Momentary improvement of hand sensation by excluding vision

Key words: tactile discrimination, 2PD, visual deprivation

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Abstract

Purpose: The aim of this study was to investigate the effects of visual input on the results in a sensory testing procedure.

Method: In 66 healthy persons sensory testing was done in a counterbalanced setting 1) with open eyes, and 2) blindfolded. The tested hand was placed behind a screen. Testing for tactile discrimination (2pd) and touch thresholds (Semmes-Weinstein monofilaments) was performed on the index finger of the dominant hand. Wilcoxon signed-rank test was used for the statistical analysis.

Result: Two-point discrimination was significantly improved when the test was performed blindfolded compared with open eyes. Touch thresholds – a less complex task – showed no difference.

Conclusion: This study demonstrated that removal of all visual input during sensibility testing results in improved test results compared to sensibility testing with visual input (opened eyes but the hand out of sight). The mechanism behind the improvement is likely rapid changes in the brain. Manipulation of visual input during sensibility testing, especially when performing tests that include an element of interpretation, influences the test result. These results highlight the importance of standardized procedures in sensibility testing.

Introduction

Assessment of touch thresholds and tactile discrimination is a routine procedure in hand surgery and hand rehabilitation in diagnosing and in follow-up after injuries and diseases of the hand. Irrespectively of specific test equipment the test procedure requires concentration and should be performed in accordance to standardized protocols where *"vision should be occluded"*[1]. However the occlusion of vision is done in various ways. Some examiners use a screen to hide the hand, and the patient has the eyes open during the test procedure. Sometimes the patient is instructed to close the eyes during the examination, look in another direction, or use an eye mask for blindfolding.

It is well known that cortical areas in the brain responsible for vision are active during tactile perception[2, 3].. The somatosensory cortex where sensory information is processed is connected to other perceptual modalities such as vision and hearing, and tactile information is integrated across modalities[4, 5]. The activity in visual cortex is e.g. enhanced by tactile stimulation.[6]. In animal studies it is described that multisensory brain areas enhance their processing of input to remaining senses when one sense is deprived. This has also been shown in blind and deaf humans[5, 7]. Blind individuals may demonstrate exceptional abilities in auditory spatial processing and such enhanced performances may be intrinsically linked to the recruitment of occipital areas deprived of their normal visual inputs [6, 8, 9.10].

There are several reports about the effects on tactile function following short-term visual deprivation. Some of the changes reported in the blind also seem to occur after short-term visual deprivation of sighted individuals[4, 6, 11]. Blindfolding for 90 min has been shown to result in a reversible improvement of performance on discriminative capacity[12]. of similar magnitude to that reported in the blind.[13]. Five days of blindfolding improves Braille character discrimination[14]. After the same period of time, fMRI studies have indicated that occipital cortex becomes responsive during both tactile discrimination of Braille characters and auditory discrimination of tones[7].

In sensory testing there is no question that the tested hand should be out of vision, but does it matter if the eyes are open or not during tactile testing?

The aim of the present study was to investigate the effects of visual input on the outcome in sensory testing.

Methods

Participants

Sixty-six healthy volunteers recruited from hospital staff (56 females and 10 males) mean aged 44 years (range 19-67 years) participated in the study. The Ethics Committee at Lund University approved the study, the study subjects gave informed consent and the experiments were conducted in accordance with the declaration of Helsinki.

Experimental procedure

The test subjects were comfortably seated opposite the examiner in a small quiet room. Apart from table and chairs the visual input was various testing equipment on shelves, a couple of posters about sensibility, and a glass-door facing an office. The room was not completely sound proof, but auditory stimulation from background notice was minimal.

Touch thresholds was established using Semmes-Weinstein monofilaments (SWM). Testing for tactile discrimination was performed with two-point discrimination (2pd). Both tests were performed on the pulp of the index finger of the dominant hand according to standardized test protocol[1]. The hand rested comfortably in supine position on a pillow. Testing was done in two consecutive settings. 1) with open eyes, and 2) blindfolded (Fig 1 a and b). The tested hand was placed behind a screen in both settings.(Fig 1). Testing was counterbalanced with every other person starting with setting 1 or 2 respectively. The test procedure took approximately 10 minutes.

