Acta Psychologica 151 (2014) 155–163

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Holistic processing and reliance on global viewing strategies in older adults' face perception

Bozana Meinhardt-Injac *, Malte Persike, Günter Meinhardt

Johannes Gutenberg University, Department of Psychology, Mainz, Germany

ARTICLE INFO

Article history:
Received 24 August 2013
Received in revised form 19 May 2014
Accepted 1 June 2014
Available online 28 June 2014

PsycINFO classification codes:
2320 Sensory Perception
2820 Cognitive & Perceptual Development
2860 Gerontology

Keywords:
Face perception
Object perception
Aging
Holistic processing
Internal and external features

ABSTRACT

There is increasing evidence that face recognition might be impaired in older adults, but it is unclear whether the impairment is truly perceptual, and face specific. In order to address this question we compared performance in same/different matching tasks with face and non-face objects (watches) among young (mean age 23.7) and older adults (mean age 70.4) using a context congruency paradigm (Meinhardt-Injac, Persike & Meinhardt, 2010, Meinhardt-Injac, Persike and Meinhardt, 2011a). Older adults were less accurate than young adults with both object classes, while face matching was notably impaired. Effects of context congruency and inversion, measured as the hallmarks of holistic processing, were equally strong in both age groups, and were found only for faces, but not for watches. The face specific decline in older adults revealed deficits in handling internal facial features, while young adults matched external and internal features equally well. Comparison with non-face stimuli showed that this decline was face specific, and did not concern processing of object features in general. Taken together, the results indicate no age-related decline in the capabilities to process faces holistically. Rather, strong holistic effects, combined with a loss of precision in handling internal features indicate that older adults rely on global viewing strategies for faces. At the same time, access to the exact properties of inner face details becomes restricted.

1. Introduction

There is increasing evidence that face recognition might be impaired in the elderly. This has been demonstrated in tasks requiring face detection (e.g., Norton, McBain, & Chen, 2009), face identification (e.g., Habak, Wilkinson, & Wilson, 2008) and emotion recognition (e.g., Calder et al., 2003). Some recent studies show that older adults perform more slowly and less accurately over a wide range of face perception tasks (Hildebrandt, Wilhelm, Herzmann, & Sommer, 2013; Hildebrandt, Wilhelm, Schmiedek, Herzmann, & Sommer, 2011). The data obtained in these studies also suggest that the structure of face-recognition abilities (i.e., face perception, face memory, speed of face cognition) remains relatively age-invariant through the adult life-span, and are clearly distinct from latent factors of object cognition (measured with four indicators for perception and one for memory — for more details see Hildebrandt et al., 2013; Wilhelm et al., 2010). This suggests that the mechanisms involved in face perception remain unaffected in nature, but become less efficient with increasing age.

Not just face perception abilities seem to decline with age, but also general cognitive efficiency (e.g., Eppinger, Kray, Mecklinger, & John, 2007; Grady & Craik, 2000; Li, Lindenberger, & Sikström, 2001; Störmer, Li, Heekeren, & Lindenberger, 2013). In the light of these findings it is important to disentangle the decrease in general cognitive functioning (i.e., executive control, working memory, or selective attention) from the decrease of face specific holistic perception in older adults (Hildebrandt et al., 2010, 2013). Holistic perception means that faces are perceived and remembered as unparsed perceptual wholes (i.e., as a "Gestalt"). As a consequence, the perceptual wholes of faces cannot be broken down into parts without impeding perception and remembering of facial stimuli. Accordingly, experimental paradigms used to test holistic face processing measure how the perception of face parts is affected by changing the face context. For example, the composite effect (Hole, 1994; Young, Hellawell, & Hay, 1987) shows that it is more difficult to judge the identity of the upper face halves of a face pair when the lower face halves disagree. Misaligning both halves cancels the effect and allows the observer to compare the upper halves independent of interference from the lower halves. The part-whole effect shows that a facial feature (e.g., a nose) is much better identified when it is embedded in the context of a face that has previously been viewed, compared to seeing this face part in isolation (Farah, Tanaka, & Drain, 1995; Tanaka & Farah, 1993). Both the composite effect and the part-to-whole effect are, however, limited to upright faces. Presenting faces upside down strongly reduces holistic effects (Xu & Tanaka, 2013). This points to the influence of expertise in face processing, since faces are learned usually in the upright orientation (Diamond & Carey, 1986).

* Corresponding author at: Department of Psychology, Johannes Gutenberg University Mainz, Binger Strasse 14-16, 55122 Mainz, Germany.
E-mail address: meinharb@mail.uni-mainz.de (B. Meinhardt-Injac).

http://dx.doi.org/10.1016/j.actpsy.2014.06.001
0001-6918/© 2014 Published by Elsevier B.V.

Up to now, the strong interaction among object parts was observed only for faces, but not for non-face object categories. Neither a composite effect nor an advantage of identifying a part in a larger whole has been found with common non-face objects (Macchi Cassia, Picozzi, Kuefner, Bricolo, & Turati, 2009; Tanaka & Farah, 1993; for an overview of common face perception paradigms and major findings see Maurer, Le Grand, & Mondloch, 2002). Corresponding to the uniqueness of faces with respect to holistic perception, a brain region in the ventral temporal lobe was identified which preferentially responds to intact and whole face stimuli (Kanwisher & Yovel, 2006; Zhang, Li, Song, & Liu, 2012).

In contrast to the vast amount of studies dedicated to holistic face processing in general, there are only two studies addressing this question in older age. In a study by Schwarzer, Kretzer, Wimmer, and Jovanovic (2010) life-span changes in holistic face processing were studied by comparing children (5-7 and 9-10 years old), younger and older adults. The task required face categorization, whereby the categories were constructed such that they allowed to do face categorization based on isolated features (analytically), or on overall similarity (holistically). The results indicate an increase in holistic face processing from childhood to young adulthood, and a decline toward late adulthood (Schwarzer et al., 2010).

