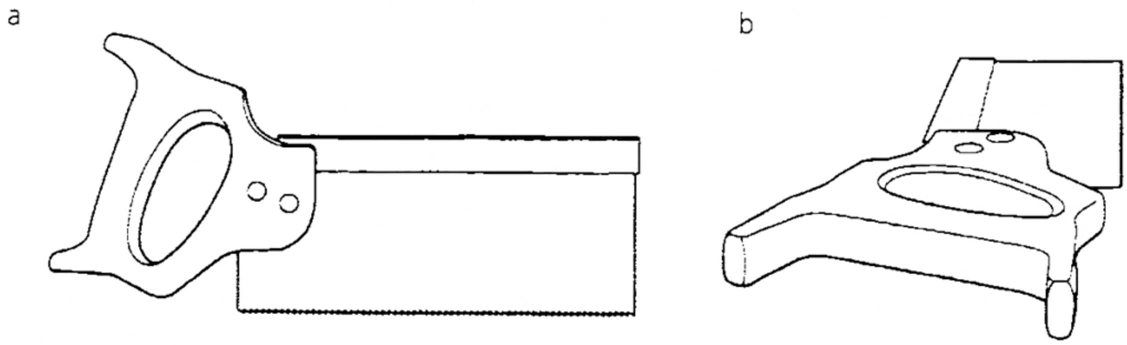

Figure 5.2.3 Two views of a saw: a, in a canonical view and b in a non-canonical view.

Language concerns not only the left hemisphere. Patients with right hemisphere damage should have unimpaired language skills. Certainly they can talk normally with a wide vocabulary and good grammar. However, there is a lack of musical quality of speech prosody[8], whereby the tone goes up and down and the words accelerate and decelerate or get louder and softer providing emotion and emphasis. Speech without prosody is like those computer-synthesized voices. Besides, prosody is not the only part of language dependent on the right hemisphere but also metaphor, sarcasm and humour.

Furthermore, the right hemisphere has other functions. It is also involved in attention, the ability to focus in something important and interesting.

It has been demonstrated that patients after right-hemisphere strokes have *neglect dyslexia* which is associated with the parietal lobe of the right hemisphere. It is about ignoring half of the world, typically the left half. Although neglect might only reflect that the right hemisphere is responsible for the left-hand side of the body, this also indicates that right-hemisphere is responsible for attention. But right-sided neglect after a left-hemisphere stroke is much rarer. Neglect is easily tested by giving the patient a line like this and asking them to mark the middle of it.

[8] Prosody: the study of rhythm, intonation, stress, and related attributes in speech

Patients with neglect may put the mark on the right-hand side, apparently ignoring the left side of the line.

Patients may also neglect other aspects of the left half of space such as eating only the food on the right half of a plate, reading only the right half part of a page, remembering only the buildings on the right side of the street, washing only the right half of the face or drawing only the right half of objects. For example in Figure 5.2.4 only the right half of the clock have been drawn or in Figure 5.2.5

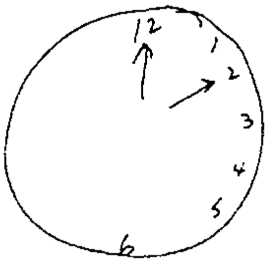

Figure 5.2.4 A clock which has been drawn by a patient with neglect dyslexia.

Figure 5.2.5 A patient with neglect has been asked to copy the drawing of flowers on the left. Their copy is on the right.

5.3 SEPARATING HEMISPHERES

It is easy to talk as if both hemispheres work as separate organs but of course they are not, both work together to create a single individual. The two hemispheres are connected by what is known as the corpus callosum by which both hemispheres communicate and cooperate.

Normal skills concern both hemispheres so what happen if the hemispheres are disconnected from each other? It is sometimes done to treat severe epilepsy. A fifteen-years-old-boy was taken as a part of the study. He was asked to draw two cubes, before and after the surgery, one with the right hand and the other with the left.

Figure 5.3.1 Drawings done before the operation.

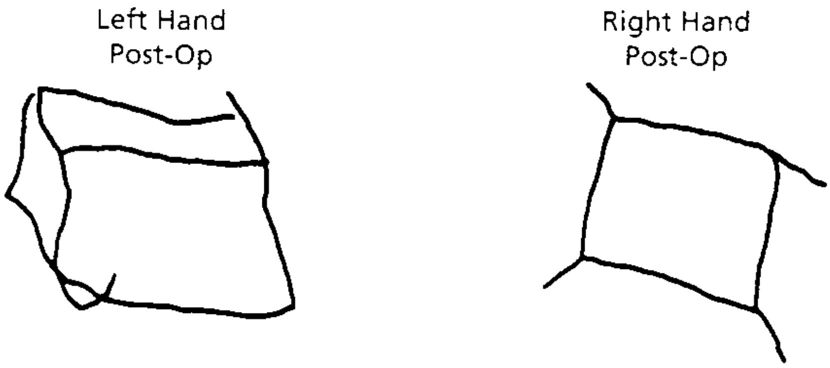

Figure 5.3.2 Drawings done after operation.

The cubes in the top were drawn before the surgery and both are quite well drawn although that done with his left hand being worse because he was right hander. However, the drawings in the bottom are not as good as the others but also are very different between each other. That done with the left hand – right hemisphere – doesn't have straight lines and they do not meet properly in the corner in spite being clearly a cube. Otherwise the cube made with the right hand – left hemisphere – doesn't really seem a cube at all. The lines are straighter and meet properly but there is not a sense of three dimensions. Neither the right nor the left hemisphere can draw a properly cube on its own.

When the corpus collasum is cut each hemisphere does what it can. The right hemisphere, driving left hand, understands three dimensional spaces and can represent three dimensional objects. It cannot draw very well, because the instructions of movement come from the left hemisphere. And the opposite applies to the left hemisphere, driving the right hand, which can produce straight lines that meet perfectly in the corner but it isn't able to understand three dimensional perspectives so the cube is unrecognisable.

The same can be seen when solving a simple problem. For example answer the following: *"Every state has a flag. Zambia is a state. Does Zambia have a flag?"* It is very obvious, the answer is yes. What is not so obvious is that questions like this have two different components each testing a different half of the brain. In this sort of experiments one part of the brain is temporally stopped by electroconvulsive shocks.

Before the shock, none have any problems answering the question, but afterwards the answer depended on which half of the brain was shocked. After a right-sided shock, leaving the left hemisphere working, the patients were almost giving logical answers: *"It is written here that each state has a flag, and Zambia is a state. Therefore Zambia has a flag"* Otherwise, when the shock was left-sided, leaving the right side working, there were given a completely different sort of answer: *"I've never been to Zambia and know nothing about its flag"* Although it's true, it doesn't solve this logical problem. The right hemisphere appears to be lack of logic so tries to solve the problem with everyday knowledge.

But when this question is asked: *"All monkeys climb trees. The porcupine is a monkey. Does the porcupine climb?"* Here one of the premises is false, since porcupines are not monkeys. That does not affect the logical structure, though: if the porcupine is a monkey and all monkeys climb trees it will be true that porcupines climb trees. After a left-sided shock, with only the right-side working, it was commented: *"Porcupine? How can it climb trees? It isn't a monkey! It is prickly like a hedgehog. It's wrong here"* The right hemisphere has knowledge of porcupines and knows what they can and can't do. With a right-sided shock, with only the left hemisphere working, the patient replied completely differently: *"Since the porcupine is a monkey, then it climbs trees"* When he was asked: *"You know that a porcupine is not a monkey, don't you?"* he replied *"it's written in the card"* The left hemisphere knows how to handle logic and the right hemisphere knows about the world.

Humour often is used to recognise two different perspectives. The "sense of humour" of the two hemispheres seems to be different. Consider the next test, the patients were given this lines and then asked to choose an ending from a list.

A new housekeeper was accused of helping herself to her master's liquor. She told him: "I'll have you know, sir, I come from honest English parents"

Patients with right hemisphere damage and a functioning left hemisphere preferred this one:

He said: "All the same, the next time the liquor disappears you're fired"

The ending is logical but unfunny. Patients with left-hemisphere damage and the right-hemisphere still working chose a totally different ending:

Then the housekeeper saw a mouse and jumped into her master's lap.

Although it's believed that left-handed are the mirror image of right-handed it is not true. Besides usually the two hemispheres coordinate the same processes, though, left-handed people have more developed the right hemisphere rather than the left and vice versa.

6. HANDEDNESS AND SKILLS

As we have seen there are two genes involved in handedness *D* and *C*. Genes continually compete with one another. Theory shows that if one of the gens has a tiny advantage over the other, the fitter gene eliminates the less fit gene over hundred or even thousands of generations.

However, handedness is a polymorphism which has two different forms caused by two different genes. Usually polymorphisms are inherently unstable. To explain why handedness is balanced we can use the heterozygote advantage. Individuals with one copy of each gene heterozygotes (*DC* individuals), are fitter than homozygotes, individuals with either two *D* or two *C* genes. The challenge is to understand what balances *D* and *C* genes. If heterozygote advantage is the casual mechanism, that means *DC* individuals will have an advantage over *DD* or *CC* individuals.

In looking for an advantage for the *DC* genotype, a good staring place is the *C* gene: its ability to confer randomness on the organization of the brain, allows cerebral asymmetries such as those for reading, writing, visuo-spatial processing and emotion. Random in small amounts can benefit complex systems. The idea will be presented by the theory of random cerebral variation, which suggests that human brains are not all alike, some having different organisations. It is an unusual theory since it is usually said that all brains are essentially similar.

Taking in account that randomness is beneficial, there mustn't be much randomness, otherwise it will destroy the whole thing. If *DC* and *CC* individuals have randomness built into their brains, all *DD* individuals have their brain organised in the same way. If *DD* individuals are squared, *CC* individuals might be the opposite, having their brain functions in any of the both hemispheres. That sort of "organisation" might not be beneficial, and perhaps explains why anomalies of handedness are found in a wide range of conditions, including dyslexia, stuttering and autism. The few per cent of people who are *CC* are disadvantaged by their chaotic lack of cerebral organization.

How might *DC* individuals be advantaged over both *DD* and *CC* individuals? The key is that in the *DC* individuals there is only a one in four chance of any modular function being changed; that is only a 25% chance. However, in *DD* individuals all the modular functions will be properly located while in *CC* individuals there is 50% chance of any modular function being in a different place. For *DC* individuals which might have one or two modules in a different place from usual. For more modules it will be as usual work, but maybe an occasional atypical module can benefit.

