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Research report

Neural correlates of intentional and incidental recognition of famous faces

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Abstract

Event-related potentials (ERPs) were used to study the relationship between intentional and incidental recognition of famous faces. Intentional and incidental recognition were operationally defined as repeated presentations of targets and nontargets within a modified Sternberg task. These repetitions elicited temporally and topographically distinct ERP modulations. A repetition effect around 300 ms (ERE/N250r) and a preceding modulation did not differ between intentional and incidental recognition, whereas a following repetition effect (LRE/N400) around 500 ms showed differences between incidental and intentional recognition. These results show that during the first few hundred milliseconds intentional and incidental face recognition relate to similar processing, indicating that familiar faces are recognized even when their identification is not required.

Theme: Neural basis of behavior
Topic: Cognition

Keywords: Face recognition; Semantic processing; ERP repetition effects; Incidental recognition; Intentional recognition; Event-related potentials

1. Introduction

From everyday experience we know that we often recognize a familiar person when we see his/her face even if we have not been looking for him/her. That is, recognition can occur unintentionally or incidentally. On the other hand, recognition appears to be facilitated when it is intended, as illustrated by—often quite embarrassing—recognition failures, for example when a familiar person was not expected in a given context. A classical description of such failure was given by Tolstoi in his masterpiece 'War and Peace' when Pierre fails to recognize his great love Natasha at his return to ruined Moscow because he had not expected to see her. To date it is unknown to what extent processes responsible for incidental and intentional recognition are the same. We therefore attempted to address the role of recognition intention for the person recognition system [4,5,37] in a context that appears to be of special everyday relevance and under conditions that are arguably most challenging.

Some evidence for incidental recognition of persons comes from studies where recognition of a face is unrelated to the task. In a behavioral study it was shown that familiar faces were recognized incidentally when expression or gender judgments had to be performed [9]. It is of special importance here that, based on this and other findings, current cognitive models of person recognition suggest parallel processing routes for face recognition and gender or expression recognition [4,5]. That is, in order to conduct a judgment about a person's gender or expression when seeing his/her face, the identification of that person appears unnecessary (but see Ref. [11]). Other studies have provided evidence that, whenever a person is recognized, also some other knowledge related to that person is accessed incidentally [6,27,32]. Though these studies suggest that familiar faces *can* be recognized incidentally and person-related knowledge *can* be accessed incidentally, they do not

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provide information to what extent incidental and intentional recognition relate to *similar* processing.

Obviously, this issue is difficult to address by purely behavioral means. Fortunately, neural activity related to cognitive processes can be measured with event-related brain potentials (ERPs). ERPs provide information about time course and intensity of neural processing; they may also demonstrate differences in brain sources, when the distributions of ERPs across the scalp are taken into account. Recent studies have demonstrated distinct ERPs that mark specific processing stages related to the perceptual processing of faces, to the recognition of faces and to the access to person-specific knowledge (for a review, see Ref. [28]). One of these ERPs is the N170, which is interpreted as indicator of aspects of perceptual processing (or structural encoding [4,5]) of faces; the N170 appears as a negative peak around 170 after face onset at temporo-parietal electrode sites and usually shows a stronger negativity over the right side of the head [1,7].

The most important ERP for this study is the so-called *early repetition effect* (ERE) [3,22,32] or *N250r* [13,34]. The ERE/N250r relates to the stage of face recognition units (FRUs), which were proposed as long-term memory representations of familiar faces [4,5,37]. Prior research suggested that the ERE/N250r indicates facilitated access to these FRUs due to short-term repetition. The ERE/N250r is revealed when ERPs to repeated faces are compared with those to faces presented for the first time. This effect consists of a positive-going amplitude modulation over frontal areas and a negative-going modulation over temporal areas, starting around 250 ms after face onset, peaking at about 300 ms and lasting for at least 100 ms. The rationale behind linking the ERE/N250r to changes in the access to stored structural representations of familiar faces bears on its much smaller amplitude or even absence for unfamiliar faces, that is faces that do not have preexisting representations. Additionally, representations similar to FRUs exist in other visual domains, for example for words or common objects, and accordingly the ERE/N250r can also be measured in those domains; importantly, the scalp topographies of the ERE/N250r often differ across domains, indicating domain-specificity of the underlying representations [2,3,14,22]. The ERE/N250r is reduced when face repetitions involve different images of the same person, supporting the notion that the effect indicates facilitated access to FRUs; because FRUs are thought to be abstract, that is image-independent representations of familiar faces, any effect directly related to the activity of FRUs should, in contrast, not vary with images [34].

