The own-age bias in face memory is unrelated to differences in attention – Evidence from event-related potentials

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Abstract

Participants are more accurate at remembering faces from their own relative to a different age group (own-age bias, OAB). A recent socio-cognitive account suggests that differential allocation of attention to old versus young faces underlies this phenomenon. Critically, empirical evidence for a direct relationship between attention to own- versus other-age faces and the OAB in memory is lacking. To fill this gap, we tested the role of attention in three different experimental paradigms, and additionally analyzed event-related brain potentials (ERPs). Experiment 1 compared learning of old and young faces during focused versus divided attention, but revealed an equivalent OAB in subsequent memory for both attention conditions. Similarly, attention manipulation during learning did not differentially affect ERPs elicited by young versus old faces. Experiment 2 examined repetition effects from task-irrelevant old and young faces presented under varying attentional load on the N250r ERP component as an index of face recognition. Independent of load, N250r effects were comparable for both age categories. Finally, in Experiment 3 we measured N2pc as an index of attentional selection of old versus young target faces in a visual search task. N2pc was not significantly different for young versus old target search conditions, suggesting equivalent orientation of attention to either face age group. Overall, we propose that the OAB in memory is largely unrelated to early attentional processes. Our findings therefore contrast predictions from socio-cognitive accounts on own-group biases in recognition memory, and are more easily reconciled with expertise-based models.

Keywords: attention; face; age; ERP; own-age bias; other age effect

1. Introduction

Humans are considered to be experts for faces. One aspect of facial expertise is that we attend more strongly to faces than to other objects. This has been empirically demonstrated by findings of stronger attentional capture by faces than objects (Bindemann et al., 2007; Hershler and Hochstein, 2005), and face processing under conditions of high perceptual load, which precludes processing of non-face stimuli (Lavie et al., 2003; Neumann et al., 2011). However, facial expertise may vary for different categories of faces. A well-established phenomenon describes the fact that participants are more accurate at remembering faces from their own as compared to a different ethnic group (own-race bias "ORB", Malpass and Kravitz, 1969; Meissner and Brigham, 2001). More importantly for present purposes, participants are also more accurate at remembering faces from their own as compared to a different *age* group (own-age bias "OAB", Rhodes and Anastasi, 2012). A recent account (Hugenberg et al., 2010) has provided an intuitively plausible explanation for these phenomena: participants may be more motivated to pay attention to faces from their own group during learning, and consequently show enhanced recognition memory. However, empirical evidence for this assumption is weak as of yet. The present study systematically addresses the question whether attention is preferentially allocated to own-age faces, and thus, whether attention can indeed explain the OAB in face memory, and is the first to additionally provide electrophysiological correlates.

Traditional explanations suggest enhanced contact and/or perceptual expertise with own-group faces as a common basis for both the own-age and the own-race biases (Valentine and Endo, 1992; Wiese et al., 2012). However, the precise underlying mechanisms remain controversial. Some researchers suggested that, as a consequence of greater experience, processing for own- and other-group faces differs during early stages of face perception. More specifically, configural (Rhodes et al., 1989), or holistic processing (Michel et al., 2006; Rossion and Michel, 2011; Tanaka et al., 2004), that is, the processing of faces as a single “Gestalt”-like representation, may be more pronounced for own- than other-group faces. In support of this assumption, a recent study showed that quality of contact with other-race faces is negatively correlated with an own-race bias in holistic processing (Bukach et al., 2012). Additionally, more experience with own-group faces may have a beneficial effect on the mental representations of own- versus other-group faces. For instance, the so-called multidimensional face space model (Valentine, 1991) suggests that each encountered face is represented as a point in an n-dimensional space, the dimensions of which reflect facial characteristics (for recent concepts of dimensions of facial variability, see (Burton et al., 2011). These dimensions result from an individual’s lifetime experience with faces, which is typically greater for own- relative to other-group faces. Consequently, the face space’s dimensions optimally differentiate between own- but not other-group faces (Valentine and Endo, 1992).

In strong contrast to contact- or expertise-based models, socio-cognitive accounts explain own-group biases by assuming spontaneous categorization of faces into either social “in-group” or “out-group” members (e.g., Levin, 2000). This categorization mechanism pre-selects in-group faces for subsequent detailed processing on an *individual* level, while segregating out-group faces for shallower *categorical* processing. According to the Categorization-Individuation Model ("CIM", Hugenberg et al., 2010), ascribing in- or out-group membership is affected by the current state of motivation to individuate a face. Accordingly, motivating participants to individuate other-group faces should reduce in-group biases by increasing performance for these faces. Two studies reported a reduced or even absent ORB when participants were informed about the effect and were additionally instructed to particularly try to individuate other-race faces (Hugenberg et al., 2007; Rhodes et al., 2009). Based on such results, the CIM assumes that selective attention moderates the own-group memory biases: whereas the motivation to individuate exemplars shifts selective attention to unique characteristics of the faces, the *absence* of this motivation results in shifting attention to category-diagnostic information (Hugenberg et al., 2010), in turn deteriorating memory performance. These differential shifts in attention towards in- versus out-group faces are suggested to explain all group biases, including the OAB. However, these assumptions hinge on the availability of attentional resources: If resources are free, a viewer can choose to devote attention to a face (or choose *not* to attend, in case of out-group faces). A more direct test of the relevance of attention for the OAB would involve investigating memory for own- versus other-group faces that were learned under restricted versus non-restricted attentional resources. This was the aim of the present study.

Surprisingly, there is very little research on whether humans actually attend differently to own- versus other-age faces. Rodin (1987) discussed superior memory for own-aged persons during real-life encounters to reflect enhanced attention to these people. In the absence of direct attention manipulation, however, the precise cognitive mechanisms underlying this effect are unclear. Additional rather indirect evidence comes from eye-tracking studies, reporting longer overall gaze time for own-age faces (Ebner et al., 2011b; He et al., 2011). To our knowledge, only one study *directly* manipulated attention: Ebner and Johnson (2010) examined interference from task-irrelevant own- versus other-age distractor faces. Participants performed either an easy or a difficult task on numbers that were superimposed on distractor faces. Critically, young participants' response times were slower when numbers were presented in combination with a young relative to an old face in the difficult task, whereas old participants demonstrated a corresponding own-age effect in the easy task. However, this study did not measure recognition memory for the two face categories, and could therefore not directly relate the findings to the OAB. Therefore, although this study thus provided initial evidence for greater interference by - and insufficient filtering of - own-age distractor faces, additional elaborated investigations are required to elucidate the role of attention on specific sub-processes of own- versus other-age face processing.

We consider event-related potentials (ERPs) well suited for addressing this question, as ERPs have been shown to be sensitive to various aspects of visual selective attention. In particular, the early posterior P1 (ca. 100 ms) and N1 (ca. 160 ms) components are larger for identical visual stimuli when attended compared to when unattended, suggesting enhanced early sensory processing of stimuli under selective spatial attention (Hillyard et al., 1998; Luck and Hillyard, 1994). Several ERPs were also consistently reported to be sensitive to faces (Bentin et al., 1996; Schweinberger et al., 2002). More specifically, the P1 is typically assumed to reflect early visual processing in general, and may relate to pictorial encoding.

Subsequent structural encoding of a face is thought to be reflected by N170 (Bentin et al., 1996), a negative peak over occipito-temporal sites at approximately 170 ms following face onset. Processes associated with this stage include detection and categorization of a face or face-like pattern. Occipito-temporal P2, a positive peak at approximately 200 ms following stimulus onset, has been suggested to relate to perceived typicality of a face (Schulz et al., 2012; Stahl et al., 2008). Finally, N250 and N250r ("r" for repetition) peak negatively over occipito-temporal sites between 230 and 330 ms, and have been linked to individual recognition of faces (Eimer et al., 2012; Schweinberger et al., 2004; Tanaka et al., 2006). Of note, recent ERP data revealed an advantage for holistic coding of own-age faces in young participants in the N250 time range (Wiese et al., 2013a). Importantly, face-sensitive ERPs are modulated by selective attention (Mohamed et al., 2009).

A previous ERP study demonstrated that facial age (but not gender) information is extracted irrespective of task demands (Wiese et al., 2008b). In addition, several publications observed differential ERP responses to old and young faces. Specifically, the occipito-temporal

N170 and its fronto-central positive counterpart (the vertex-positive potential [Jeffreys, 1989], sometimes referred to as fronto-central P200) were larger for old relative to young faces (e.g., Ebner et al., 2011a; Wiese et al., 2008a). In addition, the subsequent occipito-temporal P2 (and the negative fronto-central counterpart of this component, the N200) was larger for young relative to old faces. We therefore assumed that differentially attending to old versus young faces should manifest in these ERP components sensitive to the processing of facial age.

