
Structural and Functional Brain Asymmetries in Mirror Image People

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Abstract

Background: It is routine for most people to salute their flag by placing their hands on their hearts. However, not every person has this capability because some people are born with a reversed position of the heart as well as other organs in the body. Thus, as for the human brain, separate functions tend to be restricted within the left as well as right hemispheres. Language ability mainly occurs in the left hemisphere. However, there are other unique cases where the structure of the organs appears to be having a different location from how it appears normally. This disorder is called *situs inversus* abbreviated as *SI* and it is rare among people. **Aim:** To explore the difference in learning abilities as between *SI* individuals and normal individuals. Besides, the it also examines factors affecting the learning abilities of the *SI* individuals. **Methods:** *SI* group individuals were compared with the normal individuals to identify the disparity between these two groups. Besides, field data was collected on the views of *SI* individual in the society to identify the perception regarding their rare condition in the society. **Results:** 8 of 16 participants were *SI* positive and they showed low gamma readings in hemispheres of their brains. Language ability is controlled by left hemisphere in all the participants. **Conclusion:** Despite *SI* individuals showing a different structural brain as well as other organ composition in the body, they have equal learning abilities. The disparity emanates from other social factors affecting their incorporation in the society.

Keywords: Brain Structure, Brain Function, Learning abilities, *Situs inversus*.

Introduction

From the time a child's brain develops through to adulthood, the unrivaled worldly sulcus is more profound morally justified than the left cerebral. ^[1] Left-right contrasts in anatomical structures and elements of the CNS are available all through the set of all animals. Kennedy et al. ^[2] found that left-right asymmetry has been involved as a vital part of typical brain improvement and capacity in people, as diminishment or inversion of brain asymmetry has been connected to neurological issue including formative dyslexia, schizophrenia and extreme introvertedness. ^[3] There are likewise inquisitive contrasts in body asymmetry connected with sex. The left foot has a tendency to be bigger in women. However, the right foot is typically bigger in men. In individuals who are bisexual, more than twice the numbers of ovaries are on the left half of the body and testicles are always in their right positions. It is flawlessly typical for the left half of the scrotums to slip lower than the privilege, an example that is turned around in the event that one is a left-sided male.

Literature review

Utilizing utilitarian cerebrum imaging, the scientists additionally found that part of brain meant for language dominance was likewise swapped from the ordinary area in the left cerebral cortex to the correct side in identical representation individuals. ^[2] This inversion proposes a solid hereditary segment in controlling cerebral strength of mind capacity for this situation language. One ponders about different capacities prevailing in either the left or right half of the globe the systematic rationale of the left-cerebrum versus the innovative, natural thinking about the privilege-brained artisan. In any case, in inspecting other mind locales with known anatomical asymmetries, Ocklenburg & Güntürkün ^[4] found that huge numbers of them were not switched in individuals with situs inversus. In this manner, the plot thickens. There must be various locale particular instruments controlling left/right asymmetry in the mind notwithstanding the likelihood of natural impacts.

The human brain constitutes one of complex structures that have control of the cognitive behavior. It is for this reason that anatomical structure of cerebral cortex consists of separate lobes such as frontal, parietal, temporal and occipital lobes as well. ^[5] These lobes have control over intelligence, language, movement and vision. This distinct development of the functional region occurs during the cortical development in a process called regionalization. Scientists can best explain this phenomenon using two approach models regarding development of the above stated regions. Protomap model proposes that fundamental indications from various proliferative parts in the zone around ventricles help in the regulation of functional regionalization. Conversely, protocortex model contend that extrinsic influence like thalamocortical input are the factors responsible for the functional regionalization in human brain. ^[5] However, accumulative evidences prove that

both the models have a role to execute in the regulation of patterns in the cortex as well as establishment of cortical regionalization. Cerebralcortex contains the left as well as correct hemispheres where the left hemisphere is for logical reasoning, processing and language In addition; partial recognition dominance entails the duty of the right hemisphere. One of the most intriguing characteristics of the brain in human being is that about 90% of the world's population is right handed. Notably, the skills of the right hand are controlled from the left hemisphere. Other activities controlled from the left hemisphere include handedness, is the language ability. For instance, language ability is dominate to about 95% population of right handed people while only 70% of the left handed population have the language ability controlled from the left hemisphere. ^[5] Therefore, it is unpredictable that language ability and hand use receive their commands from the left hemisphere in most people.

