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Familiar people recognition disorders: An introductory review

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1. ABSTRACT

The aim of this introduction is to provide a general background for the individual contributions dealing with different aspects of familiar people recognition disorders. Following are the main points considered in this survey: 1) the cognitive models proposed to explain the functional architecture of processes subsuming familiar people recognition; 2) the different roles of the right and left hemisphere in identifying people by face voice and name; 3) the anatomical structures and the cognitive processes involved in face and voice recognition; 4) the interactions that exist among the perceptual processes subsuming face and voice recognition, but not people's faces, voices and proper names; 5) the patterns of multimodal defects of familiar people recognition and their implications for current cognitive models. Finally, there is a short discussion of two models advanced to explain the role of the anterior temporal lobes in people recognition.

2. INTRODUCTION

The most important channels through which we draw critical information about other people are faces, voices and proper names; indeed, they allow familiar people identification, convey important information about gender and, in the case of faces and voices, provide important cues about the age and emotional status of known and unknown people. Yovel and Belin (1) have recently reviewed accumulating evidence of the similarity between the cognitive and neural processing mechanisms engaged in perceiving faces or voices, despite the very different nature of their sensory input. Nevertheless, two important asymmetries exist among the above mentioned channels of people identification. The first asymmetry concerns the different roles of the right and left hemisphere in familiar people recognition through faces, voices and proper names. The second asymmetry concerns the efficacy with which each of these channels allows retrieving person-specific information. These asymmetries have been studied intensively in the last few years and have contributed to questioning current cognitive models of people recognition.

Most of the advances reported recently in behavioural, neuropsychological, electrophysiological and neuroimaging studies of people recognition (and of the corresponding theoretical implications) have been taken into account in this special issue of Frontiers in Bioscience. Before discussing recent advances in this area, it is important to note that, from the historical point of view, the critical role of the face as the most important perceptual channel used to recognize familiar people is reflected in both clinical data and the theoretical models advanced to explain these data. Bodamer (2) was the first to describe a specific form of visual agnosia, selectively concerning face recognition and to propose the term 'prosopagnosia' (Greek: "prosopon" = "face", "agnosia" = "not knowing"), to denote this modality-specific form of familiar people recognition disorder. The term 'prosopagnosia' has been usually adopted to describe individuals who have lost the ability to recognize faces following acquired brain damage, but are still able to identify known individuals through their voices or names. In recent years, however, an impairment in face processing, analogous to 'acquired' prosopagnosia, was recognized. It occurs in the absence of brain damage and has been labeled 'congenital prosopagnosia' (for recent reviews of the structural and functional impairment of the face processing network in congenital prosopagnosia, see (3) and Avidan and Behrmann, this issue).

People recognition disorders for voices, rather than faces, have also been reported. The first observation was that of Van Lanker & Canter (4) who labelled this disturbance 'phonagnosia'. However, this disorder has only been described in a few group studies or single case reports, often conducted with poor methodology. Thus, for many years, the study of prosopagnosia has represented the most important and almost exclusive domain of research, for studying defective recognition of famous and personally familiar people. And the first cognitive model that tried to analyse the functional architecture of processes subsuming the recognition of familiar was Bruce and Young's (5) face recognition model. This model identifies the sequential stages through which the treatment of visual information, up to the level of the structural description, allows access to person-specific semantic information. Only later did Burton et al. (6) draw on the Bruce and Young's (5) face recognition model, and develop the Interaction Activation and Competition (IAC) model, which is still the most influential general cognitive model of familiar people recognition. Both Bruce et Young's (5) face recognition model and the IAC model are based on the distinction between some lower level perceptual processes, a locus of convergence of these processes and a unitary store of higher level person-specific representations. In the IAC model, people recognition is based on the perceptual channels that process visual (face) and auditory (voice) information and on people's names which, however, belongs to the semantic, rather than to the perceptual system (7). Specific information concerning a seen face, a heard voice and a proper name are mapped onto the corresponding invariant representations within specific faces (FRUs) voices (VRUs) and names (NRUs) recognition units. The output from these modality-specific recognition units converges into person-identity nodes (PINs), which allow identifying an individual and providing access to the corresponding semantic (biographical) information. Later, I will outline the important differences between Bruce et Young's (2) face recognition model and the IAC model, which addresses the more general problem of familiar people recognition. For the moment, I would rather discuss the issue of the 'dominance' of faces in familiar people recognition, and to stress its misleading consequences for clinical studies. This dominance has, indeed, led to neglecting Ellis et al.'s (8) and Hanley et al.'s (9) description of patients showing a multimodal defect in famous people identification. In these patients a more or less severe inability to recognize familiar people through their faces and voices and (to a lesser extent) through personal name had been observed. Because these recognition disorders were due to a lesion of the anterior temporal lobes (ATLs), particularly on the right, they had both cognitive and anatomical implications. From the cognitive viewpoint they indicated the disruption of a supramodal level, namely, the person-identity node (PIN), where information coming from the FRUs, the VRUs and the NRUs converges, allowing identification of a known person. From the anatomical point of view, they suggested that this convergence of person-specific information takes place in the anterior parts of the temporal lobes, rather than in posterior occipito-temporal structures, such as the occipital face area/OFA (10) and the fusiform face area/FFA (11) for face processing or the superior bank of the superior temporal sulcus /STS (12) for voice processing . Furthermore, as familiar people recognition disorders tended to be greater for faces and voices than for personal names and the lesion prevailed on the right side, they suggested either that the right ATL plays a greater role in familiar people recognition or that different patterns of familiar people recognition disorders can be observed in patients with right and left ATL lesions. The second interpretation was confirmed by Gainotti (13) in a review paper of single cases and group studies of patients with a right and left ATL lesion, who had been submitted to an investigation of person recognition disorders.