In a series of experiments of the present study, we employed three established experimental paradigms to assess potential modulations of the OAB by different aspects of selective attention. Experiment 1 compared focused and divided attention during learning of young and old faces, and directly examined the impact of the attention manipulation on the OAB in recognition memory. Dividing attention between two tasks has been shown to reduce recollection for to be memorized verbal material (e.g., Gardiner and Parkin, 1990; Isingrini et al., 1995) and faces (Reinitz et al., 1994). If the difference in memory for young and old faces (that is, the OAB) depended on attention during learning, we reasoned that restricting attentional resources by dividing attention should reduce the effect.

For a further examination of effects of selective attention during processing of own- versus other-age faces, Experiment 2 manipulated perceptual load in a repetition priming design. Perceptual load theory (Lavie, 1995, 2005) assumes that filtering of irrelevant material – e.g., a distractor item – occurs only in case a relevant item consumes all available attentional resources, that is, under high load. Here, we measured the extent to which a distractor face was processed, by analyzing the repetition-sensitive N250r ERP component to subsequently repeated versus non-repeated faces (cf. Neumann et al., 2011, for a similar approach). In contrast to Experiment 1, and similar as in Ebner and Johnson (2010), faces in Experiment 2 remained task-irrelevant, while attentional load of a relevant letter target task was manipulated.

Finally, in Experiment 3 we investigated *spatial* selective attention allocation to a deviant old or young target face in small sets of either young or old faces by means of the N2pc component. The N2pc effect is related to visual search and describes a larger posterior contralateral negativity between 200 and 300 ms relative to the attended spatial target position (Eimer, 1996; Luck and Hillyard, 1994). In contrast to both previous experiments, where a single face competed with non-face stimuli for attentional capacity, Experiment 3 compared visual search performance for young versus old target faces among distractors of the opposite age group.

Overall, these three paradigms were used to examine attentional influences on behavioural and neuronal markers of the own-age bias in young adult participants. Young adults, in comparison with older adults, have been found to consistently exhibit an OAB of substantial magnitude (for recent reviews (Rhodes and Anastasi, 2012); (Wiese et al., 2013b)). We therefore reasoned that the chances for finding modulating influences of attention on the OAB would be maximal in young adults. We also considered the use of different experimental approaches to manipulate selective attention advantageous, since this could potentially reveal a ubiquitous pattern of attention effects across particularities of the individual experimental designs. Although this should help us achieving a broader understanding of how selective visual attention might or might not be related to the OAB, please note that we do not claim to address all possible aspects of selective attention (e.g., a consideration of temporal attention is beyond the scope of this paper). In sum, the experiments were designed to test various aspects of attention during the perceptual and mnemonic processing of young and old faces.

2. Experiment 1

As aforementioned, Ebner and Johnson (2010) observed more distraction by own-age faces. However, even when participants may be more distracted from processing task-relevant stimuli by own- as compared to other-age faces, it is still unclear whether this necessarily results in better subsequent memory. Experiment 1 examined whether varying attention during learning of old and young faces influences subsequent recognition performance for these faces. If more attentional resources during learning were allocated to own-age faces, as implied by the results of Ebner and Johnson (2010), limiting attentional resources by dividing attention between two tasks should particularly affect memory for own-age faces. Specifically, we expected that own-age faces should be better memorized than other-age faces under focused attention, whereas this advantage should be reduced or absent under divided attention.

Additionally, as discussed above, both N170 and P2 ERPs are sensitive to facial age (Wiese et al., 2008a). At the same time, N170 has sometimes been shown to be sensitive to attention manipulations (Mohamed et al., 2009). Here, we tested whether ERP differences between young and old faces are contingent on the availability of attentional resources. More specifically, we argued that in this case, and in line with previous research (Wiese et al., 2008; Ebner et al., 2012), N170 amplitudes should be more negative for old compared to young faces only if participants attended to faces (i.e., focused attention condition). If this amplitude difference reflected the fact that other-age faces are being less attended than own-age faces, it should decline when neither of the two age groups can be fully attended (i.e., divided attention). Similarly, P2 amplitudes were expected to be larger in response to young than old faces under focused attention, and this P2 age effect was expected to be reduced under divided attention.

2.1. Material and Methods

2.1.1. Participants.

Twenty-four students (8 males), aged between 18 and 35 years (*M* = 23.33 years, *SD* = 4.10) participated in Experiment 1 for course credit or monetary reward. Please note that sample size was comparable to Ebner & Johnson (2010), who had 22 participants in their Experiment 1. Four additional participants had to be excluded (two due to bad EEG quality, two for insufficient performance in the divided attention task). All participants were right-handed and gave written informed consent. They reported normal or corrected-to-normal visual acuity.

2.1.2. Stimuli.

We collected 200 young (18-29 years) and 200 old (>60 years) unfamiliar face images (50% female) from several databases [CAL/PAL (Minear and Park, 2004), GUFD (Glasgow Unfamiliar Face Database, Burton et al., 2010), FERET Face Database (Phillips et al., 1998)]. All images depicted faces in full-frontal pose with neutral expression. Images were presented with intact external features and in color, and were placed in front of a black background. All faces were equated for mean pixel intensity using Adobe Photoshop CS4, and were aligned to match in size (~7.2° by 9.6° visual angle) and position of the eyes.

Letter strings were superimposed on the nose region of the faces in the study phases[1]. Strings always contained three non-target upper case letters “K”, “M”, “Z”, and one of two possible target letters, “N” or “X”, presented at a random position in the string (e.g., “XMZK”, cf. Figure 1).

2.1.3. Procedure.

Experiment 1 and the following experiments were run in a dimly lit, electrically shielded and sound-attenuated cabin (400-A-CT-Special, Industrial Acoustics, Niederkrüchten, Germany) on a 19” CRT monitor. A chin rest was used to maintain a constant viewing distance of 90 cm.

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[1] We chose the nose region for presenting the letters because the nose is considered of comparably low diagnostic value for identifying a face, leaving more diagnostic regions (eyes, mouth) intact. Previous studies (e.g., Neumann et al., 2011) using this method have shown that identity processing can occur under these conditions.

The experiment consisted of two short practice blocks (one before each attention condition) and ten experimental blocks. Each block contained a study and a test phase. During study phases participants saw twenty face/letter composites (50 % young/old, 50 % female/male) for 1000 ms each, preceded by fixation crosses (500 ms) and followed by a blank screen (1000 ms). Participants were instructed to memorize the faces for subsequent recognition. In the focused attention condition they classified the to-be-memorized faces as fast and accurately as possible according to age ("old" vs. "young"), while in divided attention conditions participants decided which of the two target letters appeared in the letter string ("X" or "N"?). As a result, letters were irrelevant under focused, but not divided attention.

Each study phase was followed by a test phase, separated by a fixed break of 30 s. During test, the 20 faces of the directly preceding study phase were presented intermixed with 20 new faces. Faces were shown without superimposed letter strings for 2000 ms, preceded by fixation crosses (1000 ms) and followed by blank screens (1000 ms). Participants made learned/new classifications. Measures of sensitivity (d') were calculated for old and young faces, respectively. Half of the participants started with 5 focused attention blocks, followed by 5 divided attention blocks, whereas the sequence was reversed for the other half of the participants. Key assignment and assignment of stimuli to the learned/new as well as to the divided attention/focused attention task conditions were counterbalanced across participants.

2.1.4. EEG recording and data analysis.

We recorded continuous EEG using a 32-channel Biosemi Active II system (Biosemi, Amsterdam, Netherlands), including sites Fz, Cz, Pz, Iz, FP1, FP2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T7, T8, P7, P8, F9, F10, FT9, FT10, TP9, TP10, P9, P10, PO9, PO10, I1 and I2, at a sampling rate of 512 Hz from DC to 155 Hz. Note that BioSemi systems work with a "zero-ref" setup with ground and reference electrode replaced by a CMS/DRL circuit (cf.

http://www.biosemi.com/faq/cms&drl.htm for further information). Offline, signals were recalculated to average reference and digitally low-pass filtered at 40 Hz (24 dB/oct, zero-phase shift). Blink artefacts were corrected using BESA 5.1.8.10 (MEGIS Software GmbH, Graefelfing, Germany). Trials with incorrect behavioural responses, amplitudes exceeding 100 µV, or gradients exceeding 75 µV were excluded. ERP epochs of 1200 ms (200 ms pre-stimulus baseline) were analysed for study phases. Mean ERP amplitudes were taken for the P1 (100-130 ms) at O1 and O2. N170 (150-190 ms), P2 (200-300 ms), and a "late" N250 (300-400 ms) were analyzed at electrode sites P7, P8, P9, P10, PO9, and PO10.