A recurrent theme is the claim that talented individuals in such disciplines as music, mathematics or the visual arts are more likely to be left-handed. Many such claims are undoubtedly false, that though does not mean that the idea is entirely without foundation. The idea of having some more potential only can take place if the difference is too small to destroy all the brain functions. Take an example of someone with just one module in a different place than usual. This fact could only be beneficial depending on which module is randomly located and where.

Imagine that the module of understanding three-dimensional space is in the left hemisphere rather than the right. Now it is located alongside modules involved in fast, accurate, precise control of the hand; that might well benefit drawing or the visual arts. Otherwise, there might be some disadvantages, perhaps clumsiness in some activities, but as long as the advantages overweight the disadvantages, then a rearrangement of the brain may benefit that individual. Furthermore, a module specialized for understanding emotions is located in the left hemisphere rather than the right. Now it sits alongside modules involved in the production of spoken or written language, which might be beneficial for writing poetry or being an actor. To give another example, a left-hemisphere module involved in the symbolic processing of language, if located in the right hemisphere alongside modules involved in processing three-dimensional space, might perhaps be easier to carry out some forms of mathematics.

Although beneficial combinations of modules may occur more in left-handers and more precisely in *DC* individuals, there is no need to assume that left-handers in overall will be better at a particular skill than right-handers. The theory of random cerebral variation is a theory not about the mean activity of right- and left-handers, but an increased variability amongst left-handers. As we have shown cerebral variability is one of the few undoubted facts about left-handedness, especially in language.

7. ASYMMETRY AND SYMMETRY

7.1. ASYMMETRY IN BIOLOGY

A molecule is a group of atoms and they are organised in 3-d. But how are they organised? Amino acids, which like other molecules in the body, depend on the element of Carbon. Atoms differ in their valence – number of bonds they can form with other atoms – Carbon has a valence of four, Oxygen of two, Hydrogen of one and Nitrogen of three.

At the heart of an amino acid, there is a Carbon atom and it's attached to four different chemical groups, an amine group – NH_2 -, a carboxyl group – COOH -, a simple H and something usually called R. R is the group that makes each amino acid different, for example in Alanine is CH_3- otherwise in Methionine is CH_3-S-CH_2-CH_2-. However, the important fact is that if the four groups are attached to a Carbon atom there are two ways to arrange the molecule around it – we can see it in the figure below:

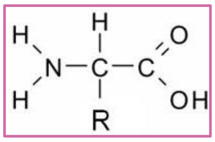

Figure 7.1 Basic structure of an amino acid.

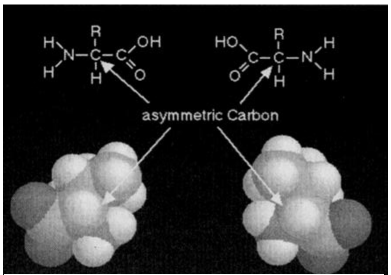

Figure 7.2 The 3-D arrangement of the atoms in the amino acids D-valine and L-valine

As we can see, one is the mirror image of the other. Amino acids come in two different forms called L- (*leavo* or left-handed) and D- (*dextro* or right-handed), and they are left- and right-handed because one rotates polarised light to the left and the other to the right. The two different types of amino acids are known as stereo-isomers or enantiomers, and are said to be chiral[9].

Many biological molecules are stereo-isomers, the L- and D- forms having very different properties. An example is the molecule Carvone, for which the L-stereo-isomer smells of caraway and the D-stereo-isomer smells of spearmint. The different smell is because of the three-dimensional shape of molecules.

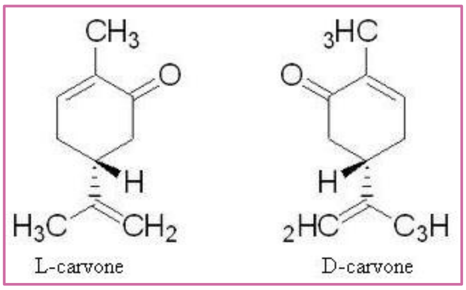

Figure7.3 Carvone's stereo-isomers.

Receptors work like smell as well. Some receptors in our body only recognise one chiral form so the other is inactive. Drug companies are keen to produce drugs that are pure stereo-isomers, whereas one can be therapeutic the other might causes unwanted side effects.

Going back to amino acids, now we consider how they are put together into proteins. The amino acids in a protein are coded in DNA by triplets of four bases – Cytosine, Adenine, Guanine and Thymine (C, A, G, T) – any of the four being at each of the three

[9] Chiral: describe objects that are mirror-images of each other.

positions to give a total of sixty-four different combinations and set together twenty amino acids.

The first step in protein synthesis is to make a RNA copy of the DNA sequence, also called duplication. After, in transcription, the immature RNA is turned into mature RNA being ready for translation. In translation, a ribosome runs along RNA, stopping at each triplet, afterwards a molecule of transfer-RNA brings the amino acid encoded and it's spliced on to the end of the growing chain of amino acid. Then the ribosome moves to the next triplet and so on until the protein has been built. Every amino acid that is added to the protein chain it is an L-amino acid like all the genetic code and the protein synthesis machine.

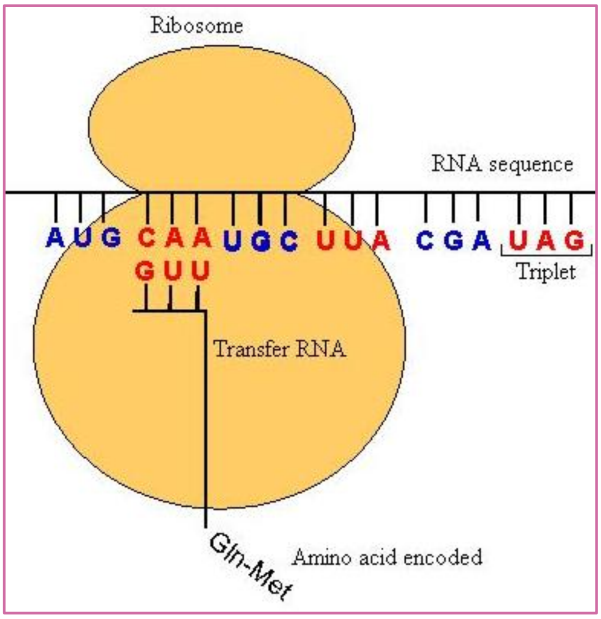

Figure 7.4 Protein synthesis, translation.

Although our bodies are built by L-amino acids, D-amino acids do occur in nature, usually in spontaneous racemisation[10] a process that happens easily in free amino acids and occurs to amino acid in proteins during cooking as well. Racemisation is disastrous for proteins because a D-amino acid has a different 3-D shape altering the overall shape of the protein and preventing it from binding properly to other proteins. Racemisation also tends to be used as a "molecular clock" for estimating the age of biological specimen. But what happen if we eat D-amino acids? Nothing, they aren't detected by the enzymes which only work for a specific 3-D structure. Although our body don't digest them in our stomach there are some specific bacteria which digest them.

Nevertheless, amphibian skin is the only place where D-amino acids have been found in vertebrates. Outside vertebrates, D-amino acids also have been found in the marine snails of *genus conus* which hunt fish by using their proboscis. Inside the proboscis, there's a disposable harpoon – like teeth – which injects toxins that cause immediate paralysis. Part of these toxins contains D-amino acid. Finally the spider *agelenopsis aperta* also paralyses its prey with venom which contain D-amino acids.

Figure 7.5 Marine snail of *genus conus*

[10] Racemisation: converting of an enantiomerically pure mixture (only one enantiomer present) into a mixture where more than one of the enantiomers are present. If the enantiomers are present in equal quantities the mixture is described as racemic.

8. LEFT-HANDERS THROUGHOUT HISTORY

As we have seen there is a noticeable minority who are left-handed and it also happened in the past. We need some idea of how many people have been left-handed in the past. One of the largest studies of handedness took place in 1986, and it has its origins in a study of how well people could smell. National Geographic published an article about smell and a short survey was included, which could be returned by post. Readers indicated many things about smells and also their age, sex and the hand used for writing. The cards were returned by over 1,100,000 Americans. Figure 7.1 shows the percentage of left-handed men and women in relation to the year of birth.

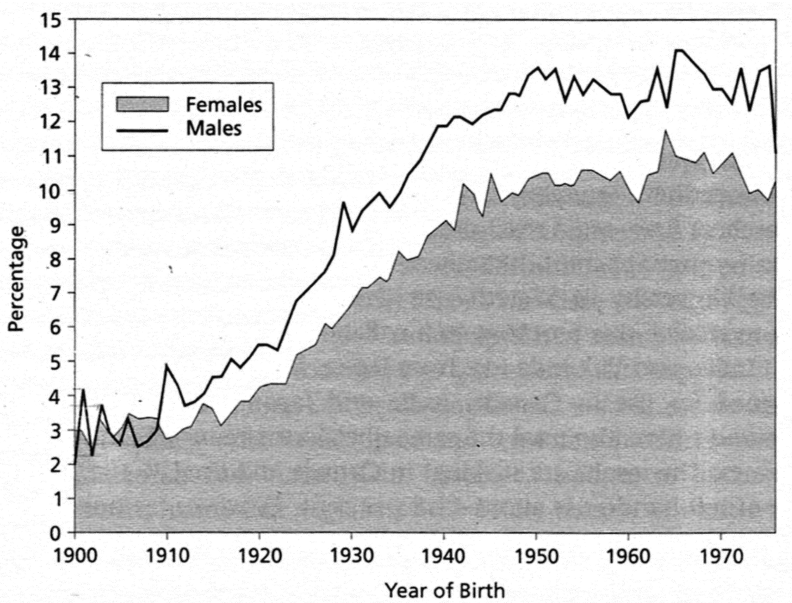

Figure 8.1 Left-handedness during the twentieth century. The percentage of men indicated by solid black line, and women by the grey shaded area.

As in most other large studies, there are somewhat more left-handed men than women. However, the most interesting is that the proportion of left-handers is seen to have increased during the twentieth century. For those born before 1910, about 3% are left-handed and by the end of the Second World War the proportion of left-handers seems to have reached between ten and eleven per cent of women and about thirteen per cent of men. Something must have caused this increase, but what?

Historical data shows that left-handedness is more common now than it was a hundred years ago. Different countries also show different rates. For example, in Canada and UK the proportion of left-handers is about 11.5%. However, as one moves across Asia this proportion falls until 7.5% in the Emirates, 5.8% in India and only 4% in Japan. Such differences also occur in Africa, 7.9% of people are left-handers in Ivory Coast and 5.1% in Sudan.