Brandler and Paracchini ^[6] noted that a scientist called Marian Annett found out that the inheritance of the shift of the right genes also shifts the manual skills in favor of the right hand and not left. Thus, right shift influence the cerebral dominance as opposed to handedness. This has an effect in the impairment of control speech systems as it allows the language ability to be controlled from the left side of the hemisphere. However, some individuals process language from either right hemispheres or both hemispheres. Such individuals also depict similar language as those individual who use the left hemisphere in language processing. Notably, individuals using both hemispheres in language processing tend to have high leaning abilities. This is because some scientists argue that such individuals have larger portion of their brain designed for language processing ^[6]. One social factor that Brandler and Paracchini ^[6] found to be affecting the learning abilities of SI individual is the need for association in the society. Statistics prove that 70% of SI individuals are stigmatized about their condition owing to the fact that they are few in the society. ^[6] This is because the SI individuals tend to feel some sense of segregation considering their condition majorly dictated by the left hand dominance. According to the beliefs of other societies, having a left hand dominance is like a curse from God. This creates a feeling that the SI individuals are some of the curse people in the society. These myths and societal misconception have a negative impact on the learning abilities of such individuals. ^[7]

While in many species every typical individual are asymmetrical in a similar course, animals with finish reflect inversion of situs inversus. Along these lines, while it is conceivable to devise conceivable transformative explanations behind why living beings may be asymmetric in any case (ideal pressing, liquid progression, amplifying surface range of tubes, and so on ^[8] There is no undeniable purpose behind why they ought to all be asymmetric to a similar bearing. It is, all things considered, much less demanding to envision a formative system for creating anti-symmetry. It is conceivable this requires particular predisposition, yet no information

demonstrates why these two intelligently unmistakable procedures must be connected. Sensory system lateralization is spread all through advancement, while a few animals frequently indicate paw inclination, the steady inclination among all people just methodologies abnormal states in man. The hereditary premise of handedness in man is still exceptionally disputable.

Problem Statement

Different parts of the brain have different tasks that work in harmony. Hoess and his colleagues^[9] say that the brain is a lateralized organ by design. This implies that the brain is subdivided in two hemispheres depending on the work assigned to each lobe. Thus, all humans' beings owe their ability of multitasking to the hemispheric structural design of the brain. However, the ability of multi-tasking tends to vary depending on sex.^[9] For instance, women are better at multi-tasking compared to men. Research done Hoess and his colleagues^[9] proves that the activation of dorsolateral prefrontal areas in females is more rapid as compared to the activation in males. This makes females to be well adapted in multi-tasking as compared to males. This reveals that 90% biological systems in animals show some degree of asymmetry, from human beings to animals; the normal variation as well as specialization gives rise to asymmetries of function and structure.

Notably, left-right behavior biases are reflective in many studies across the animal kingdom. This has resulted in a documented association between handedness and cognitive performance of individuals. However, association between cognitive ability and body laterality has been drawing divergent understanding among scholars.^[5] Some of the embryonic paths dictating that molecular dissection of the left-right hemispheres of the brain have been possible using the model of vertebrates. This gave rise to innovation of numerous pharmacological treatments of the reversal left right disorder in animals. Scientists have been facing hiccups in dealing with situs inversus disorder in patients because they patients display reversed morphological structures in major organs of the body. For instance, inversion of the location of heart required the physicians to make some of the observational structures of the hearts that would aid in addressing the issue of situs inversus. However, Leroy, Cai Bogart et al.,^[5] argues that a person with the situs inversus disorder has no advantage or disadvantage over others. Hence, despite the disorder in the location of major organs in the body, they can still function normally as other individuals with the normal positional structures in the body.

Statistics prove that 3-5% of the people with situs inversus with dextrocardia show high chances of contracting incidents of congenital heart disease.^[9] This is because dextrocardia presents in three different unique ways. Dextroversion and Dextroposition are the two related disorders that portray some predisposing factors connecting situs inversus with congenital heart diseases. Dextroversion is the abnormal positioning of

the heart where the left ventricle remains on the left but lies on the frontal part of right ventricle. ^[9] This will only be evident on electrocardiogram because it will be showing some abnormality on the readings of heartbeats. Scientists argue abnormality in the readings of heartbeats reveal more information on the abnormal operation some of different parts of the heart. Conversely, dextroposition is another disorder described by the displacement of the heart from left to right. It stems from some of the acquired lung diseases or infections around the lung. All these disorders depict several avenues of contracting congenital heart diseases on people having situs inversus.