The contrary claim that holistic face processing routines are *not* impaired in older subjects comes from another study on face composite and inversion effects in younger and older adults (Boutet & Faubert, 2006). The data gained in experiments 1 and 2 of this study yielded comparable face inversion effects in both age groups, and no inversion effects for non-face categories. In experiments 3 and 4 experimental paradigms suited to study holistic face processing (i.e., the part-whole paradigm and the composite face paradigm) were applied only to face stimuli. While an advantage in whole-face processing was revealed in both age groups, the composite effect was found only for younger adults (Boutet & Faubert, 2006). Since the composite effect is mandatory for the hypothesis of holistic processing to hold, the question whether there are deficits in holistic face processing in older adults cannot be clearly answered based on the conflicting results for inversion effects and composite effects in this study.

In the present study we revisit the question whether there are deficits in holistic face processing in older adults. We resort to the contextual congruency paradigm which has been used in several studies on holistic face processing (Meinhardt-Injac, 2013; Meinhardt-Injac, Persike, & Meinhardt, 2010, 2011a; Meinhardt-Injac et al., 2011). This paradigm was developed in order to reveal holistic integration across the whole face by assessing the strength of perceptual interactions among external (hair, ears, had and face outline) and internal (eyes, eyebrows, nose and mouth) features. In the experimental task subjects match faces by attending to one class of features, while the features of the unattended feature set change either congruently (being same when the target features are same and different when the target features are different), or incongruently (being same when the target features are different, and different when the target features are same) with the target features. Holistic integration is concluded from the performance difference achieved in congruent and incongruent contexts (see Meinhardt-Injac et al., 2010, 2011a for a detailed description).

Different from the composite face paradigm there is no artificial cutting line that separates attended and non-attended features — the face stimuli appear as natural full faces albeit they are hybrid faces, combining the internal and the external features of two different persons (see Section 2). This enables us to measure the strength of the perceptual interaction among outer and inner face parts within a natural facial context. Present findings suggest that internal and external features presented in isolation without facial context play different roles in face perception (e.g., Ellis, Shepherd, & Davies, 1979; Frowd, Bruce, McIntyre, & Hancock, 2007; Veres-Injac & Persike, 2009). Although internal features are often used in isolation, there is increasing evidence that external features strongly modulate perception of the internal facial features (Andrews & Thompson, 2010; Axelrod & Yovel, 2010, 2011; Frowd et al., 2012; Meinhardt-Injac, Meinhardt, & Schwaninger, 2009; Nachson, Moscovitch, & Umilta, 1995; Sinha & Poggio, 1996; Veres-Injac & Schwaninger, 2009). The locus of the interdependent processing of internal and external features has been found in the fusiform face area, where both types of features are glued to form holistic facial representations (Andrews, Davies-Thompson, Kingstone, & Young, 2010; Axelrod & Yovel, 2010, 2011). No comparable effects were obtained for other common visual objects (i.e., watches), suggesting that the interaction among internal and external features, as captured by the paradigm, is indeed face specific (Meinhardt-Injac, 2013). Combined with upright and upside-down presentation the contextual congruency paradigm provides reliable measures of face specific holistic processing (i.e., context and inversion effects and the modulation of the context effect by inversion) that are not shared by non-facial visual objects (Meinhardt-Injac, 2013).

Following up on these findings, the aim of the present study concerned four aspects of a possible age-related decline. First, we aimed to assess the decrease in overall matching accuracy for faces and watches from younger to older adults. A similar decrease in the accuracy for both object categories is expected if the face processing system is subject to by aging in the same way as the object related areas, while stronger decline in face matching accuracy would indicate that the face-processing system is specifically concerned. Second, we revisited the question whether there is decrease in holistic face processing in older adults (Schwarzer et al., 2010). If there are age-related differences in this domain, indicators of holistic face processing (inversion and context congruency effects) are expected to differ among young older adults. Third, comparison with non-face objects enables us to test whether congruency effects are face specific measures of holistic processing in older adults. Alternatively, they might reflect a general decline of older subjects to ignore irrelevant information, as reported recently (Gazzaley et al., 2008). If older adults suffer from general deficits in attending target features and ignoring context features, then context congruency effects should be observed with *both* stimulus categories. Finally, letting the subjects attend to either the internal or the external features of faces is apt to test feature-specific deficits that may arise with age. If older adults rely more on global contour and first-order information when perceiving faces (Daniel & Bentin, 2012), an asymmetry in matching accuracy for external and internal facial features should arise. Again, comparison with non-face control objects may reveal whether a possibly stronger reliance on external features is face specific.

2. Methods

2.1. Experimental design

Four experiments with two stimulus classes (faces vs. watches), and two task instructions ("match internal features" versus "match external features") were executed. In faces, internal features include eyes, eyebrows, nose and mouth. In watches, internal features refer to clock face with numbers and hour-hands. External features include hair, ears, head and face outline in faces, and watchcase, crown, and lug ends in watches. A same/different task was used ("contextual congruency paradigm"; see Meinhardt-Injac, 2013; Meinhardt-Injac et al., 2010, 2011a). Participants were required to compare two subsequently presented visual stimuli (faces or watches) and decide whether the two were same or different with respect to the type of features to be attended. In the "match external" task subjects were instructed to judge two sequentially presented stimuli as same when their external features were same, and as different otherwise. In the "match-internal" task they were instructed to match stimuli according to their internal features. Different subjects participated in all tasks.

In each of the four experimental runs the context congruency among internal and external features was manipulated. Context congruency