Biology differences between groups can be explained by differences in genes. Since handedness is under genetic control, it is possible that these differences are due to the genes associated with handedness: the more *C* genes there are, the more left-handers there will be. Population at the end of the 20th century seems to have more than twice as many *C* genes as they had in the beginning of the century. Genes increase in frequency if they are more successful and decrease if they are less successful. In evolution, success means to have more offspring. We need to know whether left- and right-handers have the same number of children. In the first half of the century, families were larger. Two right-handed parents averaged 3.1 children. However if one was left-handed there were 2.69 children, whereas both were left-handed there was an average of only 2.32 children. Families in 1955, two right-handed parents had an average of 2.49 children. If one was left-handed there were an average of 2.6 children and two left-handers averaged 2.6 children. This difference might have affected the proportion of genes in the population associated with left-handedness. Why did left-handers have had fewer children in the beginning of the century might be because of social pressure; a left-hander was forced to be right-handed by being abused at school, home or somewhere in society. Besides, it is obvious that by the end of the century, the incidence of left-handedness had stopped rising. This appears to be the natural rate of left-handedness in the population.

Handedness has also been studied through art from prehistory until now. In art some people have been portrayed carrying out a variety of actions. It was looked at over thousand pictures from different cultures, the earliest dating from before 3,000BC. Figure 7.2 show that the vast majority used their right hand. However, about 8% used their left-hand, a proportion similar to modern rates of left-handedness.

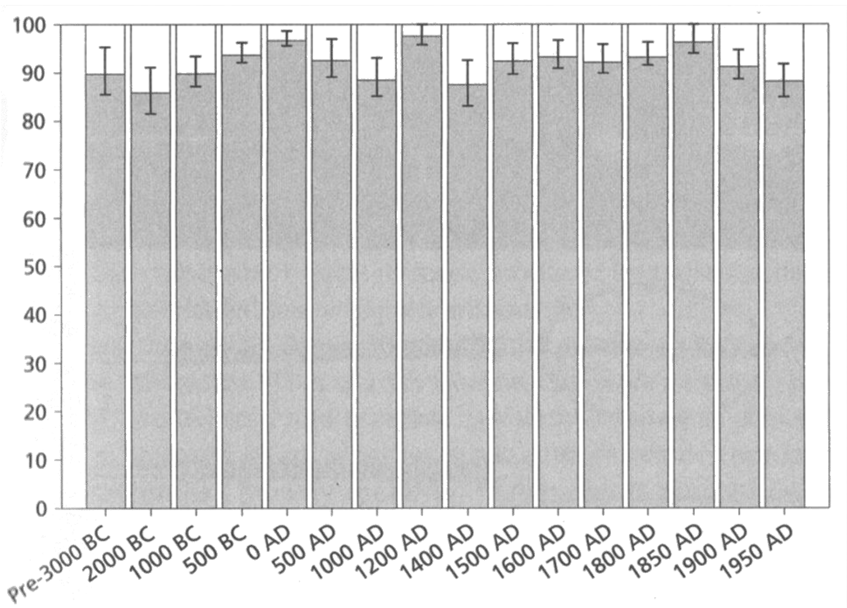

Figure 8.2 The proportion of Works of art over the past 5,000 years in which a person is using the right hand (grey bars) or the left hand (white bars) to carry out an action. The error bars indicate ninety-five per cent confidence intervals.

Our early ancestors like us were mostly right-handed. What about their ancestors? To answer it we need whether other animals exhibit handedness. The answer is yes, although only humans show right-handedness. For instance, most cats hook food using one paw rather than the other. Half cats prefer the right paw and half the left paw. Put it terms of genetic model, it is as if all animals have double *C* gene.

However, in the past twenty years researchers have found many asymmetries in the way animals use their right and left arms/legs/wings/paws or whatever. For example, the handedness of gorillas is well documented by observing their eating habits; they might take the leaves of a nettle with the left or the right. Chimpanzees, however, are different. Studies suggest that about half of chimpanzees prefer to use their right hand rather than the left, particularly in bimanual tasks. They might show right-handedness. The excess of right-handers is fairly small only about 60% being right-handed.

9. LEFT-HANDED TOOLS

Most of the tools in the world are right-handed and they are difficult to use for left-handers. According to this, many tools have been developed especially for left-handed people, such as pens, scissors, tin openers, measuring tapes, knives or even clocks.

One of the most famous left-handed tools is the pen. But how a pen can be different for left-handers? Writing with a fountain pen can be a problem, as the pen is being pushed across the page rather than pulling it, which leads problems with ink flow and the page might be drilled. The problem can be sorted out using a left-handed nib; it gives smooth ink flow from almost any angle. However, many left-handers have a wrong handwriting position which may not be the fault of the pen but poor posture or take the pen incorrectly[11].

Figure 9.1 Stabilo has developed these ergonomic pens to make left-handed writing easier.

Another tool are the scissors sometimes really uncomfortable for left-handers if these are not especially designed for them. The blades on left-handed scissors are set in a way that the left blade is always on top. This means that the cutting action is smoother and that a left-hander has a clear view of the cutting line as well. These might appear to be useless but when right-handed scissors are used, the thumb and the index finger have to be put in an unnatural way to make the scissors cut. This may cause marks on the hand and left-handers also have to look over the top blade because it obscures the cutting line. Nevertheless some companies claim to have ambidextrous scissors that suit left and right hand. This only refers to the handles, which are flexible, but their blades are still set right-handed.

Figure 9.2 On the one hand, the scissors on the left side are left-handed and have the left blade on the top. On the other side, the right hand scissors are right-hand and have the right blade on the top.

[11] There's further information about this point in section 10 Left-handed writing.

A peeler is another troublesome tool. Peelers are made somehow that you have to move it towards your body. This is not possible for a right-handed peeler held on the left hand because the cutting edge is facing the other way. Left-handed peelers have the blade cut –out reversed, so you can peel towards you.

Normal sharpeners are usually difficult to use for left-handers since you have to move your wrist on an unnatural way, clockwise and sometimes the shavings fall all over you. In left-hander sharpeners the pencil remains held in the left hand, is turned away from a natural way, anticlockwise and the shaving fall away from the body as well.

Knives have serrations on the left side giving a straight cut for right-handers, but left-handers using this sort of knives usually do curved cuts. It is because of that, that left-handed knives have the serrations on the right side of the blade avoiding this problem.

Other peculiars objects which can be different for both writers are rulers and measuring tests. Right-handed rulers have the numbers in an ascending order from left to right, but left-handed rulers have them in the opposite order, from right to left.

Figure 9.3 A left-handed ruler.

Left-handers usually hold the measure in their left hand and pull with the right, but the numbers are always upside down. When measuring with a retractable measure, most left-handers would like to measure from right to left. We lock the start of the tape over the right end of what we are measuring then hold the case with our left hand and pull to the left to expand the tape.

There are lots of more specific tools for left-handers such as clocks, which turn anticlockwise and the numbers are set in the opposite order; notebooks, where the spiral is located on the top or there are not spirals. Tin openers are also popular and there are even guitars which are made to be supported on the right leg and played with the left hand. Moreover cameras and video cameras are made for right-handers; cameras have the bottom on the right side and video cameras have the handle and the recorder bottom on the right side making it difficult for left-handers.

Figure 9.4 A left-handed clock

10. LEFT-HANDED WRITING

Writing can be very uncomfortable for left-handers and they often take the hook position while writing. This is because writing from left to right across the page is not a natural direction for left-handers, so they have to adopt an individual style. For left-handers, their hand is following the writing pushing the pen into the paper which creates too much pressure and covering the work often smudging the words they have just written.

One of the most common problems is the over-tight grip, this leads to write badly form letters, too much pressure on the tip and even an illegible style. It also makes the hand very tired. An over-tight grip can be caused by a number of related factors: the wrong pen, a slippery or shinny pen is hard to hold when you are pushing on it to write and the hand can slip down the pencil on to the nib despite being held very tightly. The wrong grip can also be another factor because left-handers are pushing the pen rather than putting it and they often us all their fingers. However, this gives far less control of the formation of the letters and the hard they try the tight the grip becomes.

Figure 10.1 A left-handed using all their fingers to hold the pen.

Another problem is smudged work; this is caused by the hand pushing the pen across the page. If the hand is following the writing line, it will automatically smudge the writing as it follows along. Cartridge pens are a particular problem for left-handers as the nib is designed to open with the rhythmic pressure of being pulled by the right hand so the ink flows evenly. In the left-hand, the nib pushes into the paper drilling it. The pressure of pushing the pen is uneven and hand following the writing is very likely to smudge the work before it dries.

The Hook handwriting position is very common among left-handers. This is when the hand is hooked around the top of the writing line in an attempt to prevent smudged work and make the pen work right. Unfortunately, the hook hand is a very slow and inefficient way of writing. It's very bad for posture and usually resulting aching hands and back ache. Eventually, there is the mirror writing which is very usual among left-handed children. When left-handers first start writing or drawing, the natural inclination is to start at the right of the paper and pull the pen to the left. They can produce perfectly turned script which can be read with a mirror. This is natural and children should not be chastised for it, just correct it and encourage to start of the left side of the page.

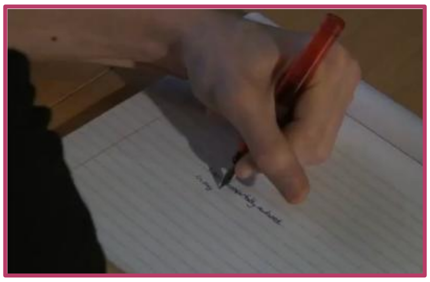

Figure 10.2 The Hook handwriting position.

Many of the problems which left-handers show while writing can be sorted out easily by following few simple guidelines. Holding the pencil properly is as simple as important. Hold the pencil lightly between the second finger and the thumb and have it resting on the middle finger. This gives better control of the pencil and allows the hand to relax. The second finger is the only one you need to move to form properly letters, the thumb just keep the pencil in place.

Figure 10.3 The ideal position for left-handers while writing.