Leroy, et al ^[5] argue that very limited intelligence have been available in functional asymmetry in the brains of SI disorder individuals. According to the study done by these authors, eight of the nine people who participated in the survey reproduced sound from their left ear as compared to the participants who reproduced sound from their right ear. All these were attributable to the left hemispheric function of language processing. Hence, despite these individuals having SI disorder, they were still using their left hemisphere in language processing. The study found out that both individuals with SI or not depicted equal abilities of learning in the sense that their language abilities are both controlled from the left hemisphere. Therefore, being that most SI individuals are exposed to some of the fatal diseases such as heart related diseases, they still have equal chances of language ability. Moreover, in rare cases where SI individuals have one command emanating from left and right hemisphere, the function output tend to be profound.

Research questions

The research focused on majorly two questions as below;

- What is the difference between situs inversus (SI) individuals and normal individuals concerning learning abilities?
- What are the social factors affecting the learning abilities of the SI individuals?

Methods

In 2009, department of neurosurgery used a total sample of 16 participants were randomly selected from students where 8 of the participants were self-reported be to SI positive. ^[5] The condition of the participants with SI disorder was confirmed through thoracic and abdominal X-rays examination before further analysis was done on them. The first eight subjects with SI were four males and four females of ages 20, 23, 24, 35, 42, 69, 25 and 30 respectively. Four were having very weak right-handedness with literacy quotient (LQ) of +38, -20, 34 and +30 respectively. ^[5] No subjects tested showed any history of neurological or psychiatric diseases.

Another group of tested subjects of four women had history of some neurological disease. For instance, one of the women aged 24 years was confirmed to have been suffering from temporal lobe epilepsy with a tough right-handedness ability of Literality Quotient +100. [5] Thereafter, the subjects were grouped according to male, female, age, and right-handedness. This was to avoid confusing the result from each group as the participants were showing different results. Eight participants were the control group for study where normal individuals with matching age and sex were used by the study to enable comparison of results. Some of the confidential information appearing from the test and were not significant in the study were kept as confidential matter to the participants. This was to keep the privacy of participants. Some of the old participants received the best care because their condition could not stand some of the weak negative effect of the X-ray examination. Valid documents that were supporting the study were obtained from relevant authorities and the informed consent of all the participants was obtained. This was to validate the research and further aid in collecting data from various institutions and individuals. [5].

The procedure to determine language dominant hemisphere was inform of a stimuli. 100 words written in French were written in 4 syllabograms with each word visually located in front of the participants. Thereafter each subject received an instruction to read a sentence once. A 64- channel MEG system recorded the magnetic signals presented from the subjects. This digitalized sensor indicator regarding to positioning of MEG signals allows alignment of both MEG as well as MRI signals, a coordinate system that entails accuracy that is anatomical and corresponding to MRI data. Further analysis of the changes in beta and gamma bands thus aided the study in determining the language dominant hemisphere. Conversely the remaining eight individuals acted as the control group having the same ages and sex as the SI group. All the tested SI participants demonstrated a more grey matter concentration round the right and left frontal petalia as compared to other contra lateral sides. The remaining eight participants were normal individuals who were not suffering from SI disorder. Table 1 represents the summary of the functional as well as anatomical asymmetry of the participants used in the study.

On top of test carried out on the participants, they were asked some questions related to their participation in the society and how they were generally feeling about their abnormal conditions. For instance, one question that was asked to every participant was his or her perception of his or her condition concerning relationship with the society. These questions were also recorded for further analysis to determine some of the factors that might have been hindering the participation of SI individuals in the society. Their views were analyzed using SPSS software to determine the significance of their responses.

Table 1: Functional and anatomical asymmetry of the participants in the study

Group			Functional asymmetry The Language dominance	Anatomical symmetry The Forward petalia	The Occipital petalia	The Planum temporal
SI	Subject	S1	R	L	R	L
		S2	R	L	R	L
		S3	R	L	R	L
		S4	L	L	R	L
		S5	R	L	R	L
		S6	R	L	R	L
		S7	R	L	R	L
		S8	L	L	R	L
		No of subjects	L	0	0	2
		S	0	3	0	8
		R	0	0	2	6
Control	No of subjects	L	8	13	8	0
		S		0	0	0
		R		0	5	5
Fisher's test		P	P > 0.005	P > 0.0005	N.S	N.S
		>0.005				

