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Research Article

Functional asymmetry in sensory discrimination in visually blind and its association to braille reading

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ABSTRACT

Background: In health, human somatosensory modality is symmetrically distributed. But highly specialised functions like skilled movements, visual sensation while reading show lateralisation. In visually blind population somatosensory modality is used for specialised function like braille reading. Thus present study was undertaken to assess somatosensory modality in visual blind & to find out its association to braille reading.
Methods: 60 visually blind participants were assessed. Detailed history about motor dominance, preferred braille finger was asked. 2 point discrimination (2PD) test was done in all 10 fingers using weber compass. 30 normal visioned controls were assessed for comparison. Unpaired t-test was used for analysis.
Results: Most participants (n=44) chose finger from right hand as preferred finger for braille reading; this was unrelated to motor handedness. In visually blind population average values of 2PD in right hand was significantly ($p<0.001$) less than right. In normal visioned subjects there was no significant difference in sensory discrimination between right and left hand.
Conclusions: Due to presence of language areas in left hemisphere (90-92% of people), all our language related modalities are inclined toward left hemisphere. Here we proved that blind people prefer right hand over left hand while reading written braille language and thus have better sensory discrimination for same. Previous studies have shown that blindness itself acts as stimulus to activate latent pathways (cross-modal plasticity) between somatosensory cortex, visual cortex and language areas. Overall we tried to prove brain is hardwired to do all language related activities preferably with right hand.

Keywords: Cerebral asymmetry, Visually blind, Sensory discrimination

INTRODUCTION

Loss of function of a particular part of brain leads to activation of latent pathways and now that non-functional part is used cross-modally for some other function this is known as cross-modal plasticity[1] Whereas unimodal plasticity is structural and functional enhancement of original area itself representing a particular modality, stimulated by functional demand.[1,2] In visually blind visual cortex is activated cross-modally by somatosensory and auditory stimuli. This leads to enhancement of somatosensory and auditory reception.[1-3] In this study we assessed somatosensory modality in visually blind population.

In evolutionary course, once highly specialized functions like skilled movement and language were acquired, symmetry of function in brain was lost to make a way for dominance.[4,5] For sensory modalities, in healthy human beings such asymmetry is evident in visual sensations while reading a language.[6] But in health, human somatosensory modality is symmetrically distributed,[7,8] but does such symmetry is maintained in visually blind? One of the biggest leap in human evolution was acquisition of written language. Reading of a language is done with visual cues in normal visioned humans. In congenitally visual blind population visual area is never used for visual perception purpose whereas in later onset blindness there is loss of function of visual cortex.[1,2] In both cases perception of written language is hindered. Thus all other sensory modalities are enhanced to compensate for language perception like auditory, somatosensory sensations.[2] But then even for symmetrically distributed modality like somatosensory system, should it occur more so on the side where language areas exists; that's question which this study asks.

In this preliminary study we tested existence of somatosensory asymmetry in visually blind using simple test of two point discrimination (2PD) and correlated it with braille reading.

METHODS

60 visually blind participants were assessed. For comparison 30 normal visioned age, sex matched control were used. Ethical clearance was obtained from Institutional Ethics Committee. Participant information sheet in braille was given to all participants as well as it was explained to all participants in a language they understand best and then informed consent form was obtained.

All participants were assessed clinically for any neurological, skin or orthopaedic disorder which can affect sensory modality. None of the participant had history old injuries to hand or history of any chronic disorder which can affect somatosensory system like diabetes, renal failure.

Detailed history about motor dominance, preferred braille finger was asked. Even though while reading braille blind subject use both hands. All blind subjects have preferred braille finger with which they can read braille very quickly and accurately. History of preferred brail finger was asked and noted carefully.

2PD test was done in all [10] fingers of hand using weber compass. A standard procedure was followed while assessing participants using 2pd. Compass with blunt point as suggested by Moberg was used as pointed object would cause pain rather than touch. Both points of compass were touched simultaneously on the skin with equal pressure leading blanching of skin with depression of not more than 1mm.[9]

Initially prongs of Webber compass were kept close together and touched on the participant's fingertip. Participant was asked about how many points he or she felt. Then slowly distance between prongs was increased and touched on the participant's fingertip. Procedure was repeated till subject felt two points. Then distance between two tips of Webber compass was measured using plastic scale. To rule out any false positive results in between during the course of testing, only one tip of Webber compass was touched and subject was asked about how many points he/she felt. The Whole procedure was repeated in case of false positive results.

Statistical analysis

The analysis was done using SPSS software. Unpaired t-test was used for comparing data. P value below 0.05 was considered as significant. Most blind participants (n=44) had their preferred braille finger on right side (Table 1).

Table 1: Comparison of number of blind participants having preferred braille finger on right side versus left.

Preferred Braille Finger (Total Participants=60)	
In right hand	In left hand
44 (43 right index & 1 right middle)	16 (all left index)

RESULTS

As we can see in the table & graph below, preferred braille finger was unrelated to motor dominance, most of the right handed as well as left handed people had their preferred braille finger in right hand (Table 2, Figure 1).

Table 2: Comparison of preferred braille fingers of blind participants with respect to motor dominance.

Motor Dominance	
Right Handed	Left Handed
48 (35 Right index, 1 Right middle & 12 Left index)	12 (8 Right index & 4 Left index))

When we see same graph as percentage of total number of that group, we can see that almost 70% of participants in each group had right index finger as preferred braille finger in right as well as left motor dominant participants (Figure 2).