2.2. Results

2.2.1. Behavioral results.

2.2.1.1. Study phases.

Participants were better at categorizing faces by age ($M = .967$) than at detecting target letters ($M = .914$), $F(1,23) = 14.85$, $p < .001$, $\eta^2_P = .392$. Mean correct RTs were faster for age categorization than letter detection, $F(1,23) = 101.21$, $p < .001$, $\eta^2_P = .815$, but also generally faster for old than young faces, as confirmed by a main effect of face age, $F(1,23) = 8.46$, $p = .008$, $\eta^2_P = .269$ (cf. Figure 2, left). The interaction face age by attention was non-significant both for accuracies, $F(1,23) = 0.26$, $p = .614$, $\eta^2_P = .011$, and RTs, $F(1,23) = 0.38$, $p = .542$, $\eta^2_P = .016$.

2.2.1.2. Test phases.

Analyses of d' revealed greater sensitivity to own-age (young) than other-age (old) faces, $F(1,23) = 29.04$, $p < .001$, $\eta^2_P = .558$, and greater sensitivity during focused than divided attention, $F(1,23) = 19.81$, $p < .001$, $\eta^2_P = .463$, but, importantly, no interaction, $F(1,23) = 0.85$, $p = .367$, $\eta^2_P = .036$ (cf. Figure 2, right). Moreover, a clear memory bias for own- relative to other-age faces was detected both in the divided, $F(1,23) = 19.95$, $p < .001$, $\eta^2_P = .465$, and in the focused attention condition, $F(1,23) = 9.37, p = .006, \eta^2_P = .290$, with even larger effect sizes under divided attention.

2.2.2. Event-related potentials in the study phases.

2.2.2.1. P1.

A repeated-measures ANOVA with factors hemisphere, face age and attention condition revealed a main effect of attention condition, $F(1,23) = 4.31, p = .049, \eta^2_P = .158$, with slightly larger P1 amplitudes under focused than divided attention.

2.2.2.2. N170.

A corresponding ANOVA with an additional factor electrode was performed. N170 amplitudes were more negative for old than young faces, $F(1,23) = 8.81, p = .007, \eta^2_P = .277$, and this difference was more pronounced at more inferior sites (cf. Figure 3), as indicated by a significant face age by electrode site interaction, $F(1,23) = 10.63, p < .001, \eta^2_P = .316$. Attention condition had no effect on N170 amplitudes, Fs < 1.

2.2.2.3. P2.

The main effect of face age, $F(1, 23) = 22.83, p < .001, \eta^2_P = .498$, with more positive amplitudes for young than old faces, and the main effect of attention condition $F(1,23) = 10.88, p = .003, \eta^2_P = .321$, with larger amplitudes under divided than focussed attention, were significant. The attention effect was more pronounced over the right hemisphere, $F(1,23) = 21.49, \eta^2_P = .483, p < .001$, and both attention and face age effects were stronger at more inferior electrodes [$F(1,23) = 16.38, p < .001, \eta^2_P = .416$; and $F(1,23) = 6.59, p = .006, \eta^2_P = .223$, for the interactions with electrode site, respectively]. Most importantly, there was no interaction of face age and attention condition, $F(1,23) = 0.01, p = .932, \eta^2_P < .001$.

2.2.2.4. "Late" N250.

ERPs were more negative for old relative to young faces, $F(1,23) = 7.80$, $p = .010$, $\eta^2_P = .253$. The right-lateralized attention effect was still reliable in this time segment, $F(1,23) = 5.72$, $p = .025$ $\eta^2_P = .199$, for the hemisphere by attention condition interaction, with more negative amplitudes under focused attention. Both attention and face age effects were stronger at more inferior electrodes [$F(1,23) = 12.07$, $p < .001$, $\eta^2_P = .344$; and $F(1,23) = 11.78$, $p < .001$, $\eta^2_P = .339$, for the interactions with electrode site, respectively]. Again, there was no interaction of face age and attention condition, $F(1,23) = 0.35$, $p = .558$, $\eta^2_P = .015$.

2.3. Summary and discussion

In Experiment 1, dividing attention between two tasks had a clear detrimental impact on memory performance, as seen by smaller d' scores for divided versus focused attention conditions. Most relevantly, while a clear OAB in recognition memory was found under focused attention, there was no evidence for a reduced OAB under divided attention (if anything, Figure 2 shows that the OAB was numerically slightly larger under divided attention). This does not support the idea that the OAB in recognition memory can be explained by stronger attention allocation towards own-group faces (Hugenberg et al., 2010). If so, dividing attention should have reduced or abolished the OAB, since fewer resources for individual processing of young faces should have been available. Rather, our data shows that an OAB can be obtained without differences in attentional allocation to the two age groups.

ERP results from the study phase are consistent with these behavioral findings. Generally, both face age and attention condition modulated ERP components, but did so in an additive rather than interactive manner. N170 was larger for old than young faces, with no evidence for an influence of attention on this component. Age effects in N170 amplitudes have been interpreted in terms of more difficult structural encoding for old versus young faces, or, alternatively, enhanced high spatial frequency information in old faces (see Wiese et al., 2008a). Similar to previous studies, P2 was increased for young faces, which may reflect more elaborated encoding for own-age (young) faces or enhanced perceived typicality (Kaufmann and Schweinberger, 2012). In the present study, we found an additional attention effect in P2 and N250, with relatively enhanced negativity for the focused versus divided attention condition. However, both components were influenced by attention and age in an additive fashion. This pattern suggests that restricting attentional resources had the expected effect of impairing perceptual face processing during learning. However, the impairment was comparable for faces of both age groups, and clearly did not selectively affect own-age faces. This implies that own- and other-age faces must have received a comparable degree of attention during focused attention at learning, otherwise the impairment by inducing a second task should not have affected other-age faces as much as own-age faces.

Interestingly, and similar to the results of Ebner and Johnson (2010), participants responded slower in the presence of young compared to old faces during learning. Ebner and Johnson suggested that slower responses in the presence of task-irrelevant own-age faces indicate greater interference by, and thus increased processing of, own-age distractor faces. At some variance, though, the RT disadvantage for own-age faces was found in both attention conditions in the present study, and thus occurred independent of potential interference with the main task. Moreover, it has to be noted that faces in the present paradigm were always task-relevant. It is therefore unclear whether the present RT disadvantage for young faces can be related to the findings of Ebner and Johnson (2010), where faces were always task-irrelevant. In order to more closely examine distractor processing, stimulus faces in Experiment 2 were always task-irrelevant.

3. Experiment 2

Experiment 1 replicated the common observation of an own-age bias in memory, critically though, with no evidence for an effect of attention during study of old versus young faces. The following experiments focused on attention effects during processing own- versus other-age faces. Specifically, Experiment 2 further examined the possibility that own- but not other-age faces are processed despite being task-irrelevant (Ebner and Johnson, 2010). For this, we adopted a previous design (Neumann et al., 2011), in which distractor face processing was examined as a function of perceptual load during target letter classification. The Perceptual Load account (Lavie, 1995, 2005) suggests obligatory processing of irrelevant material (e.g., a distractor face) if processing of task-relevant material (e.g., letter strings) spares attentional resources, whereas filtering of distractor items only occurs if the relevant material consumes all available attentional resources (that is, in high load conditions).

In previous studies (Neumann et al., 2011; Neumann and Schweinberger, 2008, 2009), we found that *despite* high load during initial presentations, an occipito-temporal negativity between 200 and 350 ms was larger for repeated as compared to non-repeated faces (N250r; see Schweinberger et al., 2002). This N250*r* (repetition) effect is thought to reflect either the transient activation of face identity representations (Schweinberger and Burton, 2003), or the updating of a stored face representation by new incoming information (Bindemann et al., 2008). Our findings of a prominent N250r elicited by probes following face distractors under high load (Neumann et al., 2011; Neumann and Schweinberger, 2008) suggested that faces are mandatorily encoded up to an identity level, even when irrelevant to a demanding task. Importantly, in this study young adult participants were tested with young faces only. Based on the results of stronger distractor interference from own-age faces (Ebner & Johnson, 2010), however, one might expect larger distractor repetition effects by own-age compared to other-age faces. Thus, N250r should be reduced or even absent for other-age probe faces, particularly under high load conditions. To test this prediction, we modified our previous study (Neumann et al., 2011) to comprise young and old distractor faces.

In Experiment 2, young adults were presented with prime displays that each contained a single old or young distractor face with a superimposed letter string. Participants performed a search task on letter strings, and attentional load was manipulated by varying the number of target letter instances contained in the string (see Jenkins et al., 2005; Neumann et al., 2011). Probes in Experiment 2 were either immediate repetitions of the previous distractor face, or new faces. Under low load, distractor face processing should occur obligatorily and thus elicit comparable N250r effects for both facial age categories. If high load reduced or eliminated distractor processing selectively for old, but not young faces, we would expect reduced or absent repetition effects in the N250r to old, but not to young faces, accordingly. If, however, distractor face encoding under high load occurred irrespective of facial age, comparable N250r modulations would be expected.

