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Holistic perception of the individual face is specific and necessary: Evidence from an extensive case study of acquired prosopagnosia

Thomas Busigny[a,*], Sven Joubert[b], Olivier Felician[c], Mathieu Ceccaldi[c], Bruno Rossion[a]

[a] Université Catholique de Louvain, Louvain-la-Neuve, Belgium
[b] Département de Psychologie, Université de Montreal & Centre de Recherche Institut Universitaire de Gériatrie de Montréal, Canada
[c] Service de Neurologie et de Neuropsychologie, AP-HM Timone, & Laboratoire Epilepsie et Cognition, INSERM U 751, Université de la Méditerranée, Marseille, France

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ABSTRACT

We present an extensive investigation (24 experiments) of a new case of prosopagnosia following right unilateral damage, GG, with the aim of addressing two classical issues: (1) Can a visual recognition impairment truly be specific to faces? (2) What is the nature of acquired prosopagnosia? We show that GG recognizes nonface objects perfectly and quickly, even when it requires fine-grained analysis to individualize these objects. He is also capable of perceiving objects and faces as integrated wholes, as indicated by normal Navon effect, 3D-figures perception and perception of Mooney and Arcimboldo face stimuli. However, the patient could not perceive individual faces holistically, showing no inversion, composite, or whole-part advantage effects for faces. We conclude that an occipito-temporal right hemisphere lesion may lead to a specific impairment of holistic perception of individual items, a function that appears critical for normal face recognition but not for object recognition.

1. Introduction

The ability to recognize people from their face is a fundamental brain function which holds a high social value. It is also an extremely complex function, which is nevertheless performed quite well in human adults. The adult human brain has developed mechanisms allowing, for instance, recognizing a familiar person from its face in less than half a second (Bruce & Young, 1986), or encoding new faces in memory effortlessly during the entire life (e.g., Bahrick, Bahrick, & Wittinger, 1975). Yet, interestingly, the field of face recognition was originally based upon the study of people who, following brain damage, have lost this expertise in recognizing faces.

Difficulty in face recognition as a major symptom in patients with cerebral disease was first reported in the nineteenth century (Charcot, 1883; Quaglino & Borelli, 1867; Wigan, 1844; Wilbrandt, 1887). However, it was Bodamer (1947) who proposed to isolate the disorder on the basis of three cases, and introduced the term *prosopagnosia* from the Greek "*prosopon*" (face) and "*a-gnosia*" (without knowledge). Prosopagnosia is classically defined as the inability to recognize individual faces following brain damage, an impairment that cannot be attributed to intellectual deficiencies or low-level visual problems (Benton, 1980; Bodamer, 1947; Hécaen & Angelergues, 1962; Rondot & Tzavaras, 1969). Prosopagnosic patients also generally still retain their ability to recognize people by other cues: the voice or other visual traits such as gait, size, clothes, or even facial features (moustache, scar, freckles, ...) or accessories (ear-rings, eyeglasses, piercings, ...).

Over the years, tens of cases of prosopagnosia following brain damage have been reported, although extensive neuropsychological investigations of prosopagnosic patients remain quite rare (e.g., Anaki, Kaufman, Freedman, & Moscovitch, 2007; Barton, 2008a; Delvenne, Seron, Coyette, & Rossion, 2004; Lhermitte, Chain, Escourolle, Ducarne, & Pillon, 1972; Riddoch, Johnston, Bracewell, Boutsen, & Humphreys, 2008; Rossion et al., 2003; Sergent & Signoret, 1992a; Sergent & Villemure, 1989).

Both in traditional (cognitive) neuropsychology and in modern cognitive neuroscience, the lesion method is seen as an invaluable and unique way of understanding normal brain function (e.g., Caramazza, 1986; Damasio & Damasio, 1989; Farah, 1990; Farah, 2004; Humphreys & Riddoch, 1987; Shallice, 1988), in particular with respect to face recognition. Such patient studies contribute to shaping our knowledge and conceptions of the processes involved in normal face recognition and their underlying neural networks.