Usually, the ERE/N250r is followed by a so-called *late repetition effect* (LRE) or *N400*, consisting of a centro-parietal positivity (or reduced centro-parietal negativity) between about 400 and 600 ms. In addition to the different time course and scalp distribution, the LRE/N400 differs from the ERE/N250r also in several other respects [22,27,28,32,33]. For example, the LRE/N400 appears to be domain-unspecific. Noteworthy, the LRE/N400 is also elicited when the prime stimulus relates to an associated person, for example when the name or an image of Hilary Clinton precedes the presentation of Bill Clinton's face [27,32]. Based on such findings, the LRE/N400 is usually interpreted as reflecting changes in the access to semantic knowledge about the depicted person (for a review, see Ref. [28]), and is therefore an ideal means for the purpose of this study.

Notably, the ERE/N250r only survives a few intervening faces, whereas the LRE/N400 can also be found when the same face or the same name of a familiar person is repeated after longer lags in the time range of several minutes [33]. At such longer lags, parietal positivities for repeated faces were found that sometimes last until around 800 ms and additional frontal modulations in the same time range were also reported [18–21]. These modulations resemble effects described for words (for a review, see Refs. [10,16,25,26]) and are usually interpreted in terms of episodic memory. Recently, ERP modulations to repeated faces have been found that were interpreted as correlates of face priming [3,12,20,33].

In the present study we attempted to employ the ERE/N250r and the LRE/N400 as electrophysiological markers for the access to FRUs and to semantic knowledge about familiar persons, respectively, as a function of whether or not the observer attempted to recognize the person in question. To this aim, we used an experimental design that incorporates both intentional and incidental recognition of famous faces without the confounding problem of using different tasks for incidental and intentional recognition. More specifically, we employed a modified version of a Sternberg memory search task [35], in which participants were first shown the face of a famous person as the target to be detected afterwards. Showing the target face at study should come close to imagining the face to look for in the real-world example above. Then at test the target face was presented several times, interspersed with nontarget faces, which were also presented repeatedly. Participants indicated by means of button presses whether a given face was the target or not. The identity of target faces was task relevant and recognition of the corresponding persons was therefore intentional. In contrast, the identity of nontarget faces was task irrelevant and therefore any recognition of the corresponding persons and access to semantic knowledge related to these persons would have been incidental.[1]

It should be noted that ERE/N250r and LRE/N400 measure the access to FRUs and semantic knowledge indirectly, that is as facilitated access when a face is repeated. It was therefore necessary to repeat both target

[1] Although ERP recordings in Sternberg-type memory search tasks for faces have been used before [3,13,29–31], with the exception of Ref. [3], these studies have used *unfamiliar* faces and therefore bear no direct relevance for the present study, which aims at the understanding of the recognition of previously *familiar* faces.

and nontarget faces and to compare repeated target and nontarget faces against unrepeated faces. For incidental recognition, the comparison took part between the ERPs to repeated nontarget face presentations and the ERPs to initial nontarget face presentations. This approach follows straightforwardly from the aforementioned studies [22,32], in which memory access at initial face presentations was measured as facilitation of the same memory access when the faces were subsequently repeated within the same task.