A correct position of the body should avoid some problems. Having our feet resting on the floor, the back being straight and the shoulders relax is the ideal body position. Furthermore, the paper position is important. To improve it, imagine a line running down the middle of the body from nose to belly button. Always place the paper to the left of the body midline and turn the page clockwise by about thirty degrees. This is the ideal hand position as it brings the hand down away from the writing giving a clear view of the writing line. The pen is being pulled towards the body with the shoulders relax and the back straight. Finally, the right hand should be keeping the paper in place by taking it slightly on the bottom right side of the page away from the writing line.

11. LEFT-HANDED MYTHS AND PROVERBS

As we have seen left has been linked to bad throughout history. This fact has developed derogatory terms, expressing disapproval in seemingly unrelated contexts. In the English language there are many proverbs which describe this fact, such as “a left-handed wife” to mean a mistress, “a left-hander or left-footer” to mean a Catholic or the minimalist “left-handed” to mean a homosexual. A “left-handed dream” is a bad dream, a “left-handed opinion” is a weak one, “to hear something over the left shoulder” is to misunderstand, “to gain something over the left shoulder” is to gain it unfairly, “to be born on the left side of the bed” is to be illegitimate and left handed achievements are those which are not the real business of a person’s life. Besides, science slips easily into such metaphors, so that substances with a negative refractive index which bend light in the opposite side as usual are described as “left-handed” materials.

There are also many myths which most of them are false and they have not a truly foundation. The most interesting myths are these below:

That left-handers die younger

Moreover, several myths have been associated with handedness, in its various forms. For example, it has been said that left-handers die younger. It is a popular myth, and is almost certainly wrong, but is still current. It began in 1988, when a brief paper suggesting that left-handers died earlier than right-handers was published. They had looked up in an encyclopaedia of baseball players, which recorded the handedness and the age at death of each player; and found that the left-handers players died at a younger age than right-handed players. In fact, there was a large difference between the lifespan of right- and left-handers; it was more than seven years. It would be equivalent to smoking 120 a day and rejecting everything in preventive medicine.

Somewhere there have to be an error. However, there is nothing wrong with the data; indeed left-handers are younger than right-handers when they die. The problem is in epidemiology[12] and its peculiar studies known as “death cohorts”, which take a group of people who have died at the same time and look backwards at their lives. The problem is that they are different age so when a twenty-five-year-old would have had their twentieth birthday five years ago, the twentieth birthday of a ninety-year-old would have been seventy years ago. Many things have changed in seventy years, including society. As we have seen (Figure 8.1) the number of left-handers has increased significantly in the twentieth century so on overage left-handers have born later in the century than right-handers. Indeed it’s logical that left-handers died younger than right-handers because they were born later not because of a shorter lifespan.

[12] Epidemiology: is the study of health-events, health-characteristics or health-determinant patterns in a population

That left-handers suffer more from immune disorders

The idea that left-handers tend to be more vulnerable to allergies and immune disorders goes back to a study published in 1982. It was said that there were a higher rate of left-handedness in patients with immune disorders. The idea was tested by distributing questionnaires to left-handers attending a London shop specialized in items for left-handers. The results where compared with a group of right-handers and another myth was born.

Then a theory was published. The central idea was that people showed different levels of testosterone during fetal development, and that testosterone can affect both brain development and the development of the immune system. Generally the theory was so complicated because it involves a hormone which is almost impossible to measure during early pregnancy. Moreover, it was also said that left-handedness and immune disorders were related. Many studies were after carried out searching for the link. The results showed that left-handers had no systematic tendency to suffer from disorders of the immune system. Probably, the first research was wrong because the questionnaires were self-reported by left-handers themselves.

That hooked writing indicates which side of the brain has language

Because thirty per cent of left-handers are hooked writers[13] and thirty per cent of left-handers have language in the right hemisphere, a theory from the 1970s was that hooked position was a marker of language in the right hemisphere. Since there weren't brain scanning to corroborate the idea, it rapidly gained currency. More systematic studies, however, have not been able to find any evidence that hooked left-handed writers tend to have language in the right hemisphere rather than the left.

That left-handers are more intelligent on average

A typical myth is that "left-handers are twice as likely to qualify for membership in Mensa, the high-IQ society". Although one study found a higher rate of left-handedness in members of Mensa, the result was unreliable, not being found in any other studies. That fact is better studied in researches that involve large part of the population. The UK National Child Development Study, which had looked over 11,000 children, showed a slightly difference in intelligence. In general, left-handers where about 0,5 points under right-handers.

That left-handers are more creative on average

The myth has been resurfaced recently in a study of company directors of traditional and dot.com companies, with the entrepreneurs being "twice as likely to be left-handed". Although there is another study which finds an excess of left-handers among architects, there is very little support in science. It is possible that left-handers can be more creative due to a more variable in their cerebral organization[14].

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13 There is further information about this point in section 10 Left-handed writing.

14 There is further information about this point in section 6 Handedness and skills.

That Picasso and Albert Einstein were left-handed

Picasso was the most famous, prolific and creative of all modern painters. Left-handers proudly proclaim him as a left-hander as we can see in many websites written for left-handers; and there are websites and books written by academic researchers that say the same thing. There is only one problem, in fact, Picasso wasn't left-handed. He was right-handed, as we can see in many photographs of him: singing his name, drawing, cutting and of course painting on many materials.

Just as Picasso, Einstein might be the most photographed scientist. There are many pictures of him writing with his right hand. No documentary evidence suggests Einstein was either a natural left-hander or a switched left-hander.

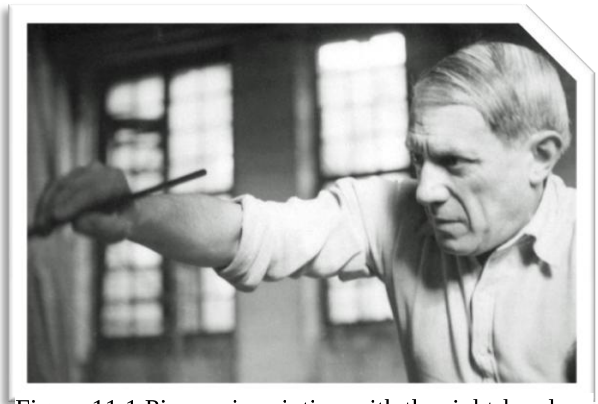


Figure 11.1 Picasso is painting with the right-hand.

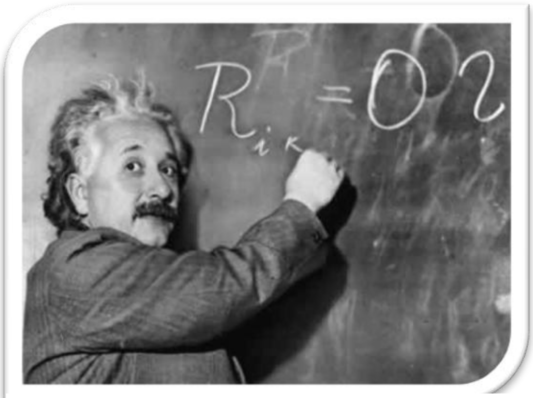


Figure 11.2 Albert Einstein is writing with his right-hand.

12. LEFT-HANDED IN HISTORY AND IN THE PRESENT

Left-handers have also been important people for the history in spite of being the vast minority. In this section we are going to see some of the most important left-handers in some areas such as politicians, actors and actresses, painters or sportsmen athletes. However, the most important left-hander has been Leonardo da Vinci who used to write in the mirror direction. He was a versatile man: painter, sculptor, architect, musician, engineer, inventor, anatomist, writer… His most famous works are the *Vitruvian Man* and *La Gioconda* also called *Mona Lisa*.

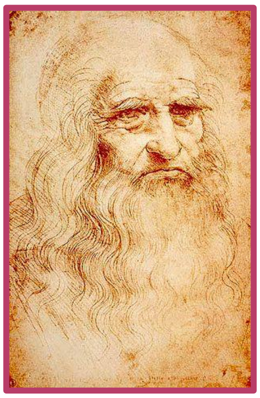


Figure 12.1 Self-portrait of Leonardo

The most famous left-handed politician might be the current president of the US Barack Obama (1961) and other presidents such as Gerald Ford (1913), Ronald Reagan (1911), George H. W. Bush (1924) or Bill Clinton (1946). There are many other politicians Benjamin Franklin, Anthony Kennedy or John McCain.


Figure 12.2. Charles Chaplin acting as Adolf Hitler in "The Great Dictator".

There are many left-handed actors and actresses, as well. For example Charlie Chaplin, Tom Cruise, Robert De Niro, Angelina Jolie, Nicole Kidman, Steve McQueen, Marilyn Monroe, Sarah Jessica Parker, Robert Redford, Julia Roberts, Bruce Willis and Oprah Winfrey.

Many athletes have been left-handed. In soccer there are Johan Cruyff, Diego Armando Maradona an Pelé (Edson Arantes do Nascimento). Many tennis players are left-handers such as Jimmy Connors, John McEnroe, Martina Navratilova, Manuel Orantes, Monica Seles and Guillermo Vilas. Finally, other athletes for instance: the swimmer Mark Spitz, the Formula 1 drive Ayrton Senna, Valentino Rossi motorcycle racer and Larry Bird and Toni Kukoc who were basketball players.

There were other important miscellaneous left-handers such as Alexander the Great, Charlemagne who was a Holy Roman emperor, King Louis XVI of France, Julius Caesar a Roman general, Queen Victoria of England, Prince Charles and William of England, Fidel Castro a Cuban leader, John F. Kennedy Jr. and Caroline Kennedy both lawyers and Matt Groening cartoonist.


Figure 12.3 Prince William and his father Prince Charles, both are left-handers.

14. ANNETT'S TEST

Please indicate which hand you usually use for each of the following skills. If you aren't sure make the act.

