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Haptic face recognition and prosopagnosia

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Abstract

Cases of cross-modal influence have been observed since the beginning of psychological science. Yet some abilities like face recognition are traditionally only investigated in the visual domain. People with normal visual face-recognition capacities identify inverted faces more poorly than upright faces. An abnormal pattern of performance with inverted faces by prosopagnosic individuals is characteristically interpreted as evidence for a deficit in configural processing essential for normal face recognition. We investigated whether such problems are unique to vision by examining face processing *by hand* in a prosopagnosic individual. We used the haptic equivalent of the visual-inversion paradigm to investigate haptic face recognition. If face processing is specific to vision, our participant should not show difficulty processing faces haptically and should perform with the same ease as normal controls. Instead, we show that a prosopagnosic individual cannot haptically recognize faces. Moreover, he shows similar abnormal inversion effects by hand and eye. These results suggest that face-processing deficits can be found across different input modalities. Our findings also extend the notion of configural processing to haptic face and object recognition.

Keywords: Touch; Face-inversion effect; Multisensory

1. Introduction

Cases of cross-modal influence have been noted since the beginning of psychological science. In 1839, Brewster reported that observers who saw indented objects (e.g., engraved seals) through an optical device that inverted apparent concavity, also experienced a haptic inversion effect when they explored these objects simultaneously by touch (Brewster, 1839). The corresponding question—is failure to recognize what one sees also associated with a failure to recognize what one touches—has rarely been raised. In light of the ongoing debate on face specificity and the importance of prosopagnosia to this discussion, it appears highly relevant to ask whether a deficit in face recognition by vision might be associated with a deficit in face recognition by touch (i.e., the haptic system).

Neurologically intact individuals process faces more by their overall configuration than by their local features (de Gelder & Rouw, 2000a; Freire, Lee, & Symons, 2000). To investigate this configural or holistic (Tanaka & Farah, 1993) recognition strategy, researchers have predominantly used the inversion effect, which is defined as a decrease in performance when recognizing inverted as oppose to upright faces (Valentine, 1988; Yin, 1969). Results that show a relatively stronger inversion effect for faces than for other mono-oriented objects have also been interpreted as evidence that faces occupy a special status (Diamond & Carey, 1986) among visually apprehended objects. This weaker inversion effect for non-face objects is presumably due to recognition that is more strongly based on features and less disrupted by inversion (Leder & Bruce, 2000).

The inversion effect plays an important role in understanding the visual deficits of patients with a category-specific recognition deficit for faces (prosopagnosia). Some prosopagnosic individuals do not demonstrate the typical inversion effect, while others process inverted faces better than upright faces (de Gelder & Rouw, 2000b; Farah, Wilson, Drain, & Tanaka, 1998). The paradoxical inversion effect (de Gelder & Rouw, 2000b) indicates that configural processing is disrupted but not totally absent. When the need for configural processing is removed (by inverting the face), a feature-based analysis can be performed more easily.

Previous studies have been confined to investigating face recognition and its deficits in the visual modality only. Yet there is no intrinsic link between vision and face recognition

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or prosopagnosia. In fact, intact lower-level visual abilities figure prominently among the diagnostic criteria for prosopagnosia. And disorders of higher cognition can either be limited to a single sensory modality or occur across more than one modality (Feinberg, Gonzalez-Rothi, & Heilman, 1986), depending on whether the information is available to more than one sensory system. Haptic face recognition has recently been demonstrated in normal individuals (Kilgour & Lederman, 2002); however, it has never been studied in prosopagnosics.

Can a prosopagnosic individual recognize faces solely by touch? We investigated this question using a haptic inversion paradigm in which our prosopagnosic participant, LH, was required to decide whether two faces (or two non-faces) were the same or different from one another. To date, LH's sense of touch has never been assessed formally. We therefore also evaluated his sensorimotor hand function.

2. Method

2.1. Participants

2.1.1. Patient

LH is a 51-year-old man who sustained bilateral occipito-temporal, right frontal, and anterior temporal lesions subsequent to a motor vehicle accident in 1968. He has been prosopagnosic since that time. Detailed neuropsychological information can be obtained in other reports (Etcoff, Freeman, & Cave, 1991; Farah, Levinson, & Klein, 1995; Farah, Tanaka, & Drain, 1995; Levine, Calvanio, & Wolf, 1980).

2.1.2. Control group

We tested seven gender-, age- and education-matched, neurologically intact participants as controls for LH (mean age = 51.3 years, S.D. = 2.3). These participants completed four blocks (18 trials/block) with the same stimuli that we presented to LH. The blocks consisted of faces and teapots, each presented in upright and inverted positions. Additionally, each control-group participant completed a visual face-recognition test (Benton, Sivan, Hamsher, Varney, & Spreen, 1994), and was within normal limits.

All participants provided informed consent. The General Ethics Research Board of Queen's University has given approval to this study.

2.2. Materials and procedures

2.2.1. Assessment of sensorimotor hand function

LH was blindfolded in all conditions but for visual face recognition. Four preliminary tests assessed LH's cutaneous thresholds, fine motor dexterity and haptic object-recognition capabilities. To determine LH's tactile sensitivity, we used von Frey hairs, consisting of nylon monofilaments of varying diameters, each calibrated to bend with the application of a specific pressure. The stimuli were applied to the volar surface of the index finger of each hand. LH was required to state whether or not he detected the stimulus. A two-alternative (Y/N) adaptive forced-choice procedure was used, with the pressure threshold calculated as the average of the pressures corresponding to five changes in response direction.

We measured LH's tactile acuity using a two-point discrimination test. We used a set of four octagonal-shaped disks, each containing pairs of rounded metal prongs (1 mm diameter) arranged around the disk circumference in order of increasing inter-prong separation. The inter-prong distance was measured from the center of each prong and ranged from 1.2 to 9.0 mm in 0.2-mm steps. The prongs were applied perpendicularly to the long axis of the volar surface of the index finger with just enough pressure for LH to determine that he was being stimulated. LH's task was to decide whether he felt one or two points. A two-alternative adaptive forced-choice procedure was used, with the two-point touch threshold calculated as the average of the inter-gap distances corresponding to five changes in response direction.

LH's fine motor control was assessed using the Grooved Pegboard Test (Lafayette Instrument, 1970), a task that requires the participant to unimanually place 25 metal pegs into holes as quickly as possible.

LH's ability to haptically identify common objects was tested using a set of 24 household objects presented to his right (dominant) hand. He was required to name these objects as quickly and as accurately as possible.

2.2.2. Discrimination of face and non-face objects

We assessed LH's haptic ability to discriminate whether an object was an upright facemask, inverted facemask, upright teapot, or inverted teapot. All the faces and the teapots were made of stoneware clay. Fig. 1 shows three pairs of both the facemasks and the teapots. The clay facemasks were models of 36 female volunteers (for details see Kilgour & Lederman, 2002). We presented an exemplar from one of these four categories of stimuli one at a time and asked LH to identify the category to which it belonged. Each combination of object-type by orientation was presented on one quarter of the 64 trials. LH was required to state whether or not the object was an upright face.

2.2.3. Visual face-matching

We also tested LH's ability to discriminate the facemasks visually. This task was completed after the primary face/nonface experiment. The methodology was identical to that described below for the haptic task.

2.2.4. Haptic inversion paradigm

LH performed a 2AFC same/different face discrimination task. A "standard" facemask was presented to LH, who manually explored it with no time restriction. The standard face was then replaced with a second "comparison" facemask to explore. LH was required to state whether the two