

Handedness and Lateralization of the Brain

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Abstract

The present study is a review of the key concepts in relation to the nature of handedness and in line with that, the phenomenon of brain lateralization. To this end, a number of articles have been overviewed and the critical concepts such as handedness and its main features, the theoretical bases for this phenomenon, the nature and functions of lateralization, and the relationship between these two concepts have been shed light on for a better understanding. Finally, the general differences between the left-handers vs. right-handers have been drawn into consideration.

Keywords: handedness, brain lateralization, psycholinguistics

1. Introduction

Human beings are unique from other species, due to their mental abilities, which have helped them discover the facts of the world and make great progressions in every aspect of scientific achievements. Despite the mental capacity, which is shared by almost all members of the human community, there are many idiosyncratic differences among them, which make every individual a unique person. The organization of brain for different mental processes may be different among people, which is one of the sources that take care of such phenomena. One of such individual differences that have been the focus of many researches is the notion of handedness.

The study of Gilbert and Wysocki, along with the experimental research of Peters, Reimers, & Manning show that the rate of left-handedness is approximately 13% in males and 11% in females [5]. Noticing that the exact percentage of lefthanders is not agreed upon in the literature, it may suffice to rely on the generalization that approximately ten percent of the population of every culture is left handed in performing tasks such as writing and other unimanual activities [2]. This fact highlights the significance of the investigation of such phenomenon and the necessity of conducting further researches in this regard, so that more mysteries about the complexities of the human mind are revealed to the world.

One area of concern, which is highly referred to as being greatly related to handedness is the brain lateralization for language functions that has to do with the question of which hemisphere is dominant regarding linguistic processes among people. In fact, most of the studies conducted so far on handedness usually focused on the relationship between handedness and language sidedness (Vuoksima, 2009). Actually, in most of the studies, the hand preference of the subjects is considered as a predictor of brain lateralization. Studies have revealed that left-hemisphere language dominance is less reported in lefthanders than in right hand individuals. The general belief is that since the right hemisphere is controlling the left side of the body, left hand people enjoy right hemisphere dominance in terms of linguistic processes to a greater degree than the right-handers do.

In spite of all these facts, the lay presuppositions about the distinction between left- and right-handers are, to some extent, different from what the literature suggest in this regard. As for the present paper, the authors were driven by their interest to embark on conducting a research on the comprehension differences among left- and right-handers. The authors' presupposition, like so many others, was that all the left-handers are right brain dominant. However, referring to the literature in this regard, they found out that this simplistic idea is not thoroughly true and is correct

only for a small group of left hand individuals; the fact is that right hemisphere dominance is more frequent among this group than among right-handers.

The present article, offers a review of the key concepts that have to be understood before any attempt to carry out a research is made, regarding right/left handedness and the related issues especially the concept of brain lateralization for language functions.

2. Handedness

Generally, providing a definition for notions is a complex matter. Academically speaking, in most of the studies the hand used by individuals in writing has been used as the most reliable index of handedness. However, there is an argument against such a single- criterion approach since writing is a learned behavior on which, teaching the skill can have an influential effect [6]. In some other researches, however, a multiple of tasks are chosen as indicators of handedness among individuals.

2.1. Left-handedness

Considering this atypical group of population, i.e. the left-handers, one interesting point made by Bosman (2004) was the negative orientation of the history toward left-handedness. He browsed the history in order to refer to the negative connotations that have been attached to the notion of left-handedness. To do so, he starts with the etymology of the word “left” in different languages and comes up with negative sides of meaning in a number of world languages (see [2] for the examples). He further draws attention to some other “anthropological examples of right/left symbolism” that prove the unkindness of the history to left-handers. He also brings some examples from different religions as to look down on the left hand as well as some anecdotes, which equate left-handedness with evil (Klar, 1999). When we take a look at our background knowledge, such negative connotations are discernable for the word “left” and we easily can find superstitions that have a bias toward the right/ left distinction.