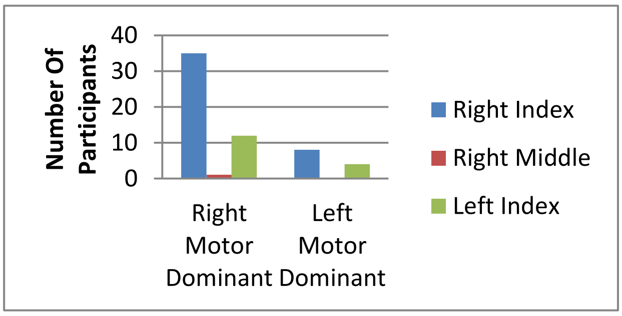

Figure 1: Comparison of preferred braille fingers of blind participants with respect to motor dominance (Total participants=60).

When we compared 2PD on right hand versus left in visually blind, we found average value 2PD to be significantly less in right hand compared to left. In normal visioned subjects there was no significant difference in sensory discrimination between right and left hand (Table 3).

Table 3: Comparison of 2 point discrimination in right side versus left side in visually blind & visually normal group.

Mean value 5 fingers± S.D.(mm)	Right Hand	Left Hand	P Value
Visually blind (n=60)	2.27±0.28	2.74± 0.46	<0.001
Visually normal controls (n=30)	3.00 ±0.57	3.18 ±0.26	0.119

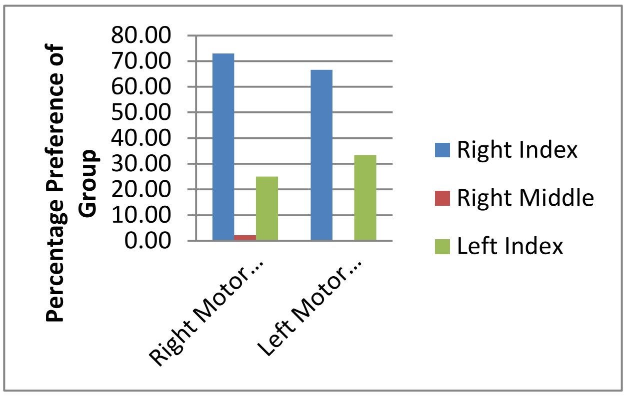

Figure 2: Pattern of preferred braille finger in percentage when divided in two groups of right motor dominant & left motor dominant

DISCUSSION

We found that in visually blind population there is asymmetry in somatosensory modality with better sensory discrimination in right hand compared to left hand. Acquisition of written language is one of highest form of evolutionary advantage human beings got over other animals. Humans perceive written language through visual stimuli. In the course of evolution highly specialized functions like language, fine motor skills are represented unilaterally as they offered no evolutionary advantages of having bilateral representation. This is unlike general somatosensory sensations which are having evolutionary advantage to sense dangerous stimuli from all sides of body.[5] Also gross motor movements are needed for maintaining balance, flight and fight hence represented bilaterally. But highly specialized function like language is represented unilaterally on left side of cerebral hemisphere in 90-92% of human population.[10]

Vision is most important sensory modality for perceiving written language and studies have shown that at least for its language related function; vision does show lateralization. Split visual field stimulation proved advantage of reading with right visual field (RVF) over left in healthy individuals.[6]

In this study we confirmed from control group that somatosensory modality for perceiving light touch shows no asymmetry or dominance in normal visioned people. As already stated this might be because perceiving stimuli like touch, pain, temperature from all direction has always offered evolutionary survival advantage even in human beings.[7,8,11]

But in special population like visually blind; loss of visual stimuli hinders perception of written language. in congenitally blind population acquisition as well as perception of written language is hindered. Loss of a function of a particular region of brain induces activation of latent cortical neuronal connections. Thus in visually blind population there occurs activation of latent pathways leading to cross-modal plasticity, utilizing visual areas for perceiving other sensations. Thus there occurs enhancement of other sensory modality like hearing and somatosensory sensations. Now auditory and tactile stimuli cross-modally activated both striate and extra-striate cortex.[2,12]

This occurs more so on side in which language areas are represented that is in left cerebral hemisphere. As during cultural evolution in civilized world, acquisition of written language has survival advantage. Thus in visually blind there is cultural pressure to learn written language (braille), which they can acquire through only tactile sensation. As we know braille involves converting simple tactile information into meaningful patterns that have lexical and semantic properties. Thus perceptual processing of Braille is mediated by the somatosensory system, language areas as well as visual cortex in blind population.[12,13,15] So just like in visually normal people having advantage of reading with right visual field because of presence of language areas in left hemisphere.6 For visually blind individuals there is obvious advantage of perceiving written language through right hand than left hand. Thus initially when these individual start acquiring written language through braille, they prefer side with which they can perceive language better through somatosensory modality.

One study showed left hemispheric CCT (Cortical Conduction Time) to transmit a somatosensory message from the subcortical to the cortical level is significantly lesser than right hemisphere.[16] Thus further explaining enhanced dominance in sensory modalities.

Furthermore expanded cortical representation with braille reading practice leads to unimodal plasticity and thus there occurs development of a finer spatial sampling of the peripheral input for individual cortical neurons. Thus enhancing fidelity in neural transmission of spatial details of a stimulus through left hand. Overall improving somatosensory perception through left hand with practice.[7]

Corballis and Morgan (1978) pointed out the general shift of human evolution away from bilaterality to lateralization, as specialized function evolved. And there exist gradients in main axes of embryologic development resulting in a 3D diagonal growth vector from right frontal-motor and primary sensory areas to left-posterior and tertiary association areas.[4,5]

Overall as previous studies have shown that blindness itself and evolutionary, cultural pressure act as stimulus to activate latent pathways (cross-modal plasticity) between somatosensory cortex, visual cortex and language areas. Thus there occurs lateralization in somatosensory modality when used for perceiving highly specialized function like written language.

CONCLUSION

The study showed that when in visually blind population somatosensory sensation shows lateralization towards left hemisphere as they have evolutionary and cultural pressure of perceiving written language.

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