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Original Article

Do Congenitally Blind Individuals have Better Haptic Object Perception Compared to Blindfolded Sighted Individuals?

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Abstract

Objective: Haptic perceptual enhancement in congenitally blind people is a subject of intense debate. There is no consensus whether the congenitally blind get the benefit of their haptic experience or the sighted get the benefit of previous visual experience when it comes to recognizing objects by manual exploration using different constraints. The present study compared haptic object perception between congenitally blind and blindfolded sighted participants in a situation where manual exploration of objects was constrained. **Methods**: Thirty congenitally blind braille readers and 30 age and gender matched controls were studied. All participants were required to identify the objects haptically, without the aid of vision. Manual exploration of the objects was constrained by permitting touching of the object with only the exposed tip of the index finger with the aim to limit cues about material information. Performance was evaluated in terms of speed and accuracy with which objects were identified. **Result:** The recognition time analysis showed that congenitally blind participants recognize objects much faster than blindfolded sighted participants. The analysis of haptic recognition rates showed that congenitally blind participants identified the objects more accurately compared to blindfolded normal sighted individuals. **Conclusion:** Congenitally blind individuals appear to possess a definite enhanced haptic perceptual ability allowing for faster and more accurate recognition of objects even when manual exploration is constrained.

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Introduction

Most human beings rely primarily on vision to gain information about their surroundings. This being said, sensory information conveyed via cutaneous and kinesthetic inputs to the brain also constitutes an important mechanism for perception of objects and the surroundings. This latter mechanism is referred to as the haptic system. Individuals with a normally functioning visual system usually identify objects using vision. In the blind however, the sense of touch is essential (1). Visual cues identify objects based on their spatial and geometric properties while the sense of touch relies largely on the material properties of the objects (2). Though several studies have reported a strong correlation between visual and haptic perception, the haptic system has also been reported to produce significant errors in certain types of spatial tasks (3), (4). Individuals who lose vision later in life (late blind) show higher performance in haptic perception as compared to congenitally blind, who perform better than normal sighted persons.

An important component of haptic perception is the use of hands for exploratory movements or manual exploration of objects. These movements are primarily of two types. The first called enclosure uses the fingers to mold around an object's contours to gauge its shape. The second, called contour following interprets smaller features of the object and confirms the findings obtained by the enclosure movement.

Constraining manual exploration during haptic recognition of objects has been reported to reduce object recognition accuracy in blindfolded normal sighted individuals (5). However it is not well known how these individuals would compare in haptic object recognition tasks using constrained manual exploration compared to the congenitally blind. The present study attempted to study this phenomenon to explore whether past visual experience, offers an advantage in object recognition in conditions where manual exploration is constrained.

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 (CARE).

Thirty 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 subjects of the same age group were randomly recruited as controls (Control group). It was ensured that none of the participants had any sensorimotor deficits of the hands in the form of leprosy, neuropathy or neuritis.

An informed written consent was obtained from each study participant. The control group was subjected to a test for visual acuity to ensure all subjects had normal vision. All the subjects were briefed in detail about the test procedures. The subjects of the control group were blindfolded for all the tests for object recognition. Each subject was given one practice session prior to testing in order to familiarize them with the test procedure. The practice session used objects different from the ones used for actual testing of the subjects.

The study protocol was based on that described by Klatzsky and Lederman (5). Fifteen common objects of everyday use were selected for the test. These were divided into three sets of five objects each as shown in Table I.

TABLE I: Sets of common objects used for the study.

Set I	*Set II*	*Set III*
Pen	Watch	Strainer
Lock	Coin	Scissor
Key	Fork (plastic)	Stapler
Lamp	Spectacles	Bangle
Candle	Comb	Foot rule (plastic)

Test procedure

The protocol required subjects to identify the objects in each of the above sets, one set at a time, using constrained manual exploration. Each subject was administered the three sets in random order. Manual exploration was constrained by (a) allowing subjects to use only a single outstretched index finger to feel the object. This did not allow subjects to hold the object and was aimed at reducing three dimensional cues, (b) making subjects wear a glove with only the distal phalanx of the index finger exposed. This ensured that subjects felt the object only by the tip of their index finger. The blind group used the index finger of the hand used by them to read Braille while the control group used the index finger of their dominant hand.

The test required both groups to identify as many objects as possible within a span of 30 seconds. Time was noted using a conventional stopwatch. The number of objects correctly identified within 30 seconds was expressed as a percentage of the total objects in the set and used as a measure of the accuracy of haptic object perception. Subjects were allowed to continue constrained manual exploration at the end of 30 seconds till such time they could identify all objects in a given set correctly. This time was taken as an indicator of the speed of haptic object perception. The same procedure was followed for each of the three sets administered to every subject. An overview of the test protocol is shown in Fig. 1. The data collected from each group was recorded on an MS Excel sheet and subjected to statistical analysis.

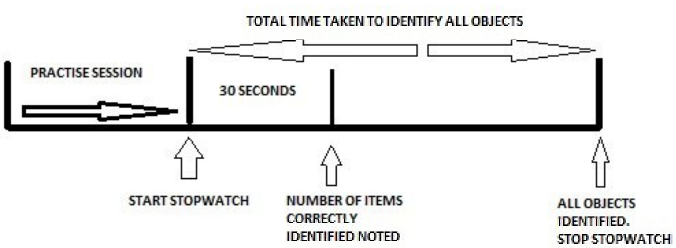

Fig. 1 : Overview of test protocol.

