Memory & Cognition
2006, 34 (4), 854-864

Recognition of faces and complex objects in younger and older adults

ISABELLE BOUTET and JOCELYN FAUBERT
Université de Montréal, Montreal, Quebec, Canada

We examined whether (1) age-associated impairments in face recognition are specific to faces or also apply to within-category recognition of other objects and (2) age-related face recognition deficits are related to impairments in encoding second-order relations and holistic information. In Experiments 1 and 2, we found reliable age differences for recognition of faces, but not of objects. Moreover, older adults (OAs) and younger adults (YAs) displayed similar face inversion effects. In Experiment 3, unlike YAs, OAs did not show the expected decline in performance for recognition of composites (Young, Hellawell, & Hay, 1987). In Experiment 4, both OAs and YAs showed a whole/part advantage (Tanaka & Farah, 1993). Our results suggest that OAs have spared function for processing of second-order relations and holistic information. Possible explanations for the finding that OAs have greater difficulty recognizing faces than recognizing other objects are proposed.

Age-related declines in recognition memory for familiar and unfamiliar faces have been widely reported (e.g., Bartlett, Strater, & Fulton, 1991; Crook & Larrabee, 1992; Maylor & Valentine, 1992). These declines are characterized by a higher proportion of false alarms to nonfamiliar faces in healthy older individuals (reviewed by Searcy, Bartlett, & Memon, 1999). It is important to examine face recognition deficits in the elderly not only because they have an impact on the social and personal lives of older individuals, but also because they have implications in the management of older eyewitnesses to crime.

Several possible explanations have been proposed for age differences in face recognition. Some have been based on memory mechanisms and have included such factors as confusion due to the increased number of faces that have been memorized with age (Chaby, Jemel, George, Renault, & Fiori, 2001), deficits in recollection of contextual information (Bartlett & Fulton, 1991; Bartlett et al., 1991; Mandler, 1980; Searcy et al., 1999), impaired memory for novel visuospatial information (Searcy et al., 1999), and difficulties in carefully matching test pictures with representations stored in memory (Bartlett, Leslie, Tubbs, & Fulton, 1989). Other explanations have been based on encoding mechanisms and have included such factors as reduced contrast sensitivity in elderly subjects (Owsley, Sekuler, & Boldt, 1981) and a reduced ability to form distinctive representations of faces (Bartlett & Fulton, 1991). Still others have focused on the interaction between the encoding and the retrieval mechanisms involved in face recognition. These have included information loss at each successive step of a computation process, which predicts more pronounced deficits for more complex abilities (Cerella, 1990; Maylor & Valentine, 1992; Salthouse, 1996a, 1996b), deficits at each stage of the face recognition process (Maylor, 1990), and an increased need for cognitive resources during performance of complex tasks, which results in higher activation of prefrontal areas (Grady, 2002).

Although support for some of these hypotheses has been reported, the interpretations proposed often have overlooked evidence that is well established in the face recognition literature. For example, it has been suggested that older adults have difficulties recognizing faces because of the reduction in contrast sensitivity associated with aging. In agreement with this hypothesis, Owsley, Sekuler, and Boldt (1981) have shown that increasing the contrast of faces can improve face recognition in this population. However, studies conducted with younger adults have shown that face recognition depends on a critical band of spatial frequencies in the middle range (reviewed by Costen, Parker, & Craw, 1996) for which sensitivity is very high and the perception of which should be least affected by low-contrast vision. Hence, although decreased contrast sensitivity may contribute to impairments in face recognition in elderly individuals, other factors must also be involved.

A more serious flaw in studies in which age differences in face recognition have been examined has been the failure to include a comparison nonface category. A number of studies have suggested that memory for objects remains relatively intact in older adults (Park, Puglisi, & Smith,

This research was supported by a fellowship from the Canadian Institutes of Health Research (CIHR) to I.B. and by CIHR Grant R0010026 to J.F. The authors thank Veronica J. Dark, Charles Collin, Cary Kogan, and three anonymous reviewers for their helpful suggestions. Correspondence concerning this article should be addressed to I. Boutet, School of Psychology, University of Ottawa, 125 University St., Ottawa, ON, K1N 6N5 Canada (e-mail: iboutet@uottawa.ca).

Note—This article was accepted by the previous editorial team, when Colin M. MacLeod was Editor.