1. Always right
2. Usually right
3. Both
4. Usually left
5. Always left

Which hand do you use to…	R				L
1. …Write?	1	2	3	4	5
2. … Throw a ball?	1	2	3	4	5
3. … Take a racket?	1	2	3	4	5
4. … Take a lighter or a match?	1	2	3	4	5
5. … Cut with scissors?	1	2	3	4	5
6. … Spin a needle?	1	2	3	4	5
7. … At the top to hold a broom?	1	2	3	4	5
8. … At the top to hold a shovel?	1	2	3	4	5
9. … Deal cards?	1	2	3	4	5
10. … Hammer a nail?	1	2	3	4	5
11. … To hold the teeth brush?	1	2	3	4	5
12. … To unscrew the lid of a jar?	1	2	3	4	5
13. … Which eye do you look by a telescope?	1	2	3	4	5
14. … Which feet do you kick a ball with?	1	2	3	4	5

15. If you use your right/left hand for all these actions, do you use the other hand for other actions?

………………………………………………………………………………

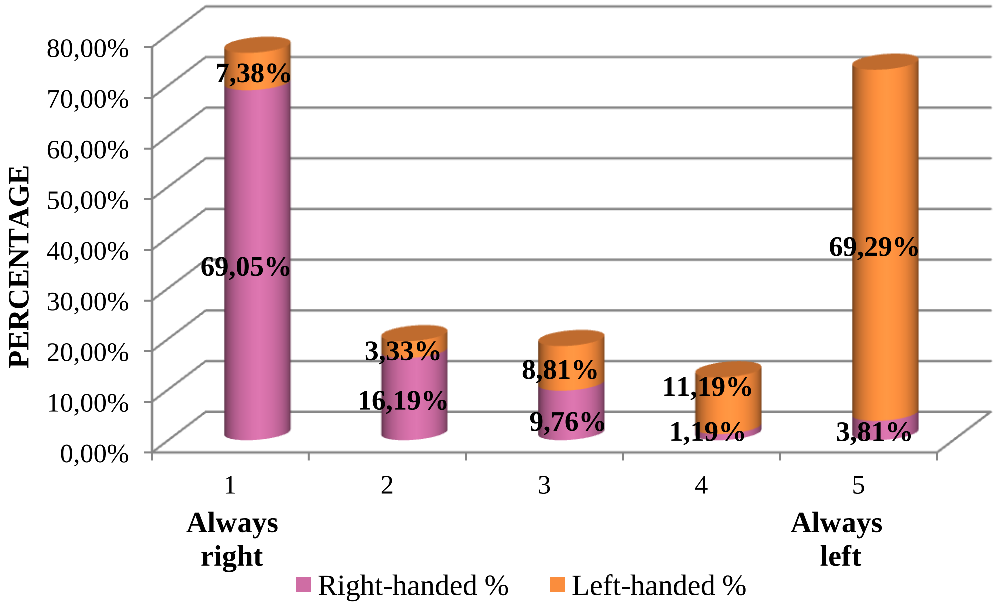
………………………………………………………………………………

16. Which hand do your relatives write with?

Mother
Father
Brother 1
Brother 2
Brother 3
Brother 4
Brother 5

⇨ Order your brothers from the oldest to the youngest.

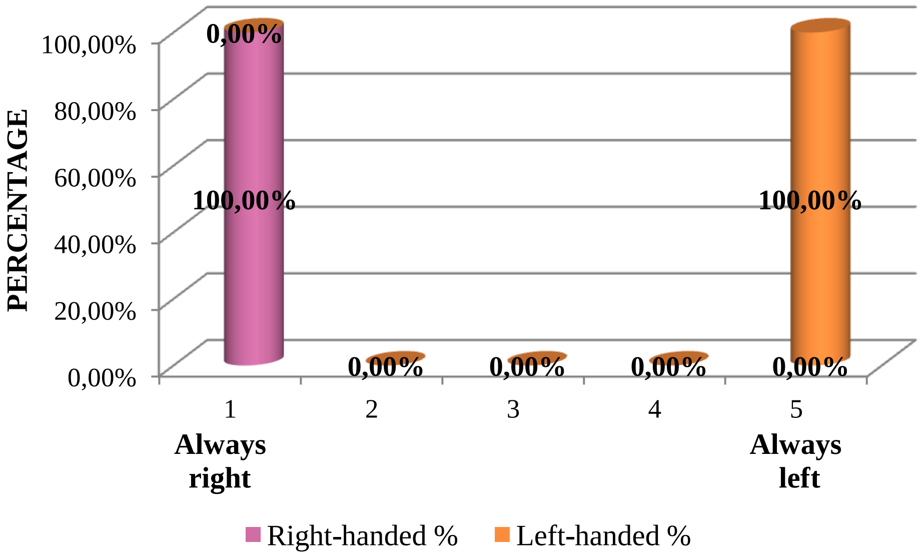
This was the test that thirty right-handers and thirty left-handers have taken throughout this year. It's called Annett's test and it gives you an idea about the laterality of people. There are many bar charts below. The first one gives a general idea and the other are for each question. All the graphs has been set equally, the horizontal axis which goes from one – always right - to five –always left - shows the possible answers and on the vertical axis it is shown the percentage. The bars are painted in to colors, the pink one show right-handers answers and the orange shows left-handers answers.



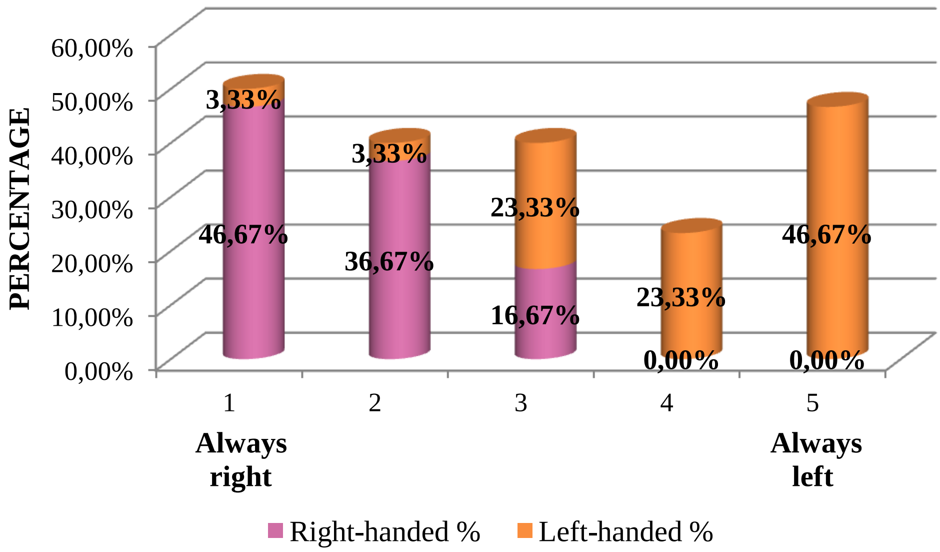
This first graph shows the overall percentage. First, we are going to analyze both bars separately to give a more detailed idea. If you focus on the pink bars – right-handers – several things are apparent. The results show a curve, high at the left side descending until almost zero at the right side. As we can see more than two thirds carries out all the tasks with their right hand, which mean they are strong right-handers. A tiny minority carries out some task with the left-hand although the data is higher than usually left. Those who have mark from two to five are weak right-handers.

However, if we focus on the orange bars – left-handers – we can also see that over two thirds carries out all the skill with their left-hand. But we might see a slight difference; the percentage descending to the left-side is not as extreme as in the pink bars. For example, 7.38% of left-handers carry out some task with the right hand, nevertheless, only the 3.81% of right-handers carries out some task with the left-hand.

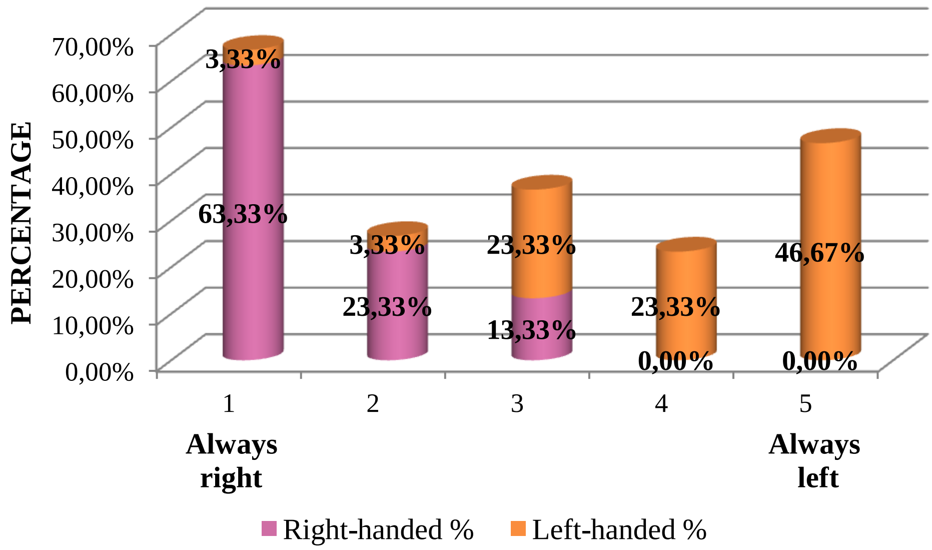
As we have seen in section 4.Laterality, right-handers tent to be more extreme than left-handers. Left-handers are less strong because of a less lateralised brain. Therefore, they carry out more activities with their right-hand and are more weak left-handers. As we will see in the other charts, these ideas will be repeated.



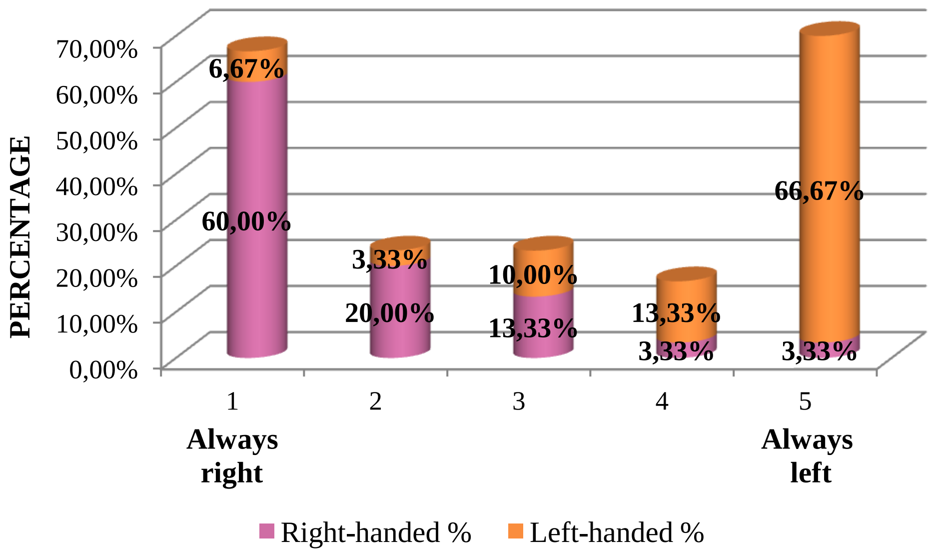
This graph belongs to the first question "Which hand do you use to write?" As we can see everybody writes only with one hand. There is nobody ambidextrous or a fixed left-handed, this might because all the respondents are from twelve to fifty years old and have not been under social pressure on writing.