From a functional point of view, there are two main debates concerning prosopagnosia, which have direct implications for understanding face recognition: (1) Can the impairment truly be restricted to face recognition (i.e. *face-specific*)? (2) What is the

* Corresponding author at: Université Catholique de Louvain (UCL), Faculté de Psychologie et des Sciences de l'Education (PSP), Unité de Cognition et Développement (CODE), Place du Cardinal Mercier, 10, B-1348 Louvain-la-Neuve, Belgium. Tel.: +32 010 47 92 60; fax: +32 010 47 37 74.
E-mail address: thomas.busigny@uclouvain.be (T. Busigny).

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nature of the disorder, that is, what is at the heart of our expertise in facial recognition, and which is lost in these patients? These two issues have proved quite difficult to resolve and are still debated (e.g., Barton, 2009; Damasio, Damasio, & Van Hoesen, 1982; De Renzi, 1986a; Hécaen, 1981; Riddoch et al., 2008; Rondot & Tzavaras, 1969; Sergent & Signoret, 1992a).

1.1. Prosopagnosia as a face-specific disorder

The issue of the specificity of the disorder has been complicated by the fact that most reported cases of prosopagnosia also present with difficulties in basic-level object recognition (e.g., Barton, 2008a; Boutsen & Humphreys, 2002; Damasio et al., 1982; Delvenne et al., 2004; Gauthier, Behrmann, & Tarr, 1999; Levine & Calvanio, 1989; Steeves et al., 2006). In many other cases, object recognition abilities were not tested sufficiently (e.g., De Renzi, 1986a; Ettlin et al., 1992; Tohgi et al., 1994; Young, Flude, Hay, & Ellis, 1993). A brief but extensive review of the neuropsychological literature points to 13 prosopagnosic patients who could be considered as presenting with a face-specific recognition disorder (Table 1). De Renzi (1986a) presented patient 4 who performed in the normal range at object and figure recognition, figure–ground discrimination, visual closure and segmentation. Patient VA (De Renzi, Faglioni, Grossi, & Nichelli, 1991) could name objects and pictures (presented under usual and unusual view) in the normal range, and succeeded at tasks of visual closure, coin discrimination, and recognition of makes of cars and personal belongings. Another patient described by De Renzi, Perani, Carlesimo, Silveri, and Fazio (1994), OR, was documented to present with an absence of impairment with respect to object naming, Italian coins discrimination, and recognition of animals, fruits and vegetables (under usual and unusual views). Takahashi, Kawamura, Hirayama, Shiota, and Isono (1995), in a study of four patients, related the case of a patient with apparently no object recognition impairment: case 3 succeeded in different tasks including overlapping figures, Gestalt completion test, Kanizsa triangle and real object naming. Schweinberger, Klos, and Sommer (1995) and Henke, Schweinberger, Grigo, Klos, and Sommer (1998) showed that the performance of patient MT was preserved in numerous tasks: recognizing overlapping figures, Gestalt completion task, object naming, animal naming and different series of similar objects to name (fruits and vegetables, symbols of German industrial brands and cars brands). Patient WB (Buxbaum, Glosser, & Coslett, 1996) presented with preserved object naming (real objects and drawings) and memory for homogeneous category of objects (glasses, under different views). Patient Anna (De Renzi & di Pellegrino, 1998) succeeded in several tasks: objects naming (color photographs and line drawings), perceptual categorization, visual segmentation and closure, and memory for homogeneous category of objects (glasses, under different views). Another study (Wada & Yamamoto, 2001) also reported a prosopagnosic patient who could perform well the tasks of overlapping figures, picture copying, recognition of letters and symbols, visual space perception, object naming (real objects, pictures, line drawings; under usual and unusual view), animal face and famous place recognition. Prosopagnosic patient PS was able to recognize objects perfectly and rapidly (Rossion et al., 2003) and could perform within-category discrimination for nonface items in the normal range of performance and speed (Busigny, Graf, Mayer, & Rossion, 2010; Schiltz et al., 2006). Barton and colleagues reported case 009 (Barton, 2008a, 2009; Barton & Cherkasova, 2005; Barton, Cherkasova, Press, Intriligator, & O'Connor, 2004), a patient who had no low-level visual impairment and was able to recognize incomplete letters, overlapping figures, real objects, vegetables and fruits, presented with a classical Navon effect, and showed some ability to process configurations of dots. Bukach, Bud, Gauthier, and Tarr, 2006 and Bukach, Le Grand, Kaiser, Bub, and Tanaka, 2008 related another case of selective impairment for faces, LR, who succeeded easily in tasks of low-level visual processing, silhouettes and object naming (under usual and unusual views). Riddoch et al. (2008) presented the case of FB, who had preserved abilities in low-level visual processing, non-living and living (birds, flowers, vegetables and fruits) objects naming, and in a task of learning associations between names and novel multipart objects. Finally, Rivest, Moscovitch, and Black (2009) published the case of DC, who performed normally in segmented object recognition, object naming, recognition of famous buildings and dog breeds.

