Available online at www.sciencedirect.com
ScienceDirect
Brain and Cognition 64 (2007) 282–289
Brain and Cognition
www.elsevier.com/locate/b&c

Right hemisphere specialization for color detection

Hitoshi Sasaki *, Akiko Morimoto, Akira Nishio, Sumie Matsuura

Department of Physiology and Biosignaling, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita 565-0871, Japan

Accepted 30 March 2007
Available online 9 May 2007

Abstract

Three experiments were carried out to investigate hemispheric asymmetry in color processing among normal participants. In Experiment 1, it was shown that the reaction times (RTs) of the dominant and non-dominant hands assessed using a visual target presented at the central visual field, were not significantly different. In Experiment 2, RTs of ipsilateral hands to lateralized chromatic stimuli revealed that the processing time was 17 ms shorter in the right hemisphere (RH) than that in the left hemisphere among the right-handed participants, whereas no significant difference was found among the left-handed participants. On the other hand, RTs to lateralized achromatic stimuli showed no such asymmetry among both the right- and left-handed participants (Experiment 3). These findings strongly suggest RH superiority for detection of color among right-handed individuals.

Keywords: Laterality; Asymmetry; Cerebral cortex; Reaction time; Color perception; Visual field; Luminance; Handedness; Humans

1. Introduction

Hemispheric asymmetry of various cerebral functions is well documented both in normal individuals and patients who suffer from serious epilepsy. The left hemisphere (LH) plays an important role in linguistic and higher order cognitive processes, such as self recognition (Conway et al., 1999; Turk et al., 2002), whereas the right hemisphere (RH) is responsible for tasks such as face recognition (Barton, Press, Keenan, & O'Connor, 2002; Haxby et al., 1994; Kanwisher, McDermott, & Chun, 1997; Sergent, Ohta, & MacDonald, 1992), and visuospatial processing (Corballis, 2003; Kimura, 1969). Although color perception is one of the important factors underlying higher visual processing, little is known about hemispheric asymmetry in color processing.

The optic nerve fibers originating from the nasal retina project to the contralateral visual cortex, while those from the temporal retina project to the ipsilateral visual cortex. The right motor cortex innervates the left hand and the left one innervates the right hand. Hemispheric asymmetry in color processing can be examined using a simple manual reaction time (RT) task using lateralized chromatic stimuli. This test is based on the double crossed projections of the visual and pyramidal pathways in humans (Berlucchi, Heron, Hyman, Rizzolatti, & Umilta, 1971; Poffenberger, 1912).

Some of data have been reported in a previous publication (Sasaki, Matsuura, Morimoto, & Fukuda, 2003a) and portions of the work have been presented in abstract form (Sasaki & Fukuda, 2002; Sasaki, Matsuura, Morimoto, & Fukuda, 2003b).

2. Experiment 1

Hemispheric asymmetry can be evaluated based on the difference in RTs to lateralized stimuli with the ipsilateral hand. The first experiment was designed primarily to evaluate a difference of RTs between the dominant and non-dominant hands using achromatic targets presented at the center of the visual field.

* Corresponding author. Fax: +81 6 6879 3619.
E-mail address: H.Sasaki@Physiol.com (H. Sasaki).

0278-2626/$ - see front matter
doi:10.1016/j.bandc.2007.03.010

2.1. Methods

2.1.1. Participants

Ten right-handed volunteers with normal or corrected normal vision (age: $M = 19.5$, $SD = 2.7$ years, 3 male and 7 female) participated in the first experiment. Most of the participants were selected from 10 groups of eight subjects each in a preliminary experiment, because they showed the smallest variability and the shortest RT in each group. In the preliminary experiment, 13 simple RTs to color stimuli (either red, green blue or yellow) presented at the center of a cathode ray tube (CRT) display were recorded. No 'ready' signal was used in the preliminary experiment. All the participants were naive to this kind of behavioral experiment and the experiments were performed with the consent of each participant.