L- Dominated by Left hemisphere

R- Dominated by Right hemisphere

S- Dominated bilaterally

N.S – insignificant

Table 1: Available from: https://www.researchgate.net/figure/38074443_fig2_Fig-2-Statistical-SAM-images-of-the-3-subjects-with-SI-showing-lateralization-of-signi

Findings/Results

As illustrated in Figures 1 and 2, the SI positive patients showed low gamma readings in hemispheres of the brain. However, the control group showed a consistent reading on left hemispheric to be controlling language ability. The pattern of asymmetry showed a consistency in all the participants where SI and

controlled group had concentration of more grey matter on the left compared to the right. Hence, all the tested groups portrayed had their abilities of language dominance controlled from the left hemisphere. SI individuals agreed that there was sometimes that they were felt stigmatized about their condition, thus hindering association of SI individuals with members of the society. The image below shows that only one person was using the right hemisphere of the brain in language dominance while the rest of the SI individuals used the left hemisphere.

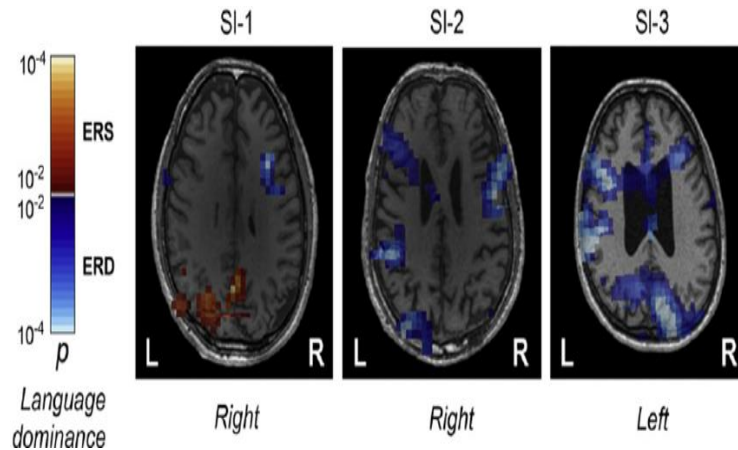
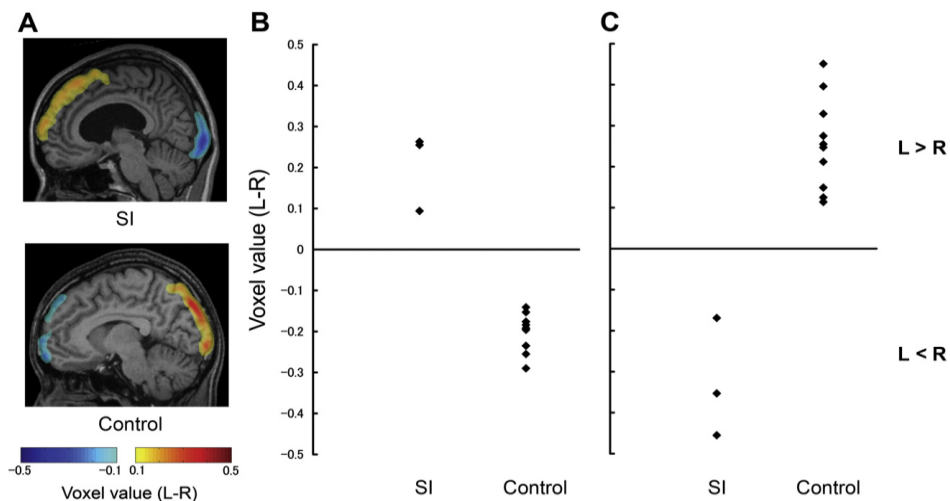


Fig. 1 Statistical SAM images of the 3 subjects with SI showing lateralization of significant ERD (blue) and ERS (orange) in the low-gamma band ($p < 0.01$). ERD was observed in the left IFG of SI-1 and in both the left and right IFG of SI-2 and SI-3. The language-dominant hemisphere was adjudged to be “right” for SI-1 ($LI = -0.7$) and SI-2 ($LI = -0.3$) and was adjudged to be “left” for SI-3 ($LI = +0.4$). L: left; R: right. Adapted from Ihara A, Hirata M, Fujimaki N, Goto T, Umekawa Y, Fujita N et al. Neuroimaging study on brain asymmetries in situs inversus totalis [Internet]. 1st ed. Journal of the Neurological Sciences; 2009 [cited 15 January 2017].