3.1. Material and Methods

3.1.1. Participants.

Twenty-eight students (10 males), aged between 19 and 27 years (*M* = 22.57, *SD* = 2.57) contributed data for course credit or a monetary reward. Data from three additional participants were excluded due to poor EEG quality. All participants were right-handed and gave written informed consent. They reported normal or corrected-to-normal visual acuity.

3.1.2. Stimuli.

A subset of the stimuli from Experiment 1 containing 140 young and 140 old faces (50% female respectively) was used. Additional face stimuli were used during practice.

Letter strings were composed from 5 upper case letters “H”, “K”, “W”, “M”, “Z”, and target letters “N” or “X”. Low load strings contained targets only (e.g., ‘XXXXXX’), whereas high load strings always included one target letter at a random position among 5 non-target letters (e.g., 'HKWMNZ'). Letter strings were superimposed on the nose region of irrelevant distractor faces during prime but not probe presentation (cf. Figure 4). Forty grayscale images of butterflies served as target items during probe presentations.

3.1.3. Procedure.

General procedure was identical to Experiment 1. Each trial started with a fixation cross for 1000 ms, replaced by the S1 prime display for 200 ms (cf. Figure 4). Following another 2000 ms fixation, S2 probes were presented for 2000 ms duration. The next trial was initiated after 1000 ms blank screen. Trial order was randomized.

Following S1 prime presentation, participants were required to indicate by key press whether the target letter was 'X' or 'N'. At S2 probe presentation, they indicated the occurrence of a butterfly (20 %) using one of the keys. No response was required for face probes. Key assignment was counterbalanced across participants. The whole experiment included 400 trials in the main phase (40 trials per condition) plus 16 practice trials. Breaks were allowed after every 40 trials.

3.1.4. EEG recording and analysis.

The EEG was continuously recorded from 144-channels at a sampling rate of 512 Hz from DC to 155 Hz using a Biosemi Active II system (Biosemi, Amsterdam, Netherlands). Sites included 128 standard Biosemi sites plus 16 inferior temporal, occipital-temporal and occipital sites. Offline processing corresponded to the procedures described for Experiment 1. Data was digitally low-pass filtering data at 30 Hz (24 dB/oct, zero-phase shift). ERPs to S2 probe faces were analysed within epochs of 1400 ms, separately averaged for each condition, and related to a 200 ms pre-stimulus baseline.

We pooled individual average ERPs from several electrodes within 14 regions of interest (ROIs, for a detailed description, see Wiese et al., 2008b). To analyze P1, mean amplitudes were calculated between 95 and 135 ms at the occipital-medial (OM) ROI. N170 (140-180 ms), P2 (180-250 ms), and N250r (250-320 ms) were analyzed at left and right occipito-temporal (OTL/OTR) ROIs.

3.2. Results

3.2.1. Behavioral results during letter detection (S1).

We analyzed mean correct response times (RTs) and accuracies to S1 letter detection using an ANOVA with repeated measures on distractor age and load. RTs were slower under high versus. low load (*M* = 671 vs. 415 ms, respectively), and responses were also less accurate (*M* = 0.72 vs. 0.96), as indicated by a significant main effect of load both for RTs, $F(1, 27) = 264.60$, $p < .001$, $\eta^2_P = .907$, and accuracies, $F(1, 27) = 334.84$, $p < .001$, $\eta^2_P = .925$. The main effect of distractor age was significant for RT data, $F(1, 27) = 12.23$, $p = .002$, $\eta^2_P = .312$, but not for accuracies, $F(1, 27) = 1.48$, $p = .234$, $\eta^2_P = .052$. Participants detected a target letter slightly faster when occurring in combination with a young than an old distractor face (*M* = 536 vs. 549 ms, respectively). No significant load by distractor age interaction was found in RTs, $F(1, 27) = 1.38$, $p = .250$, $\eta^2_P = .049$, or accuracies, $F(1, 27) = 0.21$, $p = .653$, $\eta^2_P = .008$.

3.2.2. Event-related potentials to probe faces (S2).

3.2.2.1. P1.

No effects were found in the P1 time range at OM, all *F*s < 1.70, all $p > .20$, all $\eta^2_P < .060$.

3.2.2.2. N170.

A repeated-measures ANOVA on factors hemisphere, load, repetition, and face age revealed a main effect of face age, $F(1, 27) = 4.64$, $p = .040$, $\eta^2_P = .147$, with larger N170 in response to old (*M* = -1.88 µV) than young (*M* = -1.65 µV) faces. The hemisphere by load interaction was significant, $F(1, 27) = 9.09$, $p = .006$, $\eta^2_P = .252$, suggesting larger N170 amplitudes under high than low load at OTR, and the reverse pattern at OTL (cf. Figure 5).

3.2.2.3. P2.

A main effect of face age was found, F (1, 27) = 35.24, $p < .001$, $\eta^2_P = .566$, with more positive amplitudes for young (M = 0.26 µV) than old (M = -0.13 µV) faces.

3.2.3.4. N250r.

The ANOVA revealed a main effect of face age, $F(1, 27) = 6.26$, $p = .019$, $\eta^2_P = .188$, with less negative amplitudes for young than old faces (M = -0.33 µV vs. -0.58 µV, respectively). The main effect of repetition was also significant, $F(1, 27) = 12.00$, $p = .002$, $\eta^2_P = .308$. Distractor face repetition caused more negative amplitudes compared to non-repeated faces (M = -0.67 µV vs. -0.24 µV, respectively). No further main effect or interaction was found. Critically, the interaction of face age by repetition by load was not significant $F(1, 27) = 1.12$, $p = .300$, $\eta^2_P = .040$, and no further interactions involving face age were significant, all Fs < .1,70, all $p > .20$, all $\eta^2_P < .060$.

3.3. Summary and discussion

In Experiment 2, we manipulated attentional load to own- and other-age prime faces. If own-age faces engaged more attention, increased distractor processing under high load would be expected for young compared to old faces. The ERP results did not provide any such evidence: A clear N250r effect was observed, but was unaffected by load (see Neumann et al., 2011; Neumann and Schweinberger, 2008), and, more importantly, by face age. This result clearly shows that facial identity processing even under high attentional load is not limited to faces of the own-age group. We thus consider these findings as further evidence against an interpretation of the OAB as an attention phenomenon. Although N250r was not modulated by face age, main effects of face age on N170 and P2 were comparable to those described in Experiment 1 and previous reports (Wiese et al., 2012; Wiese et al., 2008a).

Age effects were also observed in behavioral responses to S1 prime letters. Although no significant interaction of distractor age and load was observed, if anything, RTs were *faster* in the high load letter detection condition, when letter strings were presented in combination with a young relative to an old distractor face. This pattern is in contrast to an earlier study (Ebner and Johnson, 2010), in which participants responded *slower* in a difficult number comparison task when numbers were superimposed on young versus old distractor faces. Although the reasons for these discrepancies are not entirely clear, they are unlikely to reflect an insufficient load manipulation in the present study, because increasing load clearly reduced performance both in RTs and accuracies. It has to be noted that the pattern of slower responses to displays including young distractor faces was not found entirely consistently in Ebner and Johnson (2010): A larger own-age interference effect was found for neutral young faces in experiment 1, and for angry but not for neutral young faces in experiment 2.

A common aspect of both Experiments 1 and 2 and the study of Ebner and Johnson (2010) is that faces and letter/number strings were presented at the same (and therefore predictable) spatial position. Importantly, previous research using visual search tasks reported faster detection of spatially unpredictable other-race targets among own-race distractor faces than vice versa (Levin, 2000). It is well-established that the detection of feature-positive targets among feature-negative distractors is easier than the reverse (Treisman and Gormican, 1988). Accordingly, Levin (2000) suggested that faces from a different ethnic group contain an other-race defining feature (such as dark skin in African-American faces for Caucasian participants; feature-positive) whereas this feature is absent in own-race faces (feature-negative). Thus, faster responses for other-race faces were attributed to the detection of this out-group defining feature.

Levin (2000) suggested that, once categorized as belonging to an out-group, other-race faces are subjected to processing at a categorical rather than individual level, causing decreased memory and thus explaining the own-race bias.

Experiment 3 investigated whether a similar explanation may hold for the OAB, and therefore examined whether visual search is more efficient for other-age faces.

4. Experiment 3

In Experiment 3, we sought to measure attentional selection of own-age versus other-age faces in a visual search paradigm. If other-age faces are detected on the basis of an out-group defining feature, young participants should be faster to detect old target faces among young distractors than vice versa.

Additionally, we recorded ERPs to spatially unpredictable young or old target faces. Evidence is accumulating that a lateralized ERP over posterior electrodes is highly sensitive to selection of targets between distractor items occurring in one visual hemifield. Specifically, this N2pc component reflects larger contralateral negativity between 200 and 300 ms relative to the target position (Eimer, 1996; Luck and Hillyard, 1994), and can be used to assess a person's direction of attention at a given moment (Luck et al., 2000). N2pc may either reflect suppression of distractor information (e.g., Luck and Hillyard, 1994), or enhancement of target features (e.g., Mazza et al., 2007).