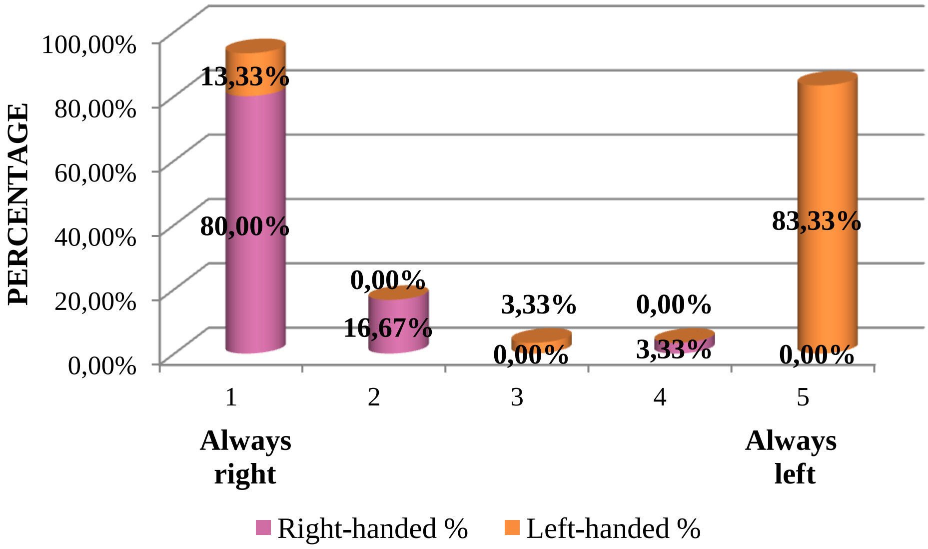
Secondly, it has been asked "Which hand do you use to throw a ball?" Here we can clearly see that right-handers are stronger than left-handers. Although the same percentage throws the ball with their "good" hand, a left-handed minority can throw it with their right-hand. Besides, the percentages on number three – both hands – are similar, though, left-handed percentage is slightly higher.



This graph belongs to the question "Which hand do you use to take a racket?" In this chart we can see again a strong right-handedness. Over half of right-handers take the racket with their right, nearly a quarter does the same usually and a minority can take it with both hands. However, nearly half of the left-handers take the racket with their left-hand, the nearly a quarter take the racket usually with their left and can take it with both hands. Finally a tiny minority take it with the right hand. This weak left-handedness might be due to social pressure. Maybe, some left-handers have been taught to take the racket with their right.

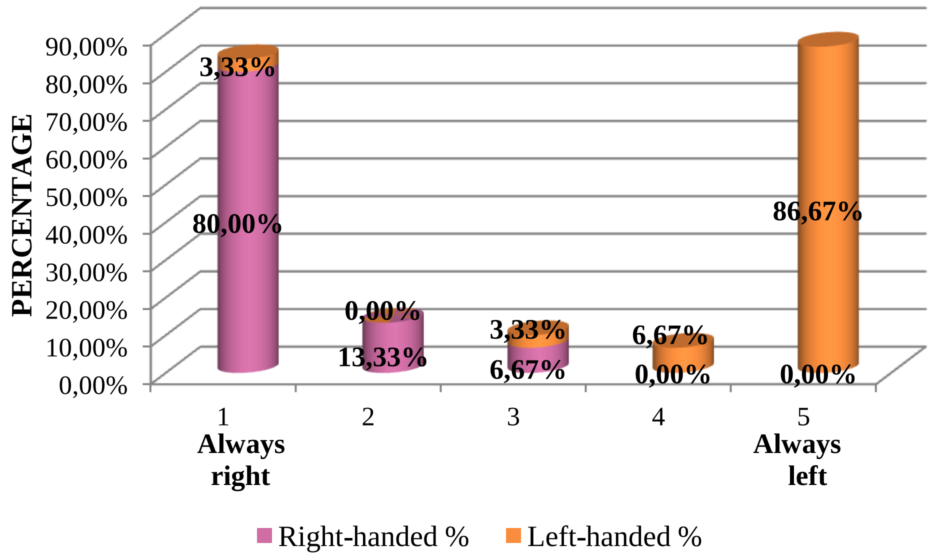


Afterwards, it has been asked "Which hand do you use to take a lighter or a match?" In this graph there is not such a strong right-handedness. Here more left-handers tent to take the lighter with their left-hand more than right-handers, so they are stronger in here. However, left-handers carry on being weaker than right-handers; more left-handers take it with their right-hand rather than right-handers.

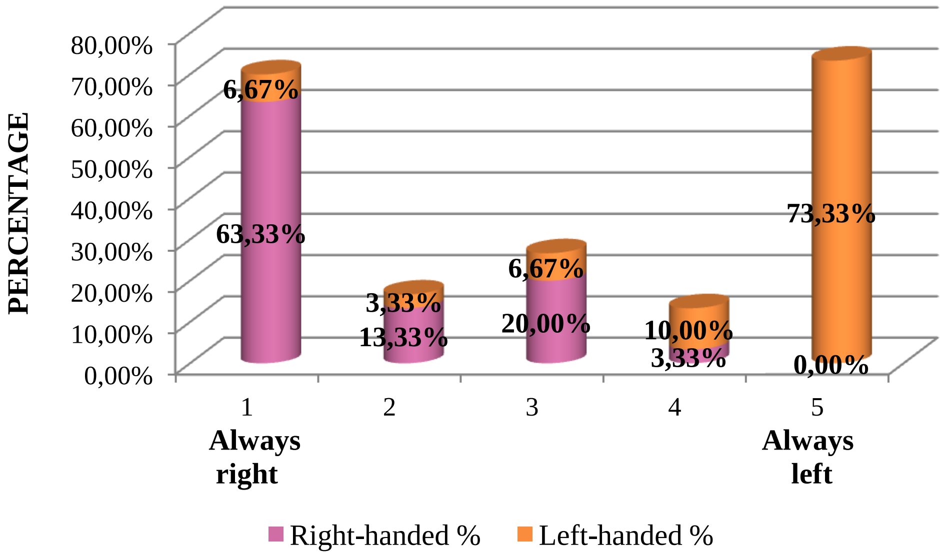


On the fifth place, there is the question "Which hand do you use to cut with scissors?" As you can see, this might be the most different chart. Indeed most right-handed cut with their right hand, the 16.67% does it usually and what is more a tiny minority usually cut with their left-hand. Although left-handers are stronger in this case, the 13.33% always cut with their right hand. Besides, the 3.33% is able to cut with both hands. This might be due to social pressure. Cutting with right-handed scissors is very difficult for left-handers - as we have seen in section 9.Left-handed tools - so they should have learnt to cut with their right-hand.

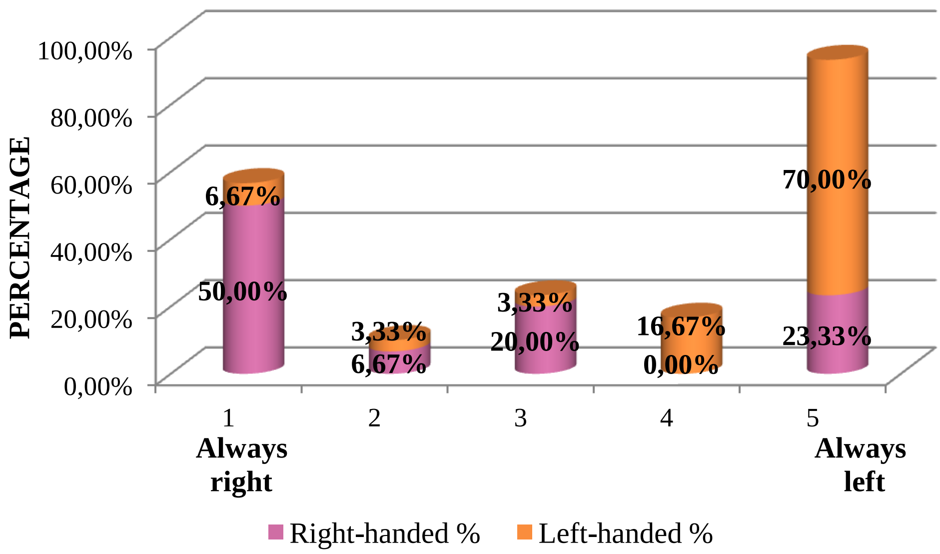
The sixth question asked was "Which hand do you use to spin a needle?" In this chart



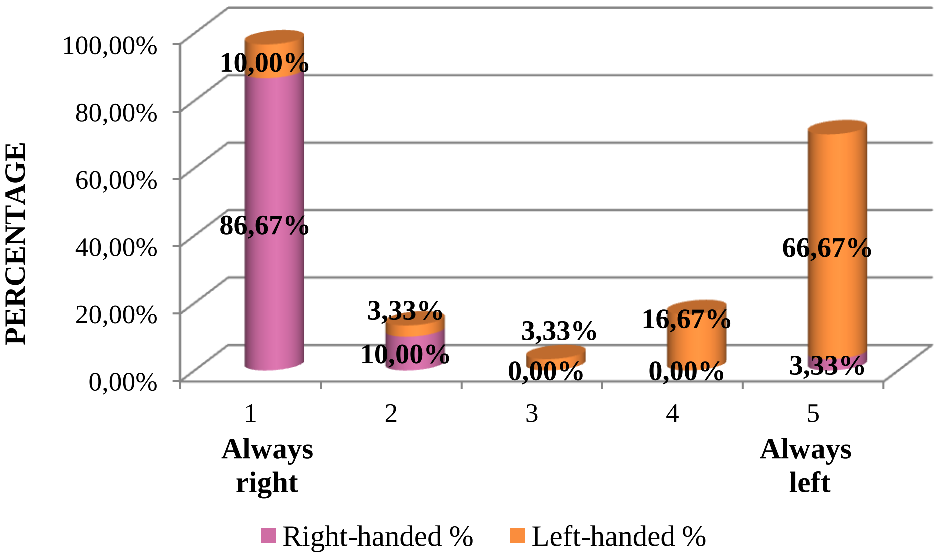
the 80.00% of the right-handers use their right hand; a minority, the 13.33% usually use their right-hand and the 6.67% can use both hand. Otherwise, more left-handers spin a needle with the left-hand, the 86.67% but nobody usually do it with the left. However, a tiny minority, the 3.33% are able to do it with both hands and the same percentage spin a needle with the right hand.