Further, in his discussion on the view of societies upon left-hander, however, Bosman continues with some positive instances of the left-handed elites of the world among artists and geniuses such as Einstein and Picasso (Bosman, 2004).

2.2. General Features of Handedness

Marchant & McGrew (1998) draw attention to two important features of handedness, which are asserted by many textbooks. They conclude, however, that these features are not fully proven by the literature, there are limitations to what have been done in this regard, and more ethnographical studies are called for. Following is presented a brief explanation together with some evidences of the conducted researches considering the two characteristics [9].

Uniqueness. Early literature on psychology reveals that handedness is unique to human beings only. Other species are thought to be evenly distributed between left- and right- preference. However, the empirical data from the studies done by MacNeilage et al. challenge these views. They claimed that handedness is wide spread among other species, especially simians as well (Marchant and McGrew, 1998).

Such contradictory findings of researches prove that for the moment nothing can be claimed confidently about the uniqueness of handedness to humans, as Marchant & McGraw (1998) truly summarize. Yet, there are evidences for hand preference among some species, which still provide no enough support for the existence of handedness or hand specialization among them.

A point to be made here is the fact that the same struggle exists between the scholars regarding lateralization of the brain among species. There have been much evidences about the lateralization and limb preference among other species, however, not all scholars have been convinced and are still regarding human beings as being unique in this regard. On the other hand, others, Corballis (2009) [3] for example, just recently admitted that the empirical evidences proved that lateralization does exist in other vertebrate species. Rogers (2007) quotes him as saying: “some

of our lateralized activities may well be distinctive to our own species, but cerebral lateralization itself is not". This claim is in line with what has been reviewed by Sun and Walsh, who, taking handedness as an evidence for lateralization concluded that human beings are the only species who have more than 90% bias to use one hand over the other [10].

Universality. Universality has to do with the fact that people from all societies show evidences of right-hand dominance in performing tasks, however the portion stated by the researchers are different due to the fact that their studies were all limited in terms of size of sampling or aspects of methodology. Nevertheless, even small- scaled studies revealed that neither geography, nor schooling play any role in the likelihood of handedness among different populations (Marchant & McGrew, 1998).

2.3. The basis for handedness

In an attempt to provide answers for the question that "what accounts for the individual differences among people in terms of their handedness?" Bishop (2001) reviews two sets of explanations [1]:

Non-genetic explanations take into account the environmental factors and the cultural transmission of handedness between generations. Many of the recent studies also support such an approach in determining the influential factors on hand preference among individuals. The study carried out by Vuoksimaa et al.(2009) is one example of such researches that ends with the conclusion that the result of their experiments "have shown that most of the variance in handedness is explained by environmental effects, while there are also some familial, probably genetic effects that are not detectible in smaller samples".

The second theoretical basis Bishop offers supports the idea that all human beings have a genetic bias to be right-handed. Some theoretical explanations suggest a sort of genetic basis for handedness and its inheritance. McManus, for example, contend that a single gene controls both handedness and language lateralization. Some quantitative evidences also have been emerging recently that prove the inheritance of handedness from parents to offspring (See [12]). However, Bishop (2001) conducted two studies using samples from twins that gave little support for the genetic theories.

In an attempt to justify the inconsistency of the research findings in this regard, Li et al.(2003) concluded that one of the sources for the lack of agreement among researchers on what accounts for the basis of handedness is the various approaches to defining handedness and the widely different methods used by the researchers to conduct experiments. They also refer to "extraneous factors such as ability, experience, and age" as another probable factor resulting in such inconsistencies. The results of their study also support this latter reasoning [8].

3. Lateralization

Brain lateralization has been defined as "the view that one of the hemispheres of the brain has or develops a special responsibility for language"[4]. Evidence for this view comes from brain damage, which may lead to different types of aphasia, brain operations, dichotic listening, etc.

As for the basis of lateralization, most of studies have focused their attention on the genes and their inheritance (Rogers, 2007). However, evidences are a lot that environment also plays a key role in the development of lateralization of the brain among populations of species. The interaction between the hormones and genetic influences on the one hand, and the experiences and the environmental factors on the other, are found to be crucial elements in the development of cerebral lateralization, mostly through affecting the size of the corpus callosum in the brain.