These pure cases of acquired prosopagnosia suggest that some processes may be *necessary* to recognize faces efficiently, and that these processes may be selectively disrupted by brain damage. While these processes might also be involved in object recognition, they would not be necessary for this function.

1.2. The holistic perception account of prosopagnosia

Regarding the *nature* of the impairment in prosopagnosia, an influential idea is that such patients have difficulties in *perceiving a face as a whole, or a Gestalt*. This long-standing view (Galli, 1964) is inspired originally from the Gestaltist approach of visual perception (e.g., Koffka, 1935/1963; Kohler, 1929; 1930/1971; Wertheimer, 1925/1967). According to the Gestaltist view and its more modern revival (e.g., Kubovy & Poremantz, 1981; Navon, 1977; for a review see Kimchi, 1992), a whole item is qualitatively different from the sum of the components, the whole exceeding the sum of its parts. Hence, what takes place in each single part already depends upon what the whole is: objects are not only made of featural elements, but also defined by the interactions between these constituents, a property that is called *configuration* or *(w)holistic property* (e.g., Navon, 2003). For instance, a face is a typical visual stimulus made of parts (eyes, nose, mouth, . . .) that are organized in a whole configuration (a symmetrical structure with two eyes on top, above a central nose and mouth).

The idea that acquired prosopagnosic patients lose their ability to perceive faces holistically is supported at four levels.

First, many patients have been described as presenting with a configural/holistic[1] processing impairment, that is, an inability to integrate simultaneously different features into a coherent global representation (RB, Davidoff, Matthews, & Newcombe, 1986; HJA, Boutsen & Humphreys, 2002; Riddoch & Humphreys, 1987; LH, Levine & Calvanio, 1989; BM, Sergent & Villemure, 1989; WL, Spillmann, Laskowski, Lange, Kasper, & Schmidt, 2000; AR, Saumier, Arguin, & Lassonde, 2001; RC, Wilkinson et al., 2009; PS, Ramon, Busigny, & Rossion, 2010). For example, Levine and Calvanio (1989) described the patient LH as being unable to "*get an immediate overview of a face [. . .] as a whole at a single glance*" (p. 159). They conceptualized this loss of visual "*configural [i.e. holistic] processing*" as a deficit in visual perception reflected by the inability to derive an "*overview of sufficient features to allow structuring or crystallization of a coherent concept*". In the same vein, Spillmann et al. (2000) described the prosopagnosic patient WL as following: "*he was unable to form a holistic percept of a given face that would have revealed its bearer's identity. Rather, he used conspicuous features for recognition [. . .]. Recognition was based on characteristic details, not faces per se [. . .]. What seems to be lacking in WL is the ability to create an integrated, unitary percept or a gestalt of a human face enabling him to assign identity to an individual*" (pp. 93, 98).

[1] In this paper, in keeping with earlier studies in the field of face recognition and recent reviews of this issue, the terms holistic and configural are used interchangeably, as synonyms, to refer to the same process (see McKone & Yovel, 2009; Rossion, 2008a; Rossion, 2009).