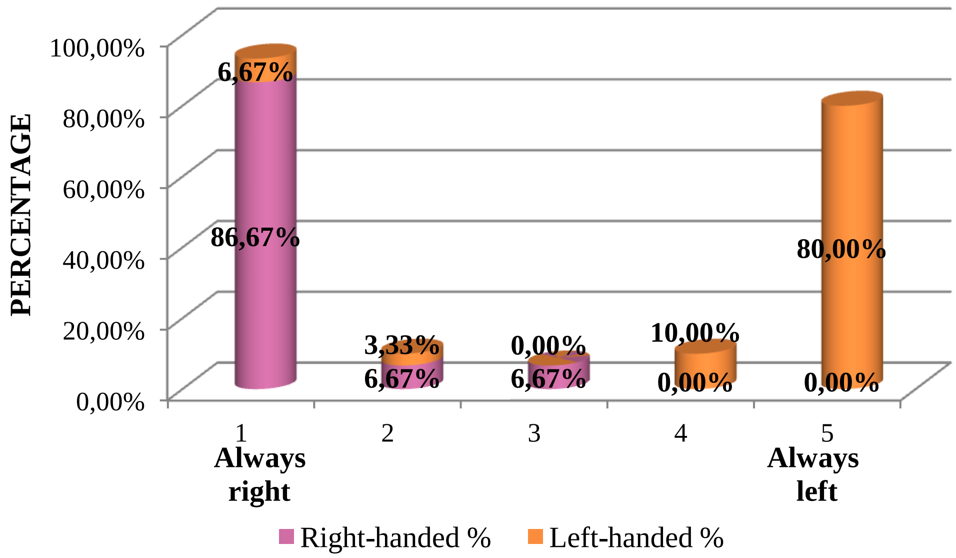
Afterwards, it was asked "Which hand do you use at the top to hold a broom?" As in the sixth question, the vast majority of left-handers hold it with their left-hand; the percentages are quite similar: the 10% usually hold the broom with the left hand at the top, the 6.67% are able to hold it with both hands, the 3.33% usually hold it with the right hand and another 6.67% hold the broom with the right hand at the top. Besides, over the half right-handers hold the broom with the right-hand. Although the 20% can hold it with both hands, only the 13.33% usually hold it with the right hand and a tiny minority usually holds the broom with the left-hand at the top.



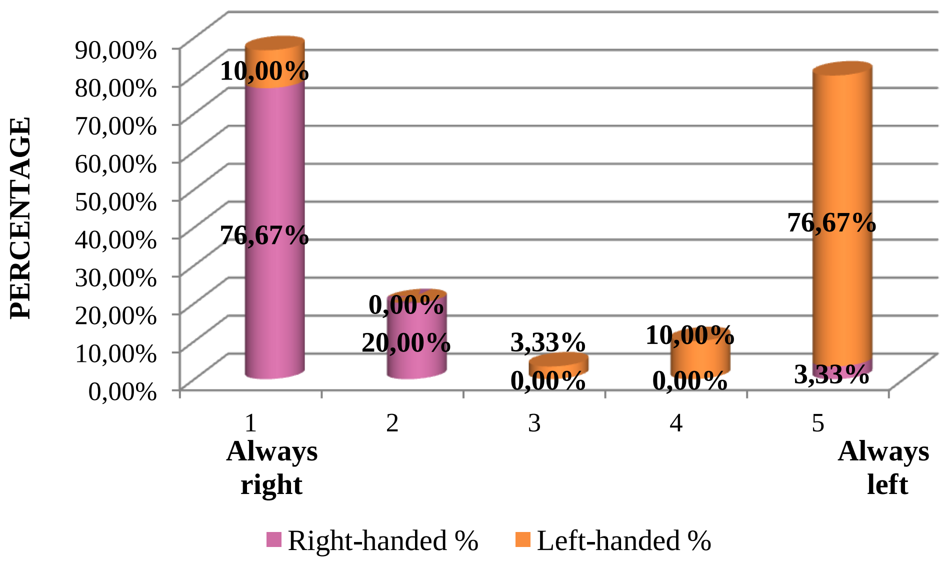
The eighth question was "Which hand do you use at the top to hold a shovel?" This might be a controversial question since some people prefer holding the broom with the "good hand" and the shovel with the other rather than hold the shovel with their "good hand". In this case, half right-handers hold the shovel with the right hand, the 6.67% usually hold it with the right as well. The 20% can hold it with both hands and nearly a quarter always hold it with the left-hand. Nevertheless, left-handers are stronger since the 70% hold the shovel with the right hand. A tiny minority hold can hold it with both hands and usually hold it with the right hand as well. Furthermore, the 6.67% hold the shovel with the right hand.



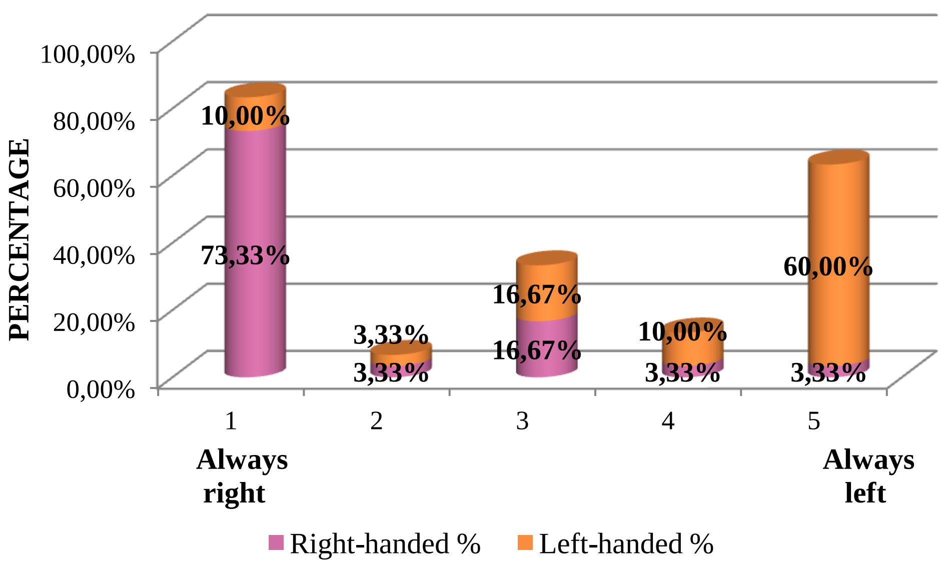
Then, it was asked "Which hand do you use to deal cards?" Here we can see a strong right-handedness and a weak left-handedness again. The vast majority of right-handers deal cards with the right hand; the 10% usually do it with the right and only the 3.33% deal cards with their left hand. However, over the half left-handers deal cards with the left-hand, nearly the 20% usually do it with the left. Moreover, a tiny minority can deal cards with both hands and also usually do it with the right hand. Eventually the 10.00% always deal cards with the right-hand.



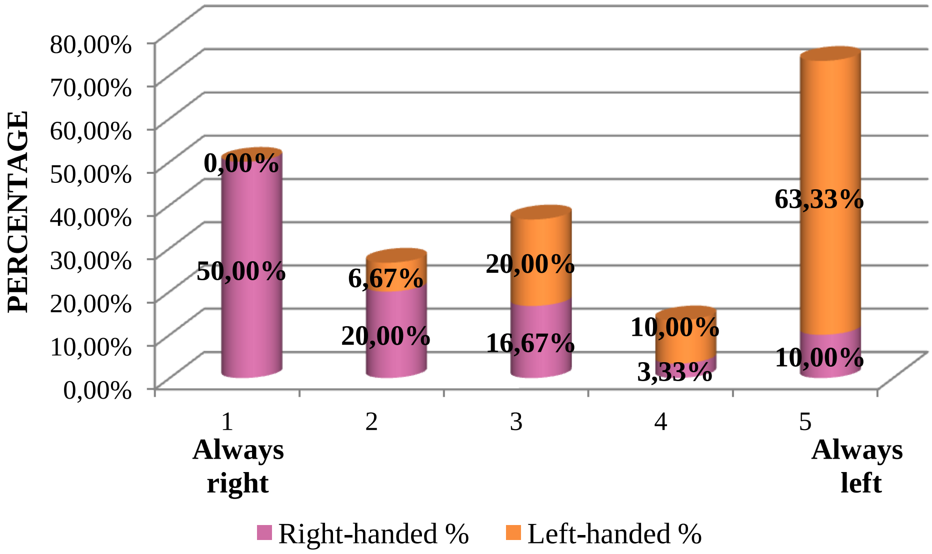
On the tenth place, it was asked "Which hand do you use to hammer a nail?" Right-handers prefer doing it with their right hand, the 86.67%. However nearly 20% of right-handers usually do it with the right hand and are available to hammer the nail with both hands. Otherwise, the 80% of left-handers always hammer a nail with the left-hand; the 10% usually do it with the left and nobody is able to hammer with both hands. However, a tiny minority usually hammers with the right-hand and the 6.67% always hammers a nail with the right hand.



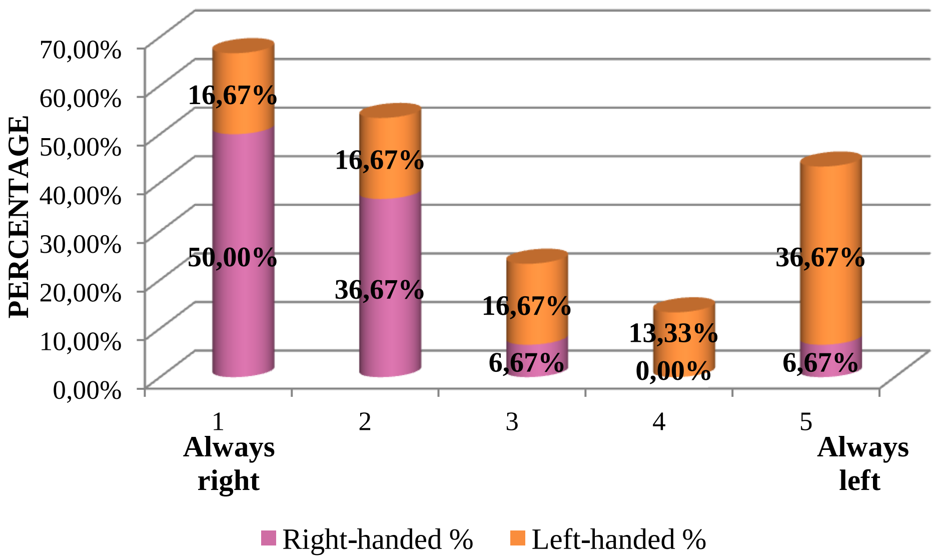
Next it was asked "Which hand do you use to hold the teeth brush?" The same percentage of right- and left-handers holds it with their "good" hand. For right-handers approximately a quarter usually holds it with the right hand and almost anybody holds it with the left hand. The 10% of left-handers usually hold the teeth brush with the left and another 10% hold it with the right. What is more, the 3.33% of left-handers hold the teeth brush indifferently.