In recent years, several parallel lines of research have investigated: (a) the anatomical structures and the cognitive processes involved in face recognition that are disrupted in prosopagnosia; (b) the neural mechanisms involved in discrimination and recognition of voices that are disrupted in phonagnosia; (c) the interactions between familiar faces and voices when they are simultaneously processed; (d) the multimodal defects of familiar people identification; (e) the relationships between hemispheric asymmetries and patterns of familiar people recognition disorders. Each of these lines of research is exhaustively discussed in this special issue and will be reviewed briefly in this Introduction, by looking at their possible implications for current models of familiar people recognition.

3. ANATOMICAL STRUCTURES AND COGNITIVE PROCESSES INVOLVED IN FACE RECOGNITION AND DISRUPTED IN PROSOPAGNOSIA

In the Introduction to this review, I pointed out that cortical areas specifically involved in face processing have been identified in the lateral occipital (OFA) and mid fusiform (FFA) areas. Most authors agree that occipital cortices are sensitive to the physical properties of a face (e.g. 10), whereas the FFA might be involved in recognizing identity (e.g. 14). Nevertheless, controversies exist regarding the exact development of the face recognition process. Some authors support a hierarchical and componential view of face processing, which assumes that faces might be first decomposed into parts in early face selective areas and then integrated into global representations in higher-order areas (e.g. 15). This might be carried out in a hierarchical feed-forward sequence, in which each area processes one aspect of the face, which is transmitted to the next area in the hierarchy (e.g. 10). However, Rossion et al. (e.g. 16, 17 and this issue) propose a reverse hierarchical neuro-functional model of face perception on the basis of neuropsychological and neuroimaging data. This model assumes that, in addition to the holistic face detection in the FFA, following early visual processing, reentrant interactions might exist between this higher-order and lower order (OFA) visual areas, and that global representations of individual faces could be built through this reentrant interaction. A second debate concerns the distinction between apperceptive and associative forms of prosopagnosia. This distinction was put forward by De Renzi et al. (18), who have proposed that 'apperceptive' prosopagnosia may consist of a defect non only in the recognition of familiar faces, but also in the treatment of unfamiliar faces and of non person-specific information (such as age, gender and emotional expression), which could be ascribed to a high-level visual defect. 'Associative' prosopagnosia, on the other hand, should consist of a specific defect in the recognition of familiar faces, in the absence of problems in the treatment of unfamiliar faces and might be due to a mnesic or associative disorder. According to Barton et al. (19-22 and this issue), from the neuroanatomical point of view apperceptive prosopagnosia could be due to disruption of the right FFA, whereas associative prosopagnosia could result from lesions of the anterior parts of the temporal lobes (ATL), and could be due to either a disconnection between facial percepts and the memory stores (23), or a loss of facial memories. Gainotti (24), however, has recently questioned these claims, surveying all the cases of patients who satisfied the criteria of associative prosopagnosia reported in the literature, to see if their defect was circumscribed to the visual modality or also affected other channels of people recognition. The review showed that in most reported patients the study had been limited to the visual modality but, when the other modalities of people recognition had also been taken into account, the defect was often multimodal, affecting voices (and to a lesser extent names) in addition to faces. Therefore, the claim of Davies-Thompson et al (this issue) that it is very important to verify with formal tests whether patients with anterior temporal lesions and face recognition disorders are or are not able to recognize others by voice is quite appropriate.