Recent studies revealed N2pc modulations for visual search tasks involving faces, typically in tasks that included the detection of emotion (e.g., Eimer and Kiss, 2007). Interestingly, these studies reported both faster detection and larger N2pc effects for threatening among neutral faces relative to happy among neutral faces, which has been interpreted as reflecting attention capture by the more relevant facial expression. Similarly, in our Experiment

3, young faces may be more relevant than old faces to young observers, and may therefore be detected faster and elicit larger N2pc effects. In contrast, if participants efficiently detected an other-age group defining feature (Levin, 2000), old faces should elicit larger N2pc effects than young faces.

4.1. Material and Methods

4.1.1. Participants.

Sixteen students (6 males), aged between 19 and 27 years (*M* = 21.19, *SD* = 2.51) participated in Experiment 3. All participants were right-handed, received course credits or a monetary compensation for partaking, and gave written informed consent. They reported normal or corrected-to-normal visual acuity.

4.1.2. Stimuli.

A subset of 160 faces (80 old, 80 young, half female) from Experiment 1 was used.

4.1.3. Procedure.

Sets of 4 same-sex faces were presented simultaneously on 4 specified locations on the screen (cf. Figure 6). Half of the sets consisted of young or old faces only (target absent), whereas the other half contained a single face from the respective other age group (target present). Target faces appeared at each of the 4 positions with equal frequency. A block design was used, with target face age held constant in each block.

In each given trial, participants were presented with a set for 200 ms, and were asked to decide whether or not a target was in the set. Sets were preceded by a fixation screen of variable duration (800-1200 ms). Following each set, another fixation screen appeared for 1300 ms, allowing for a 1500 ms response window. The experiment consisted of 8 blocks, alternating with respect to target face age. Half of the participants started with detecting old target faces, the other half with detecting young target faces, respectively. In total, the experiment consisted of 640 trials. A break was allowed after each block (80 trials).

4.1.4. EEG recording and data analysis.

We recorded the EEG using the same setup used in Experiment 1. ERP epochs of 1200 ms were analysed (200 ms pre-stimulus baseline), and ERPs were digitally low-pass filtered at 40 Hz (24 dB/oct, zero-phase shift).

ERP mean amplitudes were taken for the P1 (80-120 ms) at O1, O2, I1, Iz, and I2; and for N170 (140-180 ms) at electrode sites P7, P8, P9, P10, PO9, and PO10. We then analysed the time interval 200-400 ms in segments of 50 ms at electrode sites P7, P8, P9, P10, PO9, PO10, I1, I2, O1, & O2. Statistical analyses were performed for target present trials using ANOVAs with repeated measures on hemisphere, site, set face age (young, old), and target position (left, right).

4.2. Results

4.2.1. Behavioral results.

An ANOVA on response times for target present trials revealed no effects of target position, $F(1,15) = 3.96$, $p = .065$, $\eta^2_P = .209$. Importantly, young and old targets in target present trials were detected similarly fast, $F(1,15) = 2.66$, $p = .123$, $\eta^2_P = .151$, (cf. Figure 7), and the interaction was not significant, $F(1,15) = 2.06$, $p = .171$, $\eta^2_P = .121$.

The ANOVA on accuracies (proportion correct) for target present trials revealed a main effect of set age, $F(1,15) = 8.88$, $p = .009$, $\eta^2_P = .372$, with more accurate responses when participants detected old targets ($M = .754$) as compared to young targets ($M = .702$). Additionally, performance was better for targets in the left ($M = .757$) than right ($M = .699$) visual field, $F(1,15) = 12.83$, $p = .003$, $\eta^2_P = .461$. No interaction occurred, $F(1,15) = 0.30$, $p = .590$, $\eta^2_P = .020$.

4.2.2. ERP results.

4.2.2.1. P1.

P1 was not significantly affected by face age, $F(1,15) = 0.41$, $p = .531$, $\eta^2_P = .027$ or target position, $F(1,15) = 0.84$, $p = .375$, $\eta^2_P = .053$.

4.2.2.2. N170.

N170 was more pronounced over the right hemisphere, $F(1,15) = 5.21$, $p = .037$, $\eta^2_P = .258$. No further effects were found.

4.2.2.3. 200-400 ms (N2pc).

All four 50 ms segments revealed prominent target-position by hemisphere interactions, (200-250 ms: $F(1,15) = 7.65$, $p = .014$, $\eta^2_P = .338$; 250-400 ms: all Fs > 40, all ps < .001, all $\eta^2_P > .700$). In general, laterally presented targets generated a larger negativity over the opposite hemisphere, revealing an N2pc effect (cf. Figure 8). Additional interactions with electrode site were observed for the segments between 250 and 400 ms, but no interaction of target-position, hemisphere and face age was reliable in either segment (200-250 ms: $F(1,15) = 1.46$, $p = .246$, $\eta^2_P = .089$; 250-300 ms: $F(1,15) = 0.10$, $p = .757$, $\eta^2_P = .089$; 300-350 ms: $F(1,15) < 0.01$, $p = .970$, $\eta^2_P < .001$; 350-400 ms: $F(1,15) = 0.97$, $p = .340$, $\eta^2_P = .060$), and no further effect including face age was found. .

4.3. Summary and Discussion

The behavioral data suggest an effect of face age on performance. Participants were more accurate to detect an old target face in a young set than vice versa. In principle, this result is in line with the assumption of more efficient detection of an other-age defining feature, and thus supports the application of Levin's (2000) theoretical approach to the OAB. In contrast to Levin (2000), we found no effects in RTs. This may be due to the fact that sets in our study were presented for a much shorter duration, which may have increased the sensitivity of accuracy relative to RT measures.

Crucially, ERP results were clear-cut in that they did not provide any evidence for differential attentional selection by either of the two age categories. Specifically, N2pc and earlier components (P1, N170) were virtually identical for a young target in an old set and, vice versa, an old target in a young set. Please note that the finding of comparable N170 amplitudes for young and old faces are not in contradiction with earlier studies (e.g., Ebner et al., 2011; Wiese et al., 2008) and the results of experiments 1 and 2, which consistently found N170 modulated by face age. This is because the present Experiment 3 involved the simultaneous presentation of several old and young faces, which may well explain the observed equivalent N170 amplitudes. Importantly, in the present experiment neither early perceptual nor attentional selection processes as reflected in N2pc were affected by searching for an own- versus other-age target. These ERP findings clearly argue against the claim of an early categorization mechanism to underlie the OAB.

It may be noted that the present N2pc modulation to faces was temporally long-lasting, and in that respect resembles a sustained hemifield-dependent posterior negativity contralateral to task-relevant faces as reported earlier (Schweinberger and Sommer, 1991; Schweinberger et al., 1994). However, even the sustained part of this contralateral negativity was unaffected by searching for own- vs. other-age targets (Fig. 8). This suggests that processes unrelated to those reflected in N2pc drive the accuracy effect described above. Critically, this is in contrast to *all* socio-cognitive accounts, which assume the existence of an *early* categorization mechanism.

5. General discussion

In three experiments, we investigated the potential explanation of the OAB in recognition memory in terms of differential attention to young and old faces, as suggested by socio-cognitive accounts on face memory biases. First, Hugenberg and colleagues (2010) suggested that the motivation to attend to in-group faces is larger relative to out-group faces, which in turn results in more accurate memory for in-group faces. Second, Levin (2000) reported more efficient visual search for out-group faces due to the detection of an out-group defining feature. Accordingly, while both models clearly suggest that attention is differentially allocated to own- and other-group faces, these two models make different predictions with respect to the direction of attention effects. Importantly, the present ERP results are difficult to reconcile with both socio-cognitive accounts, in that they do not provide any evidence for preferential attention allocation to either own- or other-age faces.

Interestingly, our data also show that participants' behavioral responses to old versus young faces varied slightly as a function of attention condition. However, these effects were not in the direction expected by socio-cognitive accounts. First, responses during the learning phase of Experiment 1 were generally faster in "old" than "young" face trials in both attention conditions. Under divided attention, this effect could be interpreted along the lines of greater interference by task-irrelevant own-age faces (Ebner and Johnson, 2010). However, this explanation can certainly not hold for the focused attention condition, where faces are relevant for the task. If anything, faster responses to own-age faces could be expected in this condition, given that they were attention capturing. Secondly, our Experiment 2 actually revealed an effect in the opposite direction, with faster responses for young versus old distractor faces, despite employing very similar experimental conditions as Ebner & Johnson (2010). Finally, in Experiment 3 we found more accurate visual search for old relative to young target faces, which is principally in line with Levin's (2000) account. However, in contrast to this previous study we did not observe corresponding effects in RT, and since Levin (2000) did not report accuracies, the findings of the two studies are difficult to compare. Overall, while some of our behavioural findings are in line with socio-cognitive accounts, no consistent pattern was observed across experiments.