Applying the same rationale to intentional recognition, the ERPs to repeated presentations of target faces at test would have to be compared to ERPs to initial presentations of target faces at test. Target faces, however, have been presented already at study and the ERPs to initially presented target faces at test will likely show repetition-related modulations [3]. Similarly, the ERPs to target faces at study cannot be used as a baseline condition for target faces at test, because that would confound the contrast of interest with task differences, that is encoding- vs. retrieval-related processing. Therefore the ERPs to repeated target faces were compared against the ERPs to new nontarget faces, which are the only condition without prior memory activation.

Using this design with famous faces as stimuli, we addressed the question whether and to what extent familiar faces were recognized incidentally, for example whether FRUs and other memories related to known persons were accessed incidentally. Because the rejection of nontarget faces in the present design does not require the recognition of these faces, the expression of an ERE/N250r for repeated nontarget faces would indicate incidental access to FRUs. The additional expression of the LRE/N400 would indicate that also semantic knowledge associated with these persons would have been accessed incidentally. It should be noted that according to current models of person recognition, the recognition of persons takes place at an intermediate stage between FRUs and the access to person-related knowledge, called person identity nodes (PINs). Unfortunately, for this stage of person recognition no electrophysiological marker seems to exist. Significant access to FRUs, however, appears to be necessary for the recognition of persons via faces. Moreover, for healthy people that do not suffer from prosopagnosia, it is assumed that this access to FRUs usually leads to a corresponding activation of PINs, resulting in person recognition when the activation is strong enough [28].

2. Materials and methods

2.1. Participants

Sixteen native German speakers (11 females, 5 males) participated for course credit or payment. Their mean age was 24.6 years (range 16 to 36). All participants had normal or corrected-to-normal vision and were right-handed as revealed by an adapted version of the Edinburgh Handedness Inventory [17].

2.2. Stimuli

The set of face stimuli consisted of 207 digitized grayscale portraits of different celebrities; for stimulus evaluation see Ref. [22]. The faces were presented at a size of $2.4 \times 2.9°$ (width×height) at the center of a black computer monitor with a refresh rate of 60 Hz.

2.3. Procedure

The experiment was subdivided into different stimulus series; each of which consisted of one study trial and three to five test trials (see Fig. 1). Individual stimulus series were separated by blank screens of 2250 ms duration. All stimulus series started with the 300-ms presentation of the word “Merke” (German for to memorize), written in green. 700 ms after its disappearance, the study stimulus was presented for 1500 ms, which was to be memorized as target for the following test trials; no response was required. Following a blank screen of 1500 ms duration, a small white fixation cross was presented at the center of the screen for 1000 ms. Thereafter, the first test trial started. In each test trial, the target or an unstudied nontarget face was presented for 500 ms, followed by blank screen for 1250 ms. Targets and nontargets appeared equiprobably and randomly. Within a given test trial series, a single target and a single nontarget face were presented between 0 and 3 times; the end of a series was determined by the third presentation of a target or nontarget, whichever occurred first.

The participant sat in front of a computer monitor in a dimly lit, sound attenuated and electrically shielded chamber. In the midline of the desk, two response buttons were mounted behind each other. The participant’s task was to press the buttons for targets and nontargets with their index fingers. The button assignment to target and nontarget decisions and the hand assignment to buttons were balanced across participants. The instruction emphasized both speed and accuracy.

For each participant, different faces were used as targets and nontargets. The experiment consisted of 103 series and was subdivided by four short breaks. Including breaks, an experimental session lasted about 0.5 h. Prior to the experimental session, a practice run was conducted with three-digit numbers as stimuli until the participant was familiarized with the task.

Reaction times and correctness of responses were measured. Incorrect, missing and late responses (>1.5 s) were treated as errors.