Analysis:

Wilcoxon signed-rank test was used for the statistical analysis, and p-value below 0.05 was considered significant.

Result

The result of 2pd-testing i.e. tactile discriminative capacity was significantly better when the test was performed blindfolded. The test for touch thresholds did not show any significant changes (Table 1).

Discussion

Normally our senses are in a balanced interaction to experience and explore the surrounding world. If one sense is excluded other senses may be re-enforced to compensate for the deficit (11). Here we show in normally sighted healthy individuals that tactile discrimination is improved when *all* visual input is blocked. The speed and dynamic nature of the observed improvement in tactile discrimination, i.e. an instant and significant functional effect during blindfolding, has to our knowledge not been presented before. Likely the mechanism behind the improvement is an unmasking of normally existing but inhibited neural structures and a cross-modal activation of visual cortex that does not require the formation of new connections. With such a rapid cortical phenomenon as described here the visual areas can hypothetically be used for sensory processing of tactile stimuli.

According to the clinical standards for assessment of sensory function of the hand, the choice of instruments should be guided by empirical evidence. However, the way to exclude vision in the test procedure has not been defined clearly.

Our results specifically showed improvement in tactile discrimination as demonstrated in two-point discrimination-test during blindfolding. Two-point discrimination-testing tactile discriminative capacity as well as Semmes-Weinstein monofilament-testing touch threshold requires full concentration by the test subject. However, the visual input from the room during the test only influenced the tactile discriminative capacity i.e. the capacity to discriminate touch from one or two points on the finger tip (2pd-test). This is a test that includes a high degree of interpretation and a decision-making thus making use of other areas in the brain besides the primary somatosensory cortex.   The SWM test that just establishes touch thresholds more likely uses fewer areas in the brain besides the primary somatosensory cortex. The test subject is just instructed to say touch when he/she perceives touch on the tip of the finger.

Tactile improvement induced by short-term visual deprivation linked to rapid brain plasticity and several groups have reported reversible changes in visual cortex in sighted and non-sighted persons [6, 11, 15, 16]. Goel et al show in an animal study also how manipulation of visual input not only engage cortico-cortico inputs but also thalamocortical input [17]. This suggests that normally inhibited or masked functions in the sighted are revealed instantly by visual loss. The unmasking of pre-existing connections represents rapid, early plastic changes, which presumably can lead, if sustained and reinforced, to development of also more permanent structural changes. This long term effect with established new cortical connections is of course of interest in a re-learning perspective, and visual input is also an important part of sensory re-education following nerve injuries[18].

There is a “natural” cross-modal dynamics during tactile processing[19]., that maybe is disrupted by the visual deprivation used in our experiment. However, in a test situation with diminished tactile capacity of the hand after injuries and diseases of the nervous system, we have to refine the examination of the hands´ true tactile capacity.

Our study demonstrated that manipulation of visual experience during sensibility testing, influences the test result. An increased level of concentration / attention with focus on the tactile discrimination task when the eyes are closed, is one explanation. On the other hand concentration is maybe just an expression for a rapid cortical shift between modalities. Brain imaging studies are needed to verify the rapid cortical dynamics during theses processes.

It is concluded that our results highlights the importance of definition of a standardized procedure regarding visual input, during examination of tactile discriminative capacity of the hand.

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Figure legends

1a) Procedure 1 without eye-mask (SWM-testing)

1b) b) Procedure 2 with eye-mask (SWM-testing)

Table 1

	With eye mask	Without eye mask	
Detection of touch SWM (#) median (range)	2.36 (1.65 - 2.44)	2.36 (1.65 - 2.44)	ns
Discrimination of touch 2PD (mm) median (range)	2.5 (1.9 - 2.8)	2.8 (2.2 - 3.4)	p = < 0.001