4. NEURAL MECHANISMS INVOLVED IN VOICE DISCRIMINATION AND IDENTIFICATION AND DISRUPTED IN PHONAGNOSIA

Voice-selective cortical mechanisms have been identified by fMRI studies along the middle and anterior STS and superior temporal gyrus (STG); indeed all these regions show a greater response to vocal sounds than to non-vocal sounds (see 1, 25-29 and Mathias & von Kriegstein, this issue for reviews).

This network of temporal areas involved in speaker recognition and labelled the 'Temporal Voice Area' (TVA) is predominantly right lateralized (1, 31-33) and could be organized according to an anatomical gradient in which the posterior parts perform the acoustic analyses necessary for the perception of voices, whereas more anterior portions could have a more abstract role in perceiving the speaker's identity (1, 27-30). Thus, according to most authors, in both visual (face) and auditory (voice) modalities, posterior regions should be involved in perceptual/discriminative functions, whereas anterior regions should subsume person identification activities. All the variables and mechanisms that intervene in the perceptual analysis of voice in normal subjects have been exhaustively discussed by Mathias & von Kriegstein in this issue, but the neuroanatomical correlates of voice discrimination and voice identification processes are more controversial. On one hand, anatomo-clinical studies (e.g. 34-36) have shown that, analogously to what happens in apperceptive and associative forms of prosopagnosia, discrimination and identification of familiar voices can be dissociated by brain damage. On the other hand, inconsistent results have been obtained when the structures involved in apperceptive and associative forms of phonoagnosia (e.g. 35, 36) and those involved in the associative forms of prosopagnosia and phonagnosia (e.g. 36, 37) have been investigated. Therefore, it is not clear whether, in addition to the 'multimodal' forms of familiar people recognition disorders, there are also pure 'associative' forms of prosopagnosia and of phonagnosia, resulting from lesion of different parts of the ATLs. These anatomo-clinical questions (that still need to be resolved), are related to theoretical questions. The constructs of 'associative prosopagnosia' and of 'associative phonagnosia' are, indeed, related to modular models, (e.g. 38, 39), assuming that faces and voices are independently processed up to the level of their 'structural descriptions' and that no module can communicate with another module (e.g. the voice with the face processing system) before the level of the corresponding PINs. According to modular models, the 'structural descriptions' should include a complete perceptual specification of faces and voices and should be followed by modality-specific " 'face' and 'voice' recognition units' " ('FRUs' and 'VRUs'), allowing access to the PINs and to the person-specific semantic system. Nevertheless, recent data have questioned the modular nature of these channels of person recognition, by showing that a cross-communication between channels of person recognition probably exists before the level of the PINs.

5. INTERACTIONS BETWEEN FAMILIAR FACES AND VOICES WHEN THEY ARE PROCESSED SIMULTANEOUSLY

Impressive data, showing that a communication exists between face and voice channels of person recognition before the level of the corresponding PINs were obtained by von Kriegstein et al. (see 40-41 and Mathias & von Kriegstein, this issue, for reviews), by means of functional magnetic resonance imaging (fMRI). These authors, measured brain activity during identification tasks in which subjects focused on either the speaker's voice or the verbal content of sentences, and showed that familiar persons' voices activated the FFA when the identification task was to focus on the speaker's identity. Results pointing to an interaction between simultaneously processed familiar faces and voices were also obtained by event-related potentials (ERP) studies, that investigated audiovisual integration (AVI) in speaker recognition, with a familiarity detection task that combined static faces with voices (42) or using an experimental paradigm in which the voice was combined with a time-synchronised articulating face of corresponding or non-corresponding speaker identity (see 43 and Schweinberger et al., this issue, for more details). All these data suggest that the assessment of person familiarity can result in direct information sharing between voice and face sensory systems from the early processing stages, before accessing the person identity nodes. Some investigations (e.g. 44-45) have shown, however, that an interaction similar to that found between faces and voices is not observed between faces and names. This result suggests that the channels which process perceptual data are more closely integrated than those which process respectively perceptual and verbal data. Since increasing evidence (e.g. 1, 31-33) supports a prevalent right hemisphere (RH) lateralization of the sensory-motor systems (which allows for face and voice recognition) and a prevalent left hemisphere (LH) lateralization of the verbal name recognition system, there is likely an integration between the channels processing faces and voices, but not faces and names. The former are, indeed, processed by the same (right) hemisphere, whereas the latter are processed by different hemispheres. In any case, the existence of a communication between face and voice channels of person recognition before the level of the corresponding PINs is at variance with the modular assumptions of domain specificity and encapsulated nature of the channels of familiar people recognition (e.g. 38-39, 46) on which the IAC model is based.