As noted above, a previous study reported attention to influence memory for own- versus other-age faces (Ebner & Johnson, 2010). However, Experiment 2 of the same study revealed a possible contribution of facial expression on this attentional OAB: Distraction by own-age faces was limited to angry faces in young participants under identical conditions as in Experiment 1. While the present study only involved neutral faces, one could speculate that the attentional OAB in the previous study may be partly driven by the additional use of emotional (angry) faces. In particular, young participants may have perceived angry young faces as more threatening than angry old faces. The former may therefore have captured more attention than the latter, causing a larger interference effect. The extent to which expression may further impact the OAB in recognition memory has yet to be resolved in future studies.

Crucially, our ERP data across a variety of experiments consistently failed to support the idea of an early attention mechanism as the basis for the OAB. These data indirectly support alternative explanations for the OAB, such as expertise-based models. One possibility how expertise can shape memory representations for faces is that it may trigger differential encoding mechanisms for faces of different age groups. As already described in the introduction, relative to own-age faces, faces of another age group may be processed less configurally and/or holistically. The present research does not address holistic processing in particular, and therefore cannot directly contribute to assessing the adequacy of this account. Alternatively, a rather indirect effect of expertise has been suggested by socio-cognitive accounts: greater experience might result in larger motivation to attend to – and consequently encode – identity information in faces of the viewer's group, whereas less expertise with other-group faces may cause their categorization rather than individuation (Hugenberg et al., 2010). However, in light of our present results, with no differential effect of attention during encoding of own- versus other-age faces, this explanation seems unlikely.

Socio-cognitive accounts suggest that differences in attention to young and old faces should affect early processing stages. These early stages are reflected in well-established ERP components, such as the N170 or the N250. Here, we found that neither of these face-sensitive components were differentially modulated by attention to young versus old faces. Early effects of attention were observed in the P1 and N2pc components, consistent with previous studies (e.g., Luck et al., 1994; Luck & Hillyard, 2000), but, again, attention effects were not significantly different for old and young faces, strengthening our interpretation that early attention processes are not underlying the OAB. However, as the present research focused on attentional influences at *early* stages of encoding own- versus other-age faces, we do not intend to draw any conclusions about potentially different attentional involvement at *later* processing stages. For instance, one could speculate that – while initial orienting to own- and other-age faces is equivalent – participant are less motivated to maintain attention on other-age faces, and may therefore initiate earlier disengagement of attention from other- compared to own-age faces. Initial evidence for this possibility comes from two recent eye-tracking studies, which examined participants' scanning of old versus young faces in a passive free viewing situation (Ebner et al., 2011b; He et al., 2011). In one of these studies overall scanning time predicted an OAB in subsequently tested face recognition memory (He et al., 2011). However, eye-tracking data on this topic are still sparse and rather inconsistent, and a further study found no effect of face age on scanning behavior in young participants (Firestone et al., 2007). In a similar vein, we acknowledge that motivational factors can influence memory biases (for a recent demonstration, see Van Bavel and Cunningham, 2012). Importantly, however, our research suggests that increased early attentional orienting towards own- relative to other-age faces is unlikely to explain the emergence of an OAB in recognition memory.

It should be noted that our interpretation of no influence of early attentional processes on the OAB rests on the absence of statistically significant effects. To assess whether we had sufficient power to detect potential attention effects on the OAB, we used G*Power 3.1 (http://www.gpower.hhu.de/en.html) to estimate the sample sizes required for finding effect sizes described by Ebner et al. (2010). Effect sizes were reported between $\eta^2_P = .13$ and .20 for the critical interactions with age, and sample sizes required for detecting similar sizes (with $\alpha = .05$; $1 - \beta = .80$) were between 17 and 27. Our final samples in Experiment 1 and 2 (24 and 28, respectively) therefore had sufficient power to detect effects of this size. The majority of effect sizes for the attention by age interactions obtained and reported in the present study were indeed very small, suggesting that even testing much larger sample sizes would not have changed the overall pattern.

Finally, the conclusions from our experiments are based on testing young adult participants only. As a consequence, we cannot make any statement regarding a potential OAB in attention for older adult participants. Apart from practical issues of study design, we also considered that predictions with respect to attentional effects on the OAB in older participants may be further complicated by cognitive aging effects on attention (Madden et al., 2005). Note also that, although the OAB can in principle be established in older adults (for a recent metaanalysis, cf. Rhodes and Anastasi, 2012), several studies failed to do so (e.g., Wiese et al., 2008a; Wolff et al., 2012). Furthermore, effect sizes for differences in discriminability of own- versus other-age faces are consistently lower in older compared to younger adults (cf. Rhodes and

Anastasi, 2012, table 8), suggesting a smaller OAB for older adults when present. Considering that we found no attentional modulation of the OAB in younger participants, we believe it is unlikely that such an attentional modulation of the OAB could be demonstrated in older participants, either. One potential concern could be whether better memory for the own-aged faces in Experiment 1 might have been due to a stimulus effect rather than the OAB. Accordingly, age-unrelated stimulus characteristics, e.g., image quality or contrast, could have increased the ease of memorizing young, but not old faces. We consider this possibility unlikely for several reasons. First, we used a very large stimulus set involving 200 different identities from databases containing both young and old faces. There is no reason to assume systematic differences in image properties between young and old faces within the same database, so certain stimulus characteristics should not be indicative of age group. Secondly, we adjusted luminance and contrast across all stimuli, to further reduce the possibility of stimulus effects. Finally, the ERP data provide no evidence for a stimulus effect as an explanation for the OAB in the young adult sample. Specifically, responses were comparable between young and old faces in the P1, a component which is known to be sensitive to such low-level stimulus differences (Tobimatsu et al., 1993).

6. Conclusion

The present study systematically investigated the influence of different aspects of attention in relation to the memory bias towards own-age faces. Overall, the present experiments yield no evidence for the assumption that the OAB in memory is related to attentional biases towards own-age faces. This is in direct contrast to predictions derived from socio-cognitive accounts on own-group biases in recognition memory. However, the present data can be reconciled with alternative accounts, which do not rely on an attentional “filter” that prevents detailed processing of other-age faces. Alternatively, expertise-based accounts assume that either face-specific, that is, holistic, processing is utilized to a stronger extent by own-age faces, or that representing faces on dimensions that are optimized for coding own-age faces is less accurate in case of other-age faces. While the present study contributes relevant findings which are hard to reconcile with socio-cognitive accounts, future studies should directly test predictions derived from expertise-based accounts of the OAB, such as enhanced holistic processing of own-age faces (see e.g., Wiese et al., 2013).

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Figure captions:

Figure 1. Example face-letter composite displays during learning phases of Experiment 1.

Figure 2. Behavioral data from Experiment 1. Left: Mean response times to old and young faces for divided and focused attention tasks in the study phase. Right: d' sensitivity scores during test phases, relative to encoding conditions. Error bars indicate standard errors of the means. Note that a clear own-age bias in memory occurred irrespective of attention during encoding.

Figure 3. EPR data from 8 occipito-temporal electrodes during study phase of Experiment 1. Age effects were revealed in N170 and P2 components, with old faces eliciting larger N170 and smaller P2 amplitudes compared to young faces. An effect of task was also prominent in P2 amplitudes, with larger amplitudes for the letter task, i.e., under divided attention conditions. However, there was no interaction of attention condition and face age.

Figure 4. Example trial procedure in Experiment 2. S1 primes consisted of letter strings superimposed on distractor faces. Participants identified target letters “X” versus “N”. Following S1 primes, S2 faces were either immediate repetitions of S1 distractors (left), new exemplars of the same category (i.e., young/old, middle), or butterflies, to which participants responded via button press (right).

Figure 5. Occipito-temporal ERPs to probe presentations as a function of attentional load during previous S1 presentation. Vertical lines indicate the N250r time interval 220-350 ms. Please note that repetition modulations with more negative going ERPs to repeated versus non-repeated faces

were prominent both under low (top) and high (bottom) load, and were not modulated by face age.

Figure 6. “Target present” display example from Experiment 3. Participants indicated by button press whether or not a target item (here: young face at top left position) was present. Targets appeared with equal frequency at each of four possible locations.

Figure 7. RTs (left) and accuracies (right) from Experiment 3.

Figure 8. ERPs to target present trials in young versus old sets. In the absence of interaction with electrode site, we pooled signals from 5 electrodes per hemisphere. Note the larger negativity starting approximately 200 ms after stimulus onset for targets presented to the contralateral side (N2pc). This effect was not modulated by age.

