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RESEARCH ARTICLE

Comparative study of simple auditory reaction time in blind and blindfolded sighted individuals

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ABSTRACT

Background: The ability of blinds to adapt themselves to cope with environmental stimuli depends on the quickness of response which in turn depends on sensory perception and central processing. **Aims and Objectives:** In this study, simple auditory reaction time has been used to evaluate the processing speed of the central nervous system and coordination between sensory and motor systems in congenitally blind and sighted subjects. **Materials and Methods:** 30 congenitally blind braille readers and 30 age and gender matched controls were included in the study. Simple auditory reaction time was evaluated. **Results:** The auditory reaction time is significantly reduced, in congenitally blind participants compared to blindfolded sighted participants. **Conclusion:** Congenitally blind subjects outperformed blindfolded sighted subjects with respect to auditory reaction time.

KEY WORDS: Auditory Reaction Time; Congenitally Blind; Blindfolded Sighted Individuals

INTRODUCTION

Influence of visual defects on the human organism is always dual and contradictory. There are two theories on how the loss of one sense affects the remaining senses. In disability theory, it is explained that senses complement each other and that maximum performance occurs when the senses are complete; thus, the lack of sensory system negatively affects other systems.[1]

On the contrary, the compensatory theory states that, if conditions are favorable, defect negativity will change to compensation positivity. Such compensation in blind children will be achieved through other senses, especially hearing sense.[2]

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On the view of this, this study compared simple auditory reaction time in congenitally blind and blindfolded sighted subjects to investigate whether the blind subjects who lack one sense have an enhanced ability with the other.

Simple auditory reaction time is the time interval between the onset of the single stimulus and the initiation of response under the condition that the subject has been instructed to respond as rapidly as possible. Quicker the reaction time faster the subject can react to stimuli in the environment.[3]

Individual's reaction time is a valid indicator of the central nervous systems ability to receive and synchronize movements expressed through the peripheral nervous system. This cognitive-motor connection is a key player in many aspects of daily living like making quick decisions, athletic abilities, prevention from injuries, etc.[4]

If the pathways of the motor and sensory system are intact reaction time will be an indicator of the maturity of subject's information processing system.[5]

MATERIALS AND METHODS

The study was conducted at a blind training residential institute for girls in Mumbai. The study protocol was approved by the Committee for Academic Research Ethics.

A total of 30 congenitally blind female participants of age group 18-27 years were randomly selected for the study (blind group). An equal number of normally sighted female participants of the same age group were randomly recruited as controls (control group). The participants of blind group were totally blind or had at most some light perception without pattern recognition since birth. Moreover, the cause for blindness is pure ophthalmic in origin. All blind participants were trained in braille and received auditory training from childhood to gather and use external auditory information in daily life. Blind children were helped to build up a "sound" vocabulary with the help of talking books, games and by simply making them aware of sound of rain falling, wind blowing, etc. It was ensured that none of the participants had any known psychiatric disorder or sensorimotor deficits of the hands in the form of leprosy, neuropathy, or neuritis.

An informed written consent was obtained from each study participant. Both the groups were tested for acuity of hearing with tests of hearing. All the participants were briefed in detail about the study procedures. The participants of the control group were blindfolded during the study procedure. Each subject was given sufficient trials for a proper understanding of the test procedure.

The apparatus used is "Simple Auditory Reaction Time Analyzer" manufactured by Anand Agency, Pune, on March 15, 2004, with accuracy of ±0.001 s.

The reaction time is measured on a built-in 4 digit chronoscope with least count of 1/1000. The participants were individually tested in a soundproof room with the subject switch near them. Participant's head was stabilized in a straight ahead position. Auditory stimuli were pure sinusoidal tones of 2 kHz with duration of 170 ms was delivered through headphones.

Before giving the sound signal, the participant was asked to concentrate on the buzzer sound. Then, the auditory signal in the form of beep tone was delivered. The participant was asked to press the response key with index finger of dominant hand, on hearing the buzzer sound and the time was noted in milliseconds from the digital display. Three readings were noted and best of the three readings was taken as reaction time.

The data were analyzed statistically and unpaired *t*-test was applied using SPSS software (Version 15).

RESULTS

Age Distribution in Blind and Control Groups

We observed that the mean age group of blind participants was 24.77 ± 2.65 years while that of sighted participants was 25.20 ± 2.59 years (Table 1) which was statistically nonsignificant, and hence we conclude that the two groups are comparable.

Human Auditory Reaction Time

Auditory reaction time was noted between blind and control groups using simple auditory reaction time analyzer. Mean auditory reaction time for the blind group was 0.21 ± 0.03 s while that for the control group was 0.32 ± 0.06 s, (Table 2) which is statistically significant.