2.4. EEG recording and ERP methods

The continuous electroencephalogram (EEG) was recorded from 23 scalp positions (Fp1, Fp2, F7, F3, Fz,

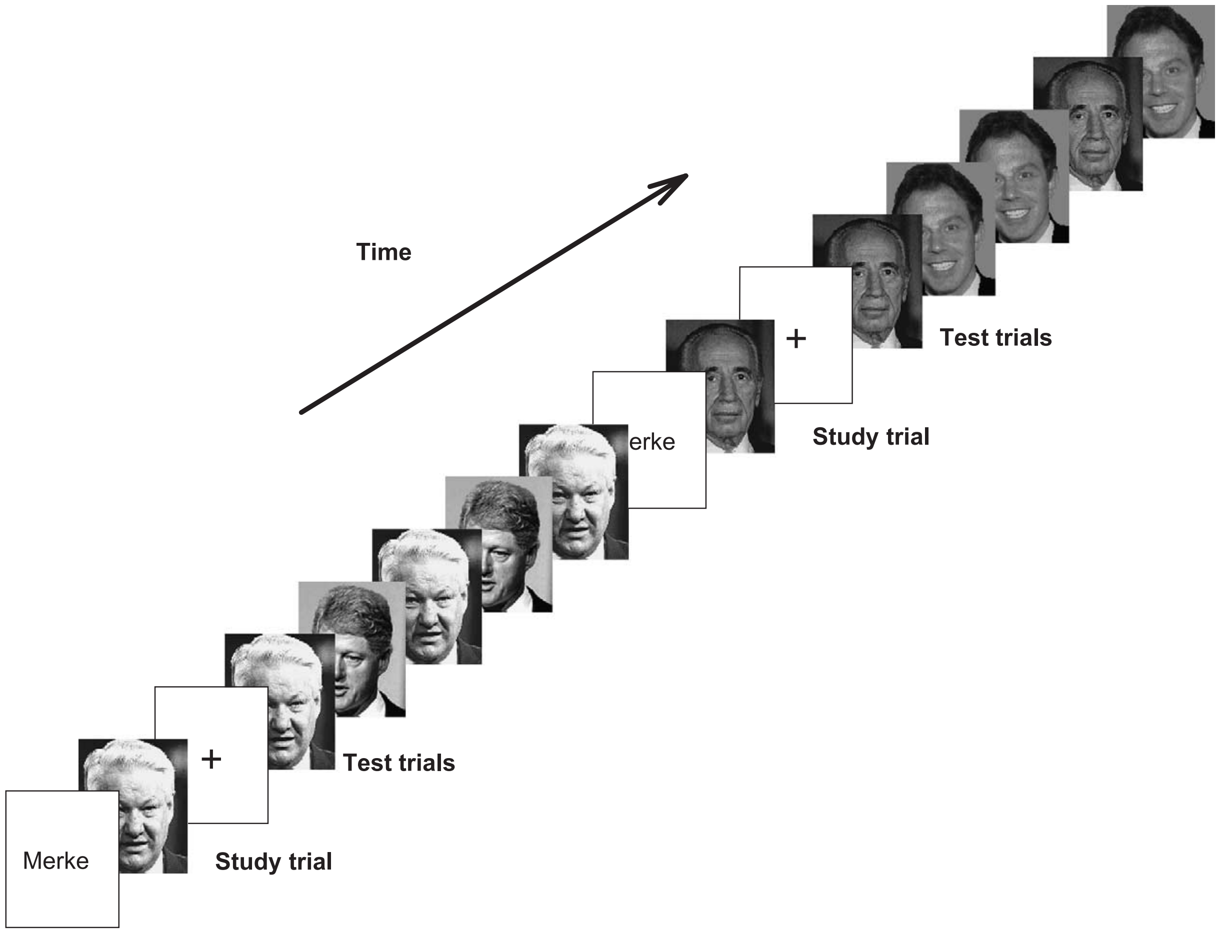

Fig. 1. Experimental design—schematic display of two consecutive series. Target stimuli for test trials are defined in study trials. In test trials, a target/nontarget discrimination has to be performed.