The twelfth question asked was "Which hand do you use to unscrew the lid of a jar?" This question indicates that over 70% of left-handers unscrew it with the right hand; a tiny minority does it usually with the right, usually with the left and always with the left as well. However, equal numbers of right- and left-handers unscrews the lid with both hands. The 60% of left-handers unscrew it always with the left, one 10% do it usually with the left and another 10% with the right hand. Eventually, a tiny minority usually unscrew the lid of a jar with the right hand.



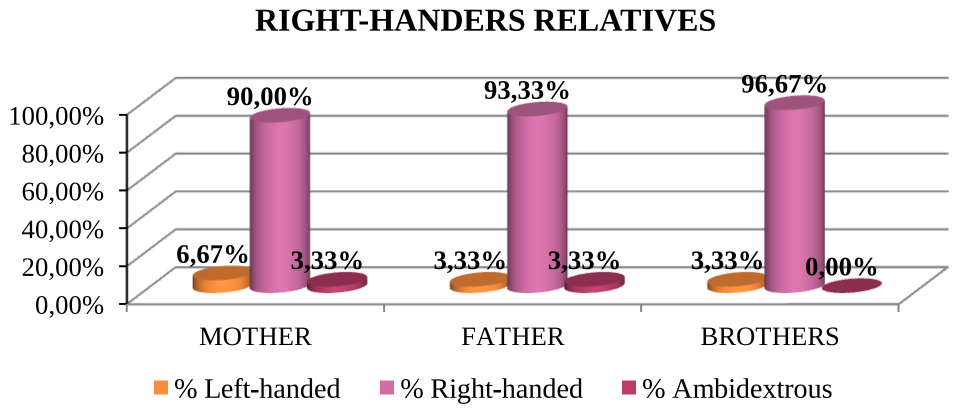
Afterwards, the question was "Which eye do you look by a telescope?" This question shows the eye dominance. As we can see, the left dominance is higher in this case. Just over two thirds of left-handers prefer looking with their left-eye. The 10% usually looks with the left, close to a quarter does not mind the eye, the 6.67% usually looks with the right eye and nobody looks with the right eye by a telescope. Otherwise, half right-handers look by a telescope with the right eye and the 20% usually does it. Nearly the 20% looks with both eyes, a tiny minority usually does it with the left eye and the 10% looks by a telescope with the left eye.

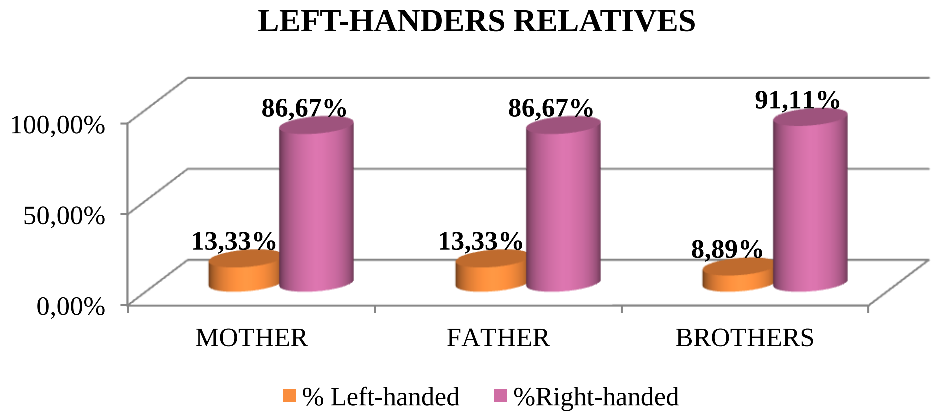


The last question was "Which feet do you kick the ball with?" In this question there is a visible strong right-footedness and a weak left-footedness. Half right-handers prefer kicking the ball with the right foot, the 36.67% usually kicks the ball with the right and equal numbers for who kick the ball with both feet and those who always kick it with the left food. However, only the 36.67% of left-handers kick the ball with the left-food and also the 13.33% usually kick it with the left. Finally there are equal numbers for those who kick the ball with both feed, usually with the right and always with the right food. This left weakness might be due to social pressure.

In the survey it was also asked which other skills the people do with the non-dominant side. For left-handers it was asked eating, doing the washing up, ironing, using the PC mouse and carrying weights. Otherwise, right-handers answers were fewer such as eating, locking the door and painting.

Eventually it was asked about their relatives' handedness, and the results are shown below:





At first sight, some things are seen. The 3.33% of right-handers parents are ambidextrous; this can be due to social pressure: they were taught how to write with their right hand because of left-handed symbolism. Right-handers tend to have more right-handers relatives as well; the *DD* genotype is more abundant in right-handers families because of that they tend to have less left-handed offspring. There are only few left-handed brothers 8.89% which indicates the abundance of the *DD* genotype.

However, left-handers have more left-handed relatives since there are more genotypes *CC* and *DC* rather than *DD*. Although there should be more left-handed women, both parents are in equal numbers for handedness 13.33% and 86.67%. The 8.89% left-handed brothers might be because the genotype *DC* is more abundance than the *CC* genotype. This fact should be due to the better conditions that *DC* people have as we have seen in Section *6.Handedness and skills.*

Another fact that cannot be shown with percentages is that left-handers have more offspring than right-handers. Left-handers have in total forty-five brothers and four of them are left-handers. Whereas right-handers only have thirty brothers and one of them is left-handed. This claims the fact that one left-handed and one right-handed have more offspring than two right-handers and less offspring than two left-handers.

14.1 TABLES

RIGHT-HANDERS	1	2	3	4	5	TOTAL
1. Write	30	0	0	0	0	30
2. Throw a ball	14	11	5	0	0	30
3. Racket	19	7	4	0	0	30
4. Lighter or match	18	6	4	1	1	30
5. Scissors	24	5	0	1	0	30
6. Spin a needle	24	4	2	0	0	30
7. Hold a broom	19	4	6	1	0	30
8. Hold a shovel	15	2	6	0	7	30
9. Deal cards	26	3	0	0	1	30
10. Hammer a nail	26	2	2	0	0	30
11. Teeth brush	23	6	0	0	1	30
12. Unscrew	22	1	5	1	1	30
13. Telescope	15	6	5	1	3	30
14. Kick a ball	15	11	2	0	2	30
Eat	28	0	0	0	2	30
Weight	29	0	0	0	1	30
Make up *(the left side)*	29	0	0	0	1	30
Paint	29	0	0	0	1	30
Open the door	29	0	0	0	1	30
Delete *(rubber)*	29	0	0	0	1	30

RIGHT-HANDERS	LEFT-HANDED	RIGHT-HANDED	AMBIDEXTROUS	TOTAL
MOTHER	2	27	1	30
FATHER	1	28	1	30
BROTHERS	1	29	0	30

LEFT-HANDERS	1	2	3	4	5	TOTAL
1. Write	0	0	0	0	30	30
2. Throw a ball	1	1	7	7	14	30
3. Racket	3	0	4	5	18	30
4. Lighter or match	2	1	3	4	20	30
5. Scissors	4	0	1	0	25	30
6. Spin a needle	1	0	1	2	26	30
7. Hold a broom	2	1	2	3	22	30
8. Hold a shovel	2	1	1	5	21	30
9. Deal cards	3	1	1	5	20	30
10. Hammer a nail	2	1	0	3	24	30
11. Teeth brush	3	0	1	3	23	30
12. Unscrew	3	1	5	3	18	30
13. Telescope	0	2	6	3	19	30
14. Kick a ball	5	5	5	4	11	30
PC mouse	6	0	0	0	24	30
Eat	6	0	0	0	24	30
Compass	1	0	0	0	29	30
Washing up	2	0	0	0	28	30
Golf	1	0	0	0	29	30
Weight	2	0	0	0	28	30
Ironing	1	0	0	0	29	30
Mobile	1	0	0	0	29	30
Remote control	1	0	0	0	29	30

LEFT-HANDERS	LEFT-HANDED	RIGHT-HANDED	AMBIDEXTROUS	TOTAL
MOTHER	4	26	0	30
FATHER	4	26	0	30
BROTHERS	4	41	0	45

15. CONCLUSIONS

As we have seen throughout the entire project, there are many ideas which have been wrong all the history and also nowadays are believed. Although I would like you to remember all the things that are explained in the pages above, I do want you to bear in mind at least these five conclusions.

In the first place, one idea which nowadays is the least believed: left-handers do not descend from alcoholic and drug addict parents: handedness is due to genetic. As it is explained, there are two alleles *D* and *C*, both combined lead to three possible genotypes: *CC, DD* and *DC*. Depending on the genotype there are more probabilities of being left- or right-handed.

Secondly, another fact which is still known and learnt: handedness does not affect intelligence in a relevant way. It is false that left-handers tent to be dyslexic or autistic, although being *DC* can affect being better at some skills. It only depends on which module you have in another place rather than having it in the normal place.

Then, I would like you to understand that there has been a lot of social pressure focused on left-handers because of symbolism. Left-handers have been a minority since the twentieth century when social pressure has decreased. Although nowadays there are more left-handers than many years ago, it appears to be that there will not ever be the same percentage of right- and left-handers.

This conclusion is for left-handers: left-handed writing is difficult due to many causes but following some simple tips it can improve. It is very important to hold the pen or pencil properly and to have a good posture while writing. I have been trying it advice since Christmas and I can say that I get less tired while writing and my hand does not hurt so much, either.

Eventually and not less important: left-handed myths are false. Although they are so popular, they have no scientific basis. Besides, some expressions which refer to left are cruel and should be avoided in the daily life.

16. THANKS

I am very grateful towards all those people who have helped me doing this project. Especially I would like to thank my tutor Mercè Viola who has advised and helped me in this project, and Jenny who has helped me practicing with the oral presentation. Besides I would like to thank to all the people who have taken the survey.

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