With regard to advantages of having a lateralized brain for different functions, findings of the studies are complex. Nevertheless, for long it was suggested by scholars that having a lateralized brain results a higher cognitive capacity. It is believed that most people enjoy a lateralized brain, with a bias toward using the right hand and in turn, the more dominant hemisphere is involved in language functions and speech, while the other hemisphere, the right one in case of most individuals, controls the emotional behavior [6].

As for the general differences between the two hemispheres, considering their asymmetry, it is generally believed that “the left brain is analytical, logical and calculating, while the right brain is holistic, visual, spatial, and emotional” (Bosman, 2004). However, this claim have to be treated with caution, since drawing a border line between the functions of the two halves is a complex task and evidences are a lot that there are a vast number of individuals in whom the organization of the brain is atypical from that of the majority.

Generally, the functionality of the two hemispheres is categorized into separate parts by some researchers. Chevalier, for example, links some cognitive processes to the right side of the brain and concludes, “The right hemisphere mostly works with the whole concepts, similarities, images and meaning, emotions and intuition, rhythm and flow, humor and mood, and far-sightedness”. On the other hand he argues that the “left hemisphere takes care of logic differences, numbers and letters, reasoning and analysis, sequentiality, literal focus, and details” (quoted by Bosman, 2004). The significant point to be repeated in this regard is the fact that -as admitted also by Chevalier himself- this is not a full dichotomous concept and the borderline between the cognitive functions of the two sides of the brain is not as clear as it may seem here. Language is a frequently cited example of such lateralized functions, for which the interaction of the two hemispheres is frequently reported in the literature.

3.1. Handedness and Lateralization

For long, hand preference in performing tasks was taken into account as an indicator of brain lateralization of the subjects of experiments. However, such an approach has been proven to work only for certain complex tasks and not for simple ones. In fact, it is claimed that for simpler tasks such as picking up the food items, the procedure is vice versa, that is, in such cases brain lateralization is the index of hand preference and the hemisphere which is most likely to be used to do the task determines which hand to be used by the animal (Rogers, 2007).

Handedness is often seen as a by-product of brain lateralization in human beings, which is also at work in the development of language among them. Nevertheless, what remains ambiguous is the fact that why it does not affect all the human beings. In fact, a minor group of the population of every culture (5%–15%) is found to be left-handed [1].

For long, it has been proven that, in case of human beings, the two concepts of brain lateralization for language and handedness are interconnected to a large degree. The relationship is in a way that right-hemisphere dominance for language is found more in case of left-handers than in right-handers. However, the exact nature of such a link is still under doubt.

With regard to this claim, it worth pointing out here that some advantages have been reported for left-handedness, for which the likelihood of right hemisphere dominance for language is more than that of right handed people. However, the exact nature of such a link is still under doubt. Deutsch and Springer, for example, assert that for the thirty percent of left-handers whose speech is in the right-hemisphere, because of proximity of the brain parts which are at work for verbal and non-verbal abilities, these two types of skills are more interconnected and interwoven (Field, 2004).

3.2. Differences between Left- and Right-handers

Some researchers report anatomical differences in the form and size of the corpus callosum in left- vs. right-handers. Such studies suggest that the corpus callosum tends to be larger in left hand individuals. Beside the behavioral differences as well as physiological ones as reported by the literature, there are some studies that suggest left-hand individuals show less left hemisphere involvement in language tasks compared to right-hand ones [13]. Such findings have resulted in the hypothesis that the organization of the brain in left hand individuals is different from that of right-handers, with left-handers having a right hemisphere or bilateral dominance with regard to language functions.