Fig. 2. Below, depicts that parts of the brain responsible for speech are different in all tested individuals. Both the control and SI groups showed a fluctuation in part of the brain responsible for their speech.



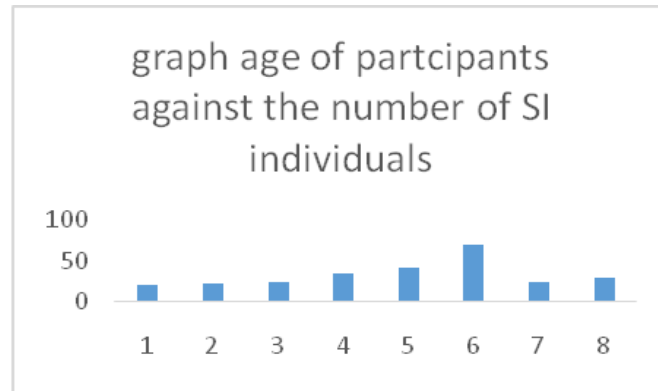
In Fig. 2. Interhemispheric anatomical asymmetry of the PT in the SI and control subjects. (A) VBM maps of the left hemisphere of representative SI and control subjects. Orange voxels indicate more gray-matter concentration in the left hemisphere, and blue voxels indicate more gray-matter concentration in the right hemisphere. (B) Distribution of the peak voxel values of the PT for all the SI (n = 3) and control (n = 11) subjects. All the subjects had more gray-matter concentration in the left PT; therefore, no significant difference in the pattern of PT asymmetry was observed between the SI and control subjects (see Table 1). L N R: more gray-matter concentration in the left hemisphere; L b R: more gray-matter concentration in the right hemisphere. Ihara A, Hirata M, Fujimaki N, Goto T, Umekawa Y, Fujita N et al. Neuroimaging study on brain asymmetries in situs inversus totalis [Internet]. 1st ed. Journal of the Neurological Sciences; 2009 [cited 15 January 2017].

From the general questions asked the SI individuals, six of them agreed to be feeling shy to freely associate with the rest of other people in the society while the remaining two confirmed to be having no challenge in associating with society members.

Table 2: Speech and language dominance comparison

SI individuals	S8	S7	S6	S5	S4	S3	S2	S1
Speech and language dominance	L-L	L-L	L-R	L-R	L-L	L-R	L-R	L-R
Control group	N8	N7	N6	N5	N4	N3	N2	N1
Speech and language dominance	L-R	L-R	L-R	L-R	L-R	L-R	L-R	L-R

Table 2 represents a summary of the findings of the study. Among SI individuals only two participants have, both speech and language dominance controlled from left hemispheres but the remaining participants show the normal grey matter composition in a normal individual. ^[1] This proves that despite the rare condition of SI individuals, most of them have normal grey matter composition in the brain. There were noticed variance between the ages of the 16 participants ^[5], Graph 1 shows the number of SI individuals from each age slot.



Graph 1: plot of age of SI individuals against number of SI individuals

Discussion

Comparing the two groups used in the study. Two main questions that the study tried to answer come out vividly. According to the first research question, SI individuals have no any advantage over the normal individuals. However, based on the arguments of Walker ^[3] under some abnormal circumstances, SI individuals tend to have high mental ability as compared to normal individuals. For instance, individuals that have their left and right hemisphere designed to give command for the language ability tend to show an increased mental activity as compared to others. ^[10] This is rare disorder among SI individuals but in many cases the SI individuals tend to have no mental ability as compared to normal individuals. Contrary to the arguments of walker ^[3] Hoess, et al., ^[9] confirms that SI individuals have equal ability of the brain and are capable of doing any task that a normal individual can do. Conversely, SI individuals face the effect of socialization. This is because most people have their own myths about SI disorder that affect the social life of SI individuals as they feel they are totally abnormal from other human beings.

Conclusion

The rare condition of SI individuals alienates them from normal individuals in the society, as they feel awkward about their condition. However, most of SI individuals develop an adaptive feature helping them in coping with societal issues. In addition, despite SI individuals showing a different structural brain as well as other organ composition in the body, they have equal learning abilities. Therefore, structural composition of the brain as well as other organs on SI individuals has a minimal impact on learning abilities. ^[8] However, relationship in the society and diseases such as congenital heart diseases associated with SI individuals can be factors that affect their learning ability.

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