F4, F8, T7, C3, Cz, C4, T8, P7, P3, Pz, P4, P8, O1, O2, M2, PO9, Iz, PO10, according to Ref. [24]) from Sn electrodes mounted in an elastic cap (Electrode-Cap International, Inc.), referenced against M1 as initial common reference and digitized with a frequency of 250 Hz. The band-pass was set to DC-50 Hz; during the experiment, channels close to saturation were reset manually. Additionally, the horizontal and vertical electrooculograms were recorded. All electrode impedances were kept below 5 kΩ.

Offline, the EEG was separated into epochs of 900 ms length, starting 200 ms before stimulus onset. The influence of blinks was corrected [8] on the basis of 20–30 prototypical blinks. Only epochs free of residual artifacts and with correct responses were averaged. A 200 ms prestimulus interval served as baseline. All ERPs were low-pass filtered using a Butterworth filter with a cutoff frequency of 12 Hz and a filter order of 8 (zero phase shift) and re-referenced to an average reference.

2.5. Statistical analysis

ERPs and difference waves reflecting memory-related ERP modulations between repeated and new faces were quantified by mean amplitude measures in relevant time segments. Scalp topographies were assessed before and after normalization by vector length [15] to eliminate the confounding influence of amplitude differences.[2] The mean reaction times, error rates and ERP measures were subjected to repeated-measures ANOVAs; all comparisons were made two-tailed. The level of significance was set to α=0.05. Greenhouse–Geisser corrections were calculated whenever

[2] The scaling approach has recently been criticized [36] for producing false significant differences between scalp topographies when the topographies had to be normalized with different scaling factors. Two possible sources for false positives were mentioned: the topography of the baseline interval against which the topographies of interest are measured, and noise. We note that there seems no easy solution for this general issue yet. However, the baseline problem does not apply to topographies of difference waves because the baseline-interval topography (and similarly the topography related to processing the baseline condition) is out-subtracted before scaling. The noise problem still remains. As far as our results are concerned, different scaling of noise cannot explain the different polarity between the ERE/N250r and the preceding ERP modulation that is evident at most electrode sites. The significant differences in scalp topography between the ERE/N250r and the LRE/N400 should be interpreted with caution, but this point is not of central importance for the conclusions drawn here.

Table 1
Performance measures across target and nontarget conditions

Condition	Reaction time in ms		Error rate in %	
	M	(S.E.)	*M*	(S.E.)
Targets				
First presentation	530	(20)	3.0	(0.52)
Second presentation	456	(18)	2.3	(0.76)
Third presentation	465	(18)	2.5	(0.73)
Nontargets				
First presentation	584	(19)	3.3	(0.76)
Second presentation	497	(16)	3.4	(0.65)
Third presentation	499	(15)	5.2	(1.02)

appropriate; the uncorrected degrees of freedom, the corrected p-value and the calculated Greenhouse–Geisser ε are reported.

3. Results

3.1. Behavioral results

Accuracy was high in all conditions, with the highest error rate of 5.2% for the third presentations of nontarget faces (see Table 1). Multiple repetition of nontargets led to an increase in the error rate, which was reflected in a significant difference between new nontarget faces and the third presentations of nontarget faces, $F(1, 15)=5.44$, $p=0.0340$.

Response times (RTs, see Table 1) to the second presentations of target faces were shorter than for the first presentations, $F(1, 15)=70.98$, $p=0.0001$; RTs for the second presentations of nontarget faces were also shorter than for new nontarget faces, $F(1, 15)=71.37$, $p=0.0001$. The effect of presenting stimuli for a third time on RTs was minor and reached significance only for a somewhat unexpected 8-ms increase of RTs to target faces, $F(1, 15)=7.01$, $p=0.0183$.