Figure 1

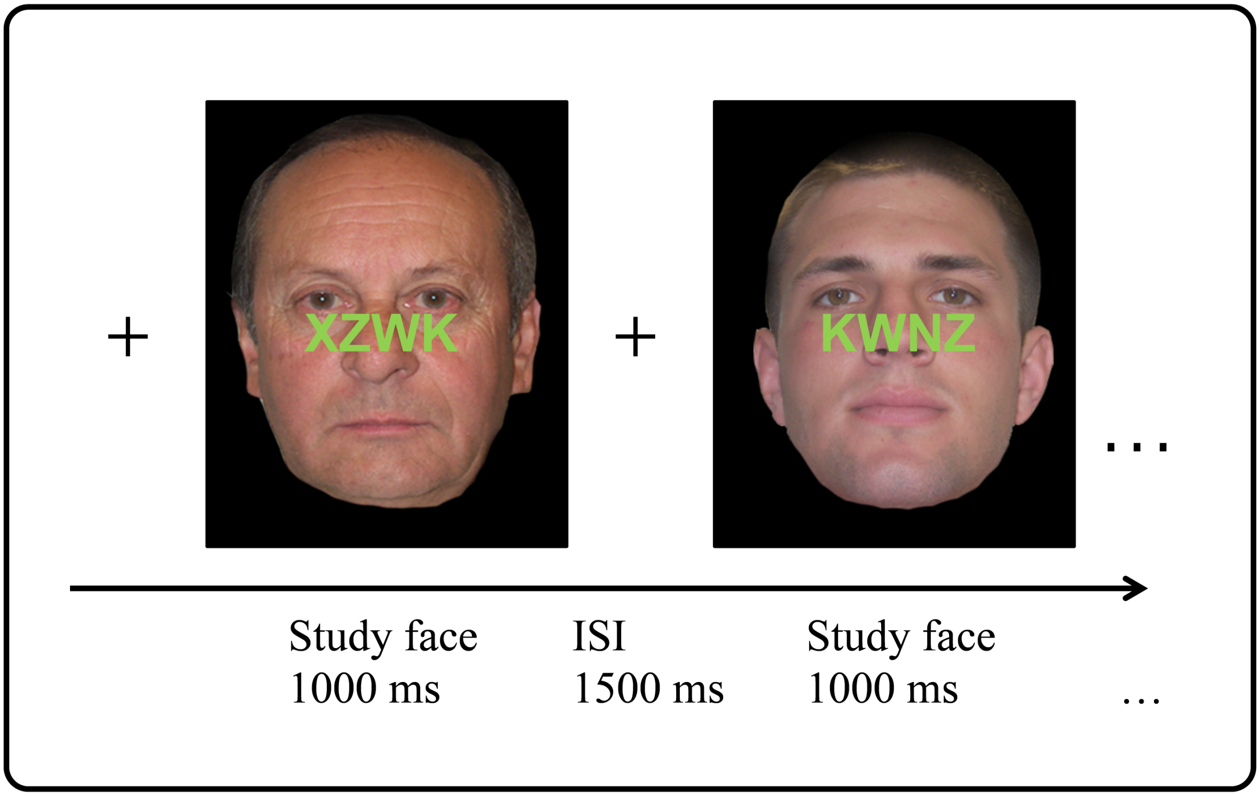
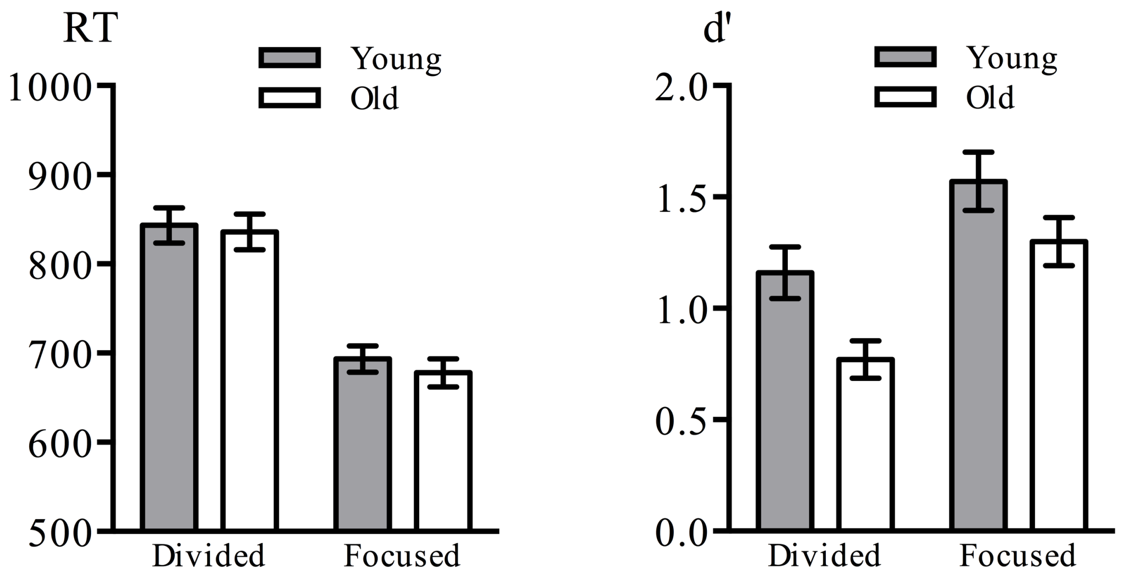


Figure 2


RT
Young
Old
1000
900
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Divided
Focused

Figure 3

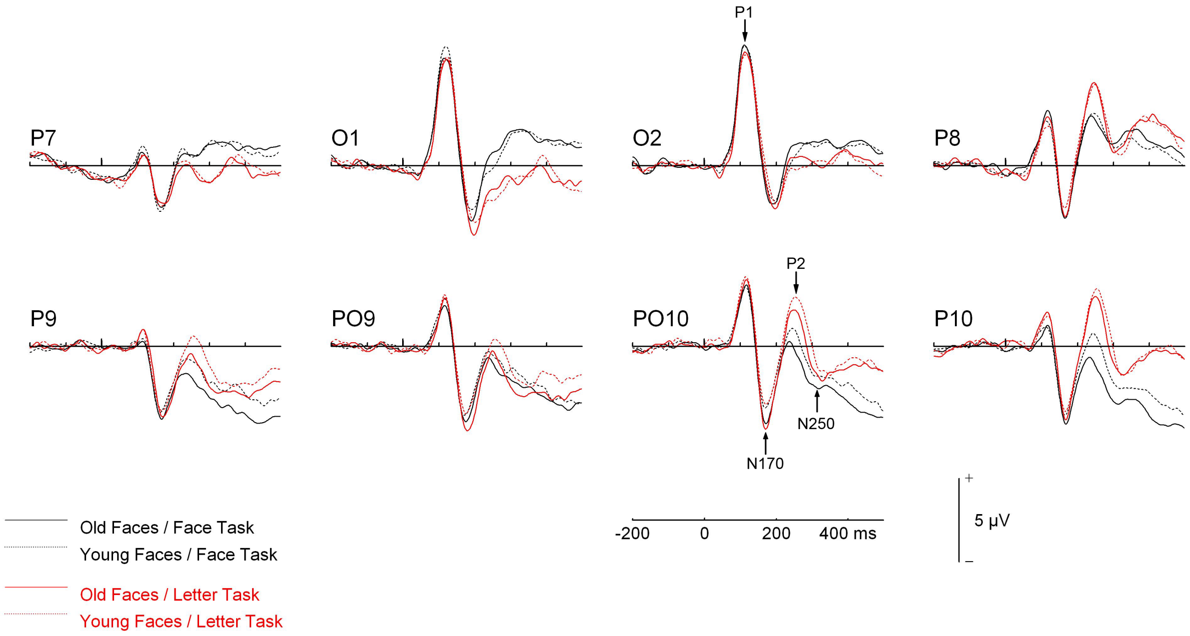

P1
P7
O1
O2
P8
P2
P9
PO9
PO10
P10
N250
N170
-200
0
200
400 ms
+
5 µV
−
Old Faces / Face Task
Young Faces / Face Task
Old Faces / Letter Task
Young Faces / Letter Task