1986; Park, Royal, Dudley, & Morrell, 1988). However, the recognition tasks previously employed failed to provide an appropriate comparison for face recognition. Face recognition is unique in two important ways: First, faces are exceptionally homogeneous and complex; second, faces are recognized at the individual level (e.g., John's face), a task requiring fine within-category discriminations. Recognition deficits in older individuals, therefore, may not be specific to faces but, rather, may extend to other objects when equivalent tasks are employed. If this is the case, deficits equivalent to those found for faces will be observed for within-category recognition of other complex objects. Such a finding would suggest that age-related face recognition deficits have little to do with face recognition per se but, rather, arise from a general deficit in recognizing individual exemplars of a homogeneous stimulus category.

Another possibility is that age-related face recognition deficits are face specific, in that they reflect impairments in mechanisms that are tailored to the idiosyncratic properties of faces. There is considerable evidence that the mechanisms involved in face recognition differ from those involved in object recognition (see the review in Maurer, Le Grand, & Mondloch, 2002). Three types of information can be used in recognition: isolated features, first-order relations, and second-order relations (Diamond & Carey, 1986; Maurer et al., 2002). Isolated features refer to the constituent parts of an object, and they can be specified without reference to other parts of the object (e.g., the eyes, nose, mouth, etc.). First-order relations refer to the spatial arrangements between isolated features (e.g., placement of the eyes above the nose, the nose above the mouth, etc.). Because they are homogeneous, all faces share the same first-order relations. Second-order relations refer to the relative size of spatial relations between parts of an object (e.g., the distance between the two eyes, the eyes and the nose, etc.) that may be specified with respect to an underlying template or schema of an average face (Rhodes, 1995; Valentine & Bruce, 1986).

Face recognition differs from object recognition because it relies more heavily on second-order relations than on isolated features. In addition to second-order relations, face recognition is believed to rely more heavily on *holistic* information, meaning that all of the information present in a face is processed as a *whole* or as a *Gestalt* (Farah, Wilson, Drain, & Tanaka, 1998; Maurer et al., 2002, p. 255). Encoding of second-order relations and holistic information may be particularly important for face recognition because faces are homogeneous and are recognized at the individual level. In contrast, recognition of objects usually takes place at the categorical level, a task that may be accomplished by identifying isolated features and first-order relations (Biederman & Kalocsai, 1998; Diamond & Carey, 1986; Moscovitch & Moscovitch, 2000). Nonetheless, there is evidence that face recognition relies more heavily on second-order relations and holistic information even when equivalent within-category tasks are used (e.g., Tanaka & Farah, 1993; Tanaka & Sengco, 1997; Yin, 1969). Therefore, age-related face recognition deficits may arise from impairments in face-specific mechanisms, such as the processing of second-order relations and holistic information.

In the present study, four experiments were conducted to investigate whether age-related face recognition deficits reflect a general impairment in within-category recognition of complex objects or impairments in the processing of second-order relations and holistic information. We employed a variety of tests that have been successfully employed to illustrate the crucial role that second-order relations and holistic information play in face recognition. In Experiments 1 and 2, the face inversion effect (FIE) was tested. The FIE refers to the finding that face recognition is more significantly impaired by inversion than is recognition of other complex objects (see the review in Valentine, 1988). These experiments also allowed us to explore potential age differences in within-category recognition of nonface objects, because evaluation of the FIE requires that recognition of both faces and nonface objects be measured. In Experiment 3, we used the composite effect, whereby two halves from different faces are more difficult to recognize when they are horizontally aligned than when misaligned (Young, Hellawell, & Hay, 1987). In Experiment 4, we tested the whole/part advantage, whereby recognition of a face part is superior in the context of a face than in isolation (Tanaka & Farah, 1993). These tests were measured in younger adults (YAs) 18 to 35 years of age, as well as in healthy older adults (OAs) 65 years of age and over.

EXPERIMENT 1

In Experiment 1, the FIE was evaluated by comparing recognition of upright and inverted faces and nonface objects in both YAs and OAs. Houses and chairs were chosen as comparisons for faces because, as for faces, it is possible to select stimuli so that all the individual exemplars in each category share the same features arranged in the same first-order configuration. Moreover, houses and chairs are as familiar to most observers as faces are.

The FIE is characterized by an interaction between image category and orientation such that the difference between the recognition of upright versus inverted faces is more pronounced than the difference between the recognition of upright versus inverted objects. Although inversion has been shown to disrupt the processing of both second-order relations and holistic information (see the review in Maurer et al., 2002), recent studies that have carefully controlled for both of these constructs suggest that the FIE is largely attributable to a disruption in the processing of second-order relations (Leder & Bruce, 2000; Leder, Candrian, Huber, & Bruce, 2001). Recognition of inverted faces may be particularly difficult because reference points normally used to process second-order relations become difficult to extract following inversion. In contrast, nonface objects may be recognized, using salient features, even when a within-category task is employed (Moscovitch & Moscovitch, 2000). Because salient features can be easily identified whether the object is upright