DISCUSSION

The data from our study suggest that auditory reaction time is significantly reduced, in congenitally blind participants compared to blindfolded sighted participants.

Blind subjects in the study group were trained from childhood to use auditory cues to localize events in their environment. This early auditory training might have resulted in increased concentration and alertness toward external environmental stimuli resulting in use dependent plasticity and better special skills in intact modalities.

In the pre-operational level, mental images lead to reappearance of what that has been previously perceived. According to the theory of sensory compensation, children who are deprived of visual experience and mental imagery can have mental imagination based on their auditory sense. When auditory imagination is addressed naturally full attention is drawn to stimuli and vocal-verbal patterns. In other words, the imagination of what that is auditory is the alternative of the imagination of what that is visual.[6]

Blind humans seem to have a better temporal resolution for auditory stimuli than sighted humans as well.

Congenitally blind subjects outperformed sighted subjects in auditory temporal order judgment tasks.[7] Spectral and temporal discrimination are known as central auditory skills,

Table 1: Comparison of age between blind and control groups

Variable	Groups (mean±SD)				Unpaired *t*-test applied	
	Blind		Control		*P*-value	Difference
Age (years)	24.77	2.65	25.20	2.59	0.173	Non-significant

SD: Standard deviation

Table 2: Comparison of human auditory reaction time (s) between blind and control groups

Variable	Groups (mean±SD)		Unpaired *t*-test applied	
	Blind	**Control**	***P*-value**	**Difference**
Auditory reaction time 1	0.21±0.06	0.33±0.09	0.0000005551	Significant
Auditory reaction time 2	0.22±0.05	0.30±0.07	0.0000093875	Significant
Auditory reaction time 3	0.19±0.05	0.33±0.09	0.0000000015	Significant
Average auditory reaction time	0.21±0.03	0.32±0.06	0.0000000000	Significant

SD: Standard deviation

and therefore, it has been hypothesized that better auditory-perceptual skills in the blind are due to faster or more efficient processing in cortical auditory areas.[8]

Cross-modal plasticity often develops after long-term sensory deprivation which occurs early in life like congenital blindness. It can strengthen other sensory systems to compensate for the lack of vision by the formation of new connections with the visual cortex that no longer receive sensory input. Through cross-modal plasticity, the auditory, and visual cortices are interconnected and also there is an expansion of auditory cortex which enhances the abilities of the auditory system in the blind, making them more superior in auditory tasks like syllable detection.[9]

Expansion of auditory cortical area causes recruitment of more neurons in auditory processing. As a result, a particular note of sound frequency which would activate a smaller set of neurons now activates larger set of neurons making them more frequency specific and quick. This reduces auditory reaction time in blinds.[10]

Event-related brain potentials (ERP) allow a direct measurement of central processing of auditory stimuli. ERPs are extracted from the ongoing electroencephalogram in blind and sighted subjects. Moreover, it was found that blind subjects had shorter latencies of N1 which is a negative deflection of ERP, and they detect auditory stimuli faster than sighted participants.[11]

On the contrary, according to disability theory, vision is necessary to calibrate in particular spatial perception of the other senses. Therefore, blindness could be detrimental to the processing in the remaining senses as well.

Also in another comparative study of auditory reaction time, it was found that both the groups showed similar performance, reflecting that, the perception and response toward auditory stimulus are same in both the groups and loss of one sense do not reflect on the overacting of other sense. Due to defects in their visual system, they have greater reaction time.[3] Researchers believe that this additional time is spent more to plan and initiate movements.

Our finding that congenitally blind subjects significantly outperform blindfolded normal sighted people suggests the superiority of the blind individual with regard to central auditory function.

This difference might be due to early auditory training and habit of concentration to auditory stimuli by the blinds, which produces the great expansion of auditory map. The expansion of auditory cortical representations is based mainly on the activity-dependent modifications of synaptic circuitry.[10]

Age also plays an important role in these plastic changes. The age of onset of auditory training as well as onset of blindness have both been shown to be critical for the extent of reorganization. Blindness when occurs early in life not only makes the sensory cortex more responsive to other senses but also improves sensory-motor coordination resulting in faster auditory reaction time in blinds.[10]

While in the early blind individual recruitment of visual areas for processing of nonvisual cues like touch and hearing (cross-modal plasticity) might be responsible for the enhancement of auditory and tactile in blinds.[12]

During childhood, our motor abilities are more malleable and our auditory cortex has sensitive periods for self-organization.[12]

We can motivate parents of blinds for early musical and auditory training as a part of rehabilitation.

CONCLUSION

Congenitally blind subjects outperformed blindfolded sighted subjects with respect to auditory reaction time.

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