Figure 4

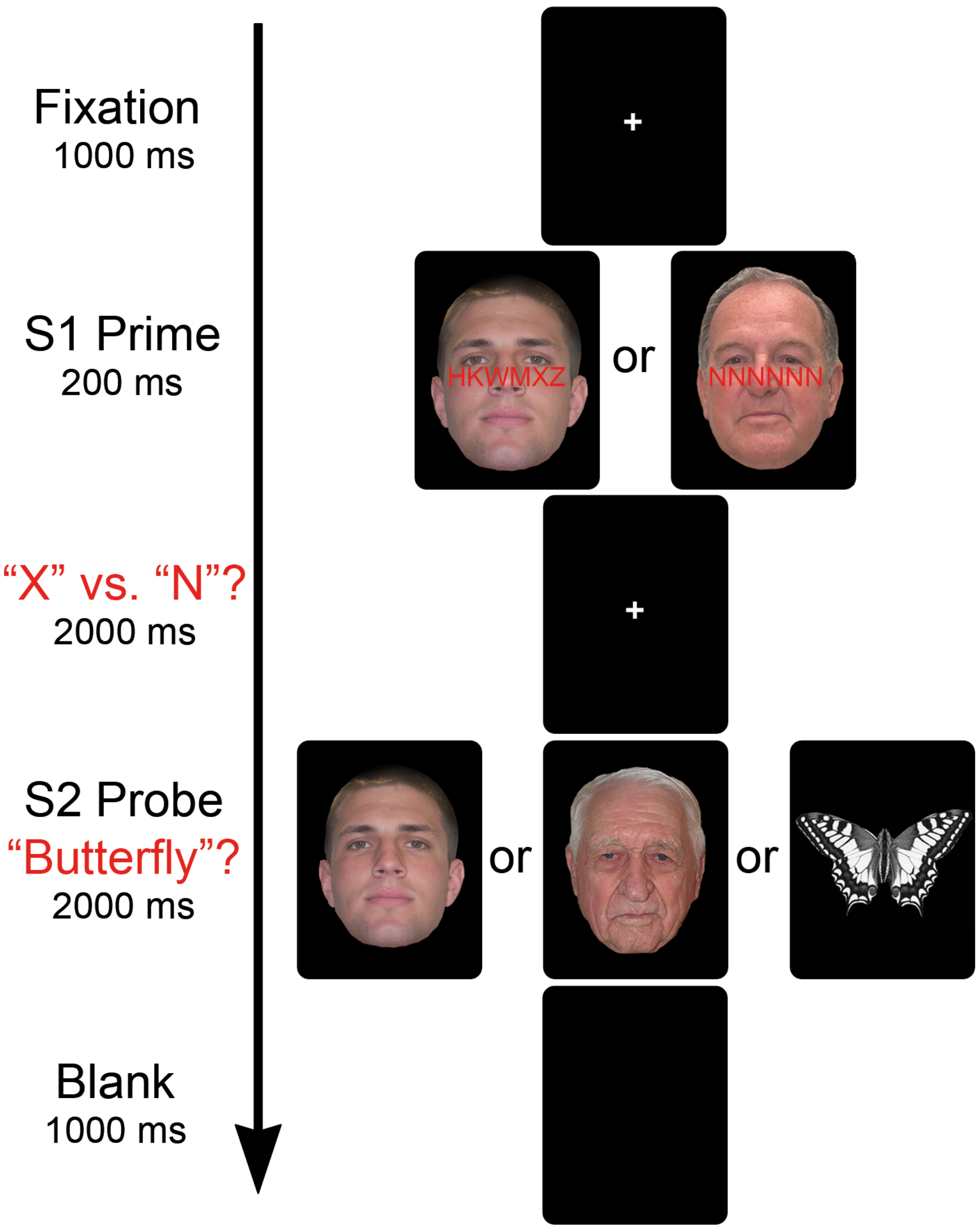
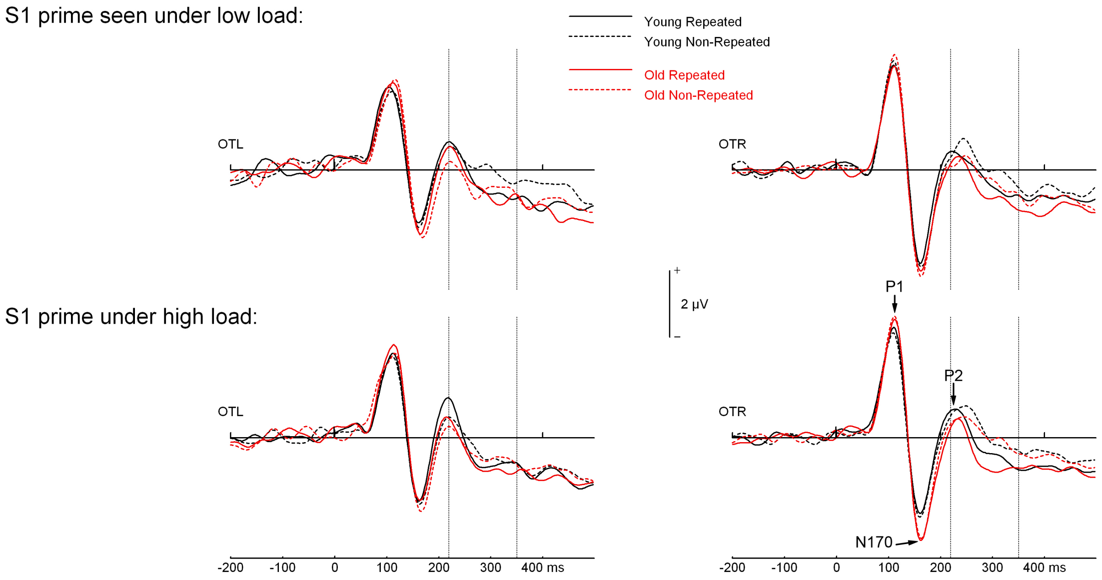

Fixation
1000 ms
+
S1 Prime
200 ms
HKWMXZ
or
NNNNNN
"X" vs. "N"?
2000 ms
+
S2 Probe
"Butterfly"?
2000 ms
or
or
Blank
1000 ms

Figure 5


S1 prime seen under low load:

S1 prime under high load:

Figure 6

Figure 7

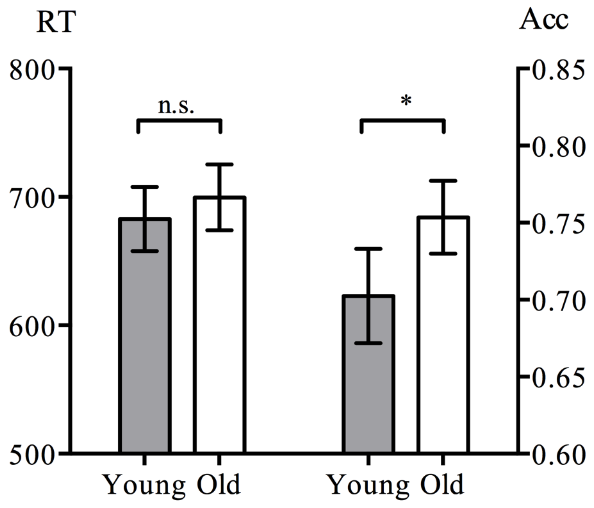
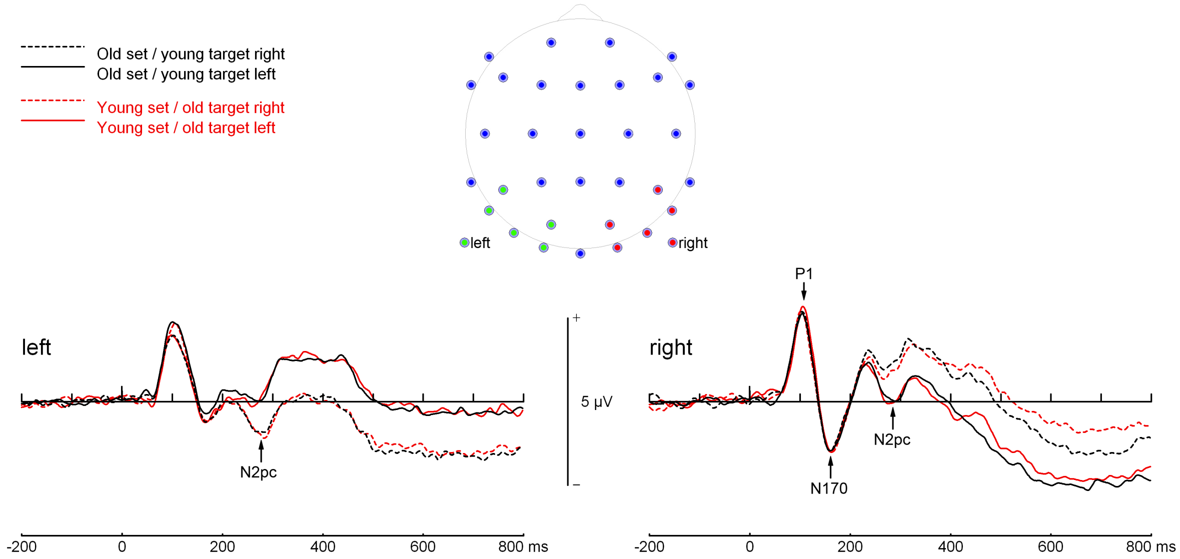

RT
Acc
800
700
600
500
0.85
0.80
0.75
0.70
0.65
0.60
n.s.
*
Young
Old
Young
Old

Figure 8


Old set / young target right
Old set / young target left
Young set / old target right
Young set / old target left
left
right
left
right
P1
N170
N2pc
N2pc
+
5 µV
–
-200
0
200
400
600
800 ms
-200
0
200
400
600
800 ms