The data was analyzed using SPSS software (Version 15). An unpaired t-test was used to analyse differences between the blind and control group.

Results

The congenitally blind and control groups were comparable in terms of age, 24.7±2.6 years and 25.2±2.5 years respectively.

A comparison of the times taken by the blind and control group to identify objects in each of the three sets is shown in Table II. The blind group was able to identify objects on an average 17 to 20 seconds faster than the control group. This difference was consistent across all the three sets of objects tested and was statistically significant.

TABLE II : Comparison of Time required for Object Identification between Blind and Control Groups.

Groups	*Time taken to identify objects in set I (s)*	*Time taken to identify objects in set II (s)*	*Time taken to identify objects in set III (s)*
Blind	33.85±12.68	32.76±10.80	32.29±13.35
Control	50.85±8.44	49.35±10.82	52.10±10.83
p value	0.0000000889	0.0000001658	0.0000000418

The blind group also showed significantly higher accuracy in identification of objects, (93% to 99%) compared to the control group (68% to 76%). This difference, again, was consistent across all the three sets of objects used for the study (Table III).

TABLE III : Group-wise Object Identification accuracy in Blind & Control Groups.

Groups	*Accuracy of object identification set I (%)*	*Accuracy of object identification set II (%)*	*Accuracy of object identification set III (%)*
Blind	99±5	98±6	93±12
Control	68±21	76±18	74±21
p value	0.0000000001	0.0000000269	0.0000978394

Discussion

The data from our study suggests that haptic object perception is significantly better, both in terms of accuracy and speed, in congenitally blind participants compared to blindfolded normal sighted individuals during constrained manual exploration.

Haptic perception abilities have different dimensions that range from simple recognition of patterns and forms to perception of texture of materials to identification of more complex three-dimensional geometry. Each of these phenomenon use different patterns of neuronal processing and synthesis of tactile information. The presence or absence of visual information, visual experience and visual memory can affect some of these neuronal processes.

Whether congenitally blind persons have enhanced haptic perceptual ability has long been debated. A comparison of haptic material perception in congenitally blind and blindfolded sighted participants found material representation to be comparable in both groups, and concluded that there was no extra advantage of visual experience to sighted participants when it came to haptic material perception (6).

Visual experience, however, has been shown to play a role in haptic 3-D shape perception where late blind individuals outperform their sighted counterparts while congenitally blind individuals are no better than sighted controls. This suggests that though blindness does lead to an enhancement of tactile abilities, early visual experience may play a role in facilitating haptic 3-D shape discrimination. [7] With respect to haptic identification accuracy of familiar 3-D objects, studies report either no difference between early blind and visually experienced, i.e. late blind and blindfolded normal sighted individuals (8, 9) or differences that favour only the visually experienced i.e. late blind [8] or both, the late blind and blindfolded normal sighted individual (10). Lederman et al have reported that the congenitally blind do poorer than normal sighted individuals on tests of haptic recognition using 2-D displays of common objects. The study reports a 10% correct response in the congenitally blind compared to a 34% correct response in normal sighted individuals (2).

The finding that congenitally blind perform better than blindfolded normal sighted individuals in haptic perception when the haptic exploration is constrained may be due to the advantage conveyed to blind subjects by their education in mobility skills and also their primary reliance on controlled, sequential processes (i.e. via haptic perception) during navigation, leading to superior working memory abilities in terms of both the amount that can be processed, and the ability to recall the sequence in which information was presented (11, 12).

Blind individuals also need to develop a vast memory of cutaneous and kinesthetic information in order to manage their daily life independently. This makes their haptic system more superior than sighted individuals in haptic object recognition.

Interestingly, when cutaneous and kinesthetic information is limited by restraining manual exploration, as for example in the present study, haptic object recognition has been found to be impaired to differing degrees in terms of accuracy and response time. The present study used different ways by which the nature and amount of spatial information was restricted. Firstly, we limited the duration of manual exploration to 30 seconds. This probably had its own important consequences, since it known that haptic representation of object shape is constructed over time (13). Increasing haptic exploration time has shown to improve matching performance. We additionally made the subject explore the objects only with a single outstretched index finger with an exposed fingertip. This was done to encourage a contour-following exploratory procedure, which involves tracing along edges. It resulted in depriving our subjects of normally available kinesthetic spatial cues. This forced sequential pick up of object contours necessitates a process of spatio-temporal integration, and slows the subject considerably. It thus imposes a heavy memory load on temporal integration that frequently leads to error.

Our finding that congenitally blind subjects significantly outperform blindfolded normal sighted people both in the accuracy and speed of haptic perception during constrained manual exploration of objects suggests that the congenitally blind benefit from their enhanced haptic experience. It also suggests that visual experience and visual imagery might not have a significant role in haptic perception during constrained manual exploration. Our data also suggests that training in reading braille could be a possible factor responsible for enhanced haptic perception in the congenitally blind. It would therefore be interesting to explore the temporal characteristics of enhanced haptic perception in the congenitally blind to assess differences, if any, between early versus late exposure to tactile training strategies for the blind.

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