3.2. ERP results

At incidental recognition, the ERPs to repeated nontargets differed from the ERPs to new nontargets starting around 150 ms (Figs. 2 and 4). Similar differences were found for intentional recognition when ERPs to repeated target faces were compared with ERPs to new nontargets (Figs. 2–4). The ERPs to the first presentation of target faces within the test series (i.e. initially presented target faces) also differed from the ERPs to new nontarget faces in a similar way (Figs. 3 and 4). These ERP modulations were further quantified by mean amplitude measures in the time segments 150–200, 200–250, 250–350, 350–450 and 450–550 ms. The 150–200-ms segment was chosen to measure effects in the time range of the N170, the 250–350-ms segment was intended to capture the ERE/N250r and the 450–550-segment corresponded to the peak of the LRE/N400; the other time segments were arbitrarily chosen. For the following comparisons (across different time segments

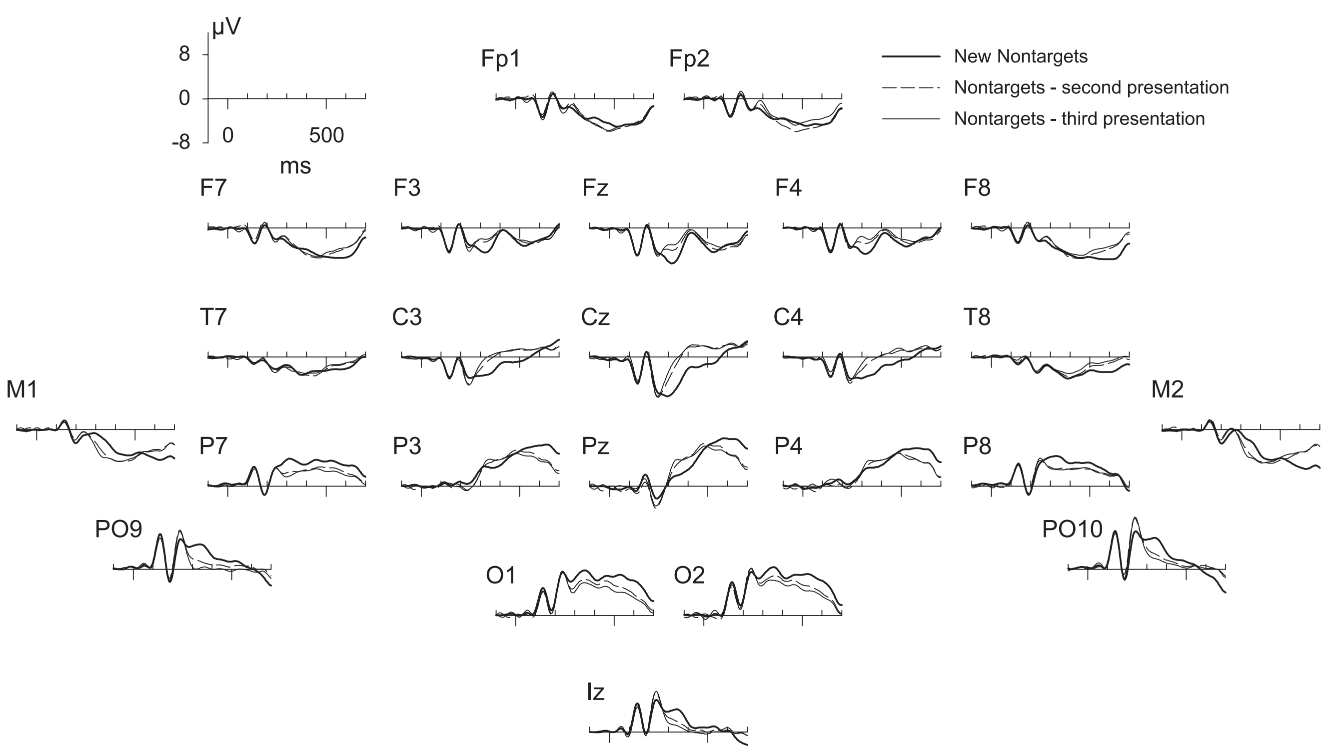

Fig. 2. ERPs at all electrodes for incidental recognition (nontarget face repetition) in comparison to new nontarget faces. Note the ERE/N250r around 300 ms at frontal and lateral posterior sites and the LRE/N400 around 450 ms at central/parietal sites.