Such a conclusion is the line of reasoning for what Thillers et al. (2007) has examined with regard to sex differences in terms of cognitive skills in left- and right-hand individuals. Their findings revealed that right hand women outperformed men in tasks assessing episodic memory and verbal fluency, while the right hand men have higher degrees of cognitive ability in performing visiospatial tasks. In case of lefthanders, however, they found out that such sex differences are very much smaller in magnitude. In reasoning for such findings, they assumed that greater right-hemisphere involvement in language functions in left hand individuals could be the cause of such less differences. Their data supports the fact that right- hemisphere dominance or even a more bilateral pattern in language functions, a phenomenon which is more typical to women, can enhance the cognitive ability of the individuals in performing verbal tasks such as verbal episodic memory and verbal fluency. This means that brain organization of the left-hand men is more similar to women, considering language functions. This conclusion is based on the claim that females have lower degrees of language lateralization compared to men.

It is worth mentioning here that just like many other aspects of lateralization and handedness among individuals, there are some studies that came across the opposite results about sex differences in lateralization of language. Using different methods of observation, such reviews failed to detect any sex differences among individuals, considering lateralized linguistic functions [13]. Therefore, again, we can easily observe the lack of agreement among scholars, even after years of investigation.

In spite of all these differences reported above, nevertheless, it is also to be mentioned here, that in most of the investigations carried out so far, little evidence has been found that suggests the superiority of right-handers over left-handers in terms of cognitive skills. There are however, differences between the two groups in terms of cognitive skills. The results of the studies are complex, in that some report higher cognitive achievements on the part of right-handers while on the contrary there is evidence of left-handedness as being a favor (See Thillers et al., 2007 for evidences).

Cognitive styles, rather than cognitive skills, are also regarded as the difference point between the two groups of individuals in some studies. Coren, for instance, introduces the two thinking styles, the convergent style vs. the divergent one, and draws a connection between handedness and these two thinking styles. The first one has to do with the bottom-up style of using the details to come up with a single answer, while the latter is a more top-down process of moving from a whole in order to discover the existing associations. He relates the divergent style to left-handedness. This is in accordance with the dominance of the right hemisphere, which is reported as to be more holistic than the left one [11].

In fact, considering the cognitive functions and information processing among the left-handers, evidences are a lot that the approaches taken by the two hemispheres are different in a way or the other. For example, there is a tendency to relate the right hemisphere to visualization.

Despite all these, the existing findings of the literature on the superiority of right-handers to lefthanders do not give consistence results. Some studies such as the work of Orton, for example, suggest that “reading disability and speech problems might be more prevalent in those lacking consistent cerebral asymmetry, as reflected in mixed- or left-handedness” (quoted by Corballis et al., 2009). Such claims, however, are challenged by the results of other researches such as that of Petrinovich, and Goldman, and the one conducted by McManus and Mascie-Taylor, which has reported no difference between the left- and right-hand individuals in terms of their IQ. (Corballis et al., 2009).

Moreover, the results of the study by Corballis et al. (2009) indicate that in spite of the intellectual deficits among ambidextrous, probably due to their lack of cerebral dominance, there is no evident difference between left- and right- hand individuals in terms of their intellectual abilities, their IQ in particular.

Generally, there are bunches of studies that suggest the idea that the intellectual disabilities are more prevalent among those who lack a one-hand preference, i.e. those who lack a handedness

consistency. The findings of Crow, Done, and Leask [7], and those of Peters, Reimers, and Manning came up with evidences that support such a claim (Corballis et al., 2009).

4. Conclusion

The aim of this paper was to cast some light on some of the critical concepts to be understood regarding handedness and its connection to lateralization of language functions within human's brain. By overviewing the literature on the nature of handedness and lateralization and summarizing the results of the experimental studies as well as the theoretical basis of these phenomena, we may come up with the conclusion that almost in every aspect of this area of research the findings of the studies have brought up conflicting results. It is most probably due to the delicateness of the nature of such investigations and diversity of the methods used by the researchers. However, it seems that in order to undertake any research on this general topic, clear definitions of the key concepts seem necessary. Furthermore, considering the existing gaps in this realm of knowledge, researches are called for so that results that are more reliable are achieved and ambiguities are removed and stronger theories emerge in this regard.

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