2.1.2. Apparatus and stimuli

An achromatic solid circle with a diameter of 2 deg ($x = 0.283$, $y = 0.320$, CIE) was presented on a CRT display (Panasonic TX-D7P35-J, Tokyo, Japan, with a resolution of 800×600 dots at 60 Hz, 9300 K). The luminous intensity of the target was 12, 14, or 18 cd/m^2 with a uniform gray background of 10 cd/m^2. The CRT display was placed at a distance of 57 cm from the participant's eye. All the visual stimuli were generated using a graphic generator (VSG Series Three, Cambridge Research Systems Ltd., Rochester, England).

RT was measured using a programmable logic controller (Keyence KV24AT, Osaka, Japan). All experiments were controlled by a computer (Power Macintosh 7300/180, Apple, USA), using a hand-made program (HyperCard, Apple) and a serial/parallel interface.

Electro-oculogram (EOG) was recorded from two small electrodes with a diameter of 5 mm placed 2 cm above or below the lateral edges of right and left eyes. The signal was amplified with a time constant of 1.5 s and with a high-cut filter at 60 Hz (Nihon Kohden, EEG-4316, Osaka, Japan) and was recorded on a computer (Power Macintosh 7100/80AV, Apple) after being digitized at 400 Hz (MacLab, AD Instruments, Tokyo, Japan). If the amplitude of EOG exceeded 50 μV, which corresponded to an eye-movement of 3 deg, or if an eye blink occurred at the time of stimulus presentation, the trial was omitted from later analysis. In addition, trials with RTs longer than 400 ms were omitted from later analysis. Thus about 10% of the trials were omitted as error trials in all three experiments.

2.1.3. Procedure

Participants were seated in a sound-attenuated chamber, facing the CRT display. The participant's head was loosely restrained by using a chin rest, and the participant was asked to fixate at a small cross (0.5 deg, 0.5 deg) at the center of the CRT. An auditory 'ready' signal preceded the onset of the target stimulus by 1–4 s ($M = 2.5$ s), and the delays were delivered in a quasi-random order.

Two blocks of experiments were performed with an inter block interval of about 5 min (Fig. 1). In each block, participants were encouraged to press the key as quickly as possible to each stimulus presented at the center of visual field. Before starting each block, participants were instructed which hand to use and the order of hand use was randomized among the participants. Each block consisted of 15 trials with a randomized inter trial interval of 15 s ranging from 10 to 20 s. The median RT was calculated for each block for each participant. The mean value was then obtained for each condition (right or left hand).

2.2. Results

Fig. 2 shows RTs with the dominant (right) and non-dominant (left) hands to three different target luminance (12, 14 and 18 cd/m^2). RT decreased gradually as a function of stimulus intensity. In any stimulus intensity examined, however, there was no significant difference between the RTs of the right and left hands. Similar results were obtained for the mean of these three luminance conditions, shown at the extreme right column in Fig. 2 (12–18 cd/m^2). Statistical analysis using analysis of variance (ANOVA) showed that only the effect of luminance was significant, $F(2,18) = 5.85$, $p < .01, \eta p^2$ (partial eta square) = .394, and both the effect of hands and the interaction between these two factors were not significant, $F(1,9) = 0.02$, N.S., and $F(2,18) = .55$, N.S., $\eta\ p^2 = .06$, respectively.

2.3. Discussion

The results of Experiment 1 suggest that the dominant hand has no advantage over the non-dominant hand for the simple RT task, in which triggering simple hand-movement-initiation is required. This finding is well consistent with previous studies (Adam & Van Veggel, 1991; Annett & Annett, 1979; Hayes & Halpin, 1978), thus confirming the validity of the present experimental procedures. The time required for the response selection and/or the motor control processes, which can be assumed to exist between stimulus presentation and the response (Schmidt & Lee, 1998), were also suggested to be similar between the RTs by the dominant and non-dominant hands. This means that no correction is required when comparing RTs by the dominant and non-dominant hands in the following experiments.

3. Experiment 2

In Experiment 2, we evaluated the hemispheric difference of color processing by comparing RTs of the right and left hands to chromatic stimuli presented to the ipsilateral visual field of both right- and left-handed individuals.