6. DIFFERENT PATTERNS OF IMPAIRED RECOGNITION OF FAMILIAR PEOPLE IN RIGHT AND LEFT ATL LESIONS AND THEIR IMPLICATIONS FOR CURRENT COGNITIVE MODELS

In the section of this introductory review dealing with the varieties of prosopagnosia and their putative neural substrates, we said that the nature of face recognition disorders observed in patients with lesions of the ATLs is particularly controversial, because some authors (e.g. 19-23) consider them as forms of associative prosopagnosia and others (e.g. 8-9) as forms of multimodal people recognition disorders. To clarify this issue, Gainotti (13) referred to a previous paper (48) that had shown a different pattern of familiar people recognition disorders in patients with right and left temporal lobe atrophy and undertook a careful review of all group studies and single case reports of patients with right and left ATL lesions whose familiar people recognition disorders had been investigated. Results of this review consistently showed that different patterns of impaired recognition of familiar people can be observed in patients with right and left anterior temporal pathology. These patterns consisted of a loss of familiarity feelings and of person specific information retrieval from face stimuli, when the right temporal lobe was damaged and of a prevalent impairment in finding their names when the anterior parts of the left temporal lobe were selectively damaged. Results of this review were confirmed by several authors with respect both to the greater defect in face and voice recognition (e.g. 49-50) of patients with right ATL lesions and the prevalent impairment in finding people's names of patients with left ATL lesions (e.g. 51-53 and Waldron et al., this issue). These different patterns of familiar people recognition disorders in patients with right and left temporal lobe atrophy are at variance with the IAC model, which assumes: (a) that familiarity judgments are taken at the supra-modal PIN's level, whereas Gainotti's (13) data showed that they are taken at the level of the modality-specific recognition units; (b) that PINs do not store semantic information, but simply provide a modality-free gateway to a single semantic system, in which information about people is stored in an amodal format. This claim led to the prediction that a similar amount of semantic information should be retrieved in response to face and name cues in right and left temporal lobe patients showing a relatively intact familiarity judgment, because these patients should also have an intact PIN. On the contrary, Gainotti's results showed that right ATL patients had selective difficulty in accessing person-specific information from faces, irrespectively of the level of impairment of their familiarity feelings. Hanley (this issue) also cites two case reports by Semenza et al (53) and Verstichel (54) who, in spite of having an intact familiarity for both famous faces and famous names, recalled a very different amount of semantic information from these modalities. The former retrieved no person-specific information from their faces, but could provide specific biographic information in response to people's names, whereas the latter was impaired only when recalling semantic information from their names. Results inconsistent with the IAC assumption that PINs provide a modality-free gateway to a single semantic system (where information about people is stored in an amodal format) have also been obtained in investigations conducted in normal subjects (55-60) by evaluating the person-specific information that these subjects drew from faces and voices. Indeed, all of these authors showed that normal subjects make significantly more "unfamiliar" decisions and give significantly more 'familiar-only' responses in the voice condition than in the face condition (see Gainotti, this issue, for a more detailed description of these investigations). These results undermine the IAC model because, if PINs provide a modality-free gateway to a single system (storing semantic information about people), and if familiar-only responses reflect a block between the PINs and this semantic store, there should be no reason to expect that the number of familiar-only responses will be greater for voices than for faces.

7. MAIN MODELS ADVANCED TO EXPLAIN THE CRITICAL ROLE OF THE ATLs IN FAMILIAR PEOPLE RECOGNITION DISORDERS

Two main models have been advanced to explain the critical role of the ATLs in familiar people recognition disorders. According to the first model (e.g. 61-62 and Hanley, this issue), the ATLs (and in particular the Right ATL), could play a leading role in social cognition. Disorders of face and voice recognition found in patients with right ATL lesions and defects in naming familiar people observed in patients with left ATL lesions should be considered (according to this model) as part of this social cognition defect. The second model (13, 47, 63) assumes that: (a) the loss of familiarity feelings and the inability to access person-specific semantic information from faces and voices reflect the leading role of the right ATL in constructing representations based on perceptual material, whereas (b) disorders in retrieving familiar names reflect the leading role of the left hemisphere in representations mainly based on verbally-coded information. Data supporting the second model were obtained by Snowden et al. (47, 63). These authors showed that semantic dementia patients with predominantly right temporal lobe atrophy perform worse on the picture than on the word version of the semantic memory 'Pyramids and Palm Trees' test (64), and that the opposite finding is observed in patients with predominantly left temporal lobe atrophy. This result, which suggests that the different format of right and left ATL representations is not limited to familiar people, but also extends to other conceptual domains, is consistent with results obtained by other authors (see 65 for review). In any case, further investigations are needed to clarify the meaning of the different patterns of person recognition disorders shown by patients with right and left ATL lesions.

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