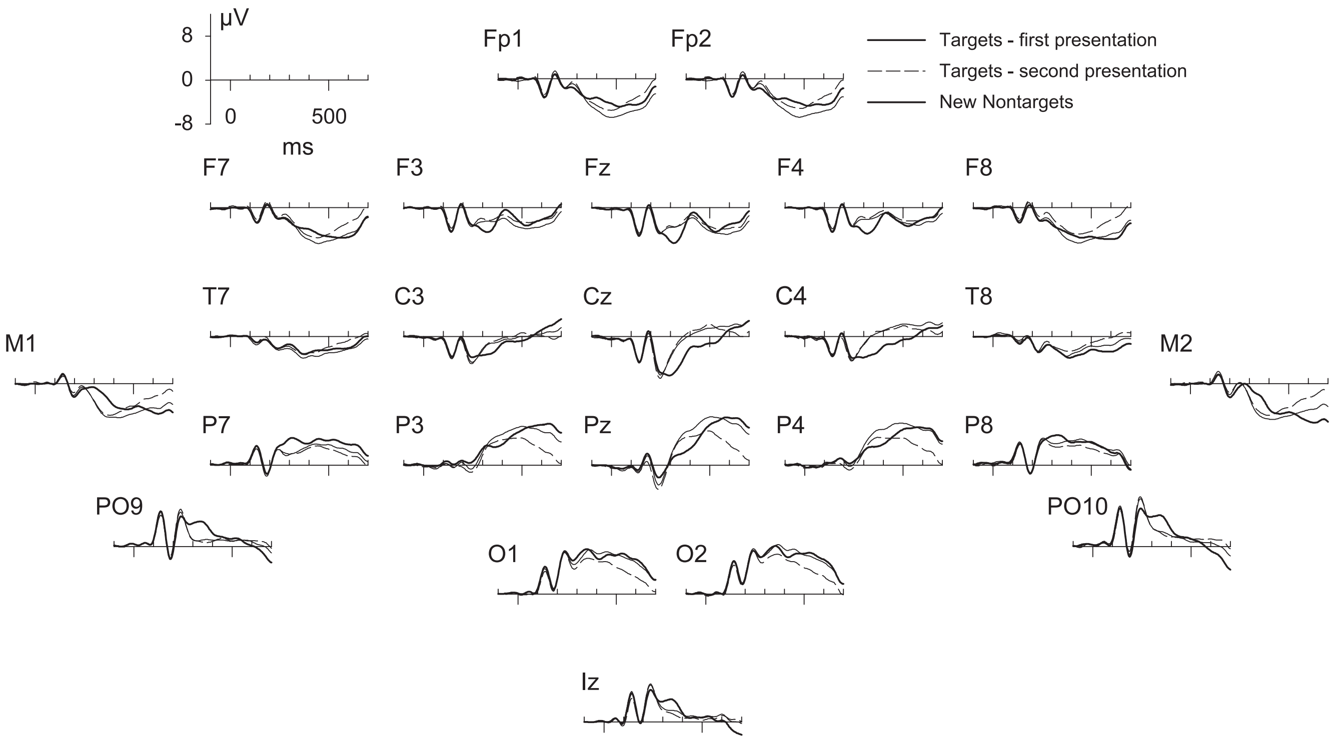

Fig. 3. ERPs at all electrodes for intentional recognition (target face repetition) in comparison to new nontarget faces. Note the ERE/N250r around 300 ms at frontal and lateral posterior sites and the LRE/N400 around 450 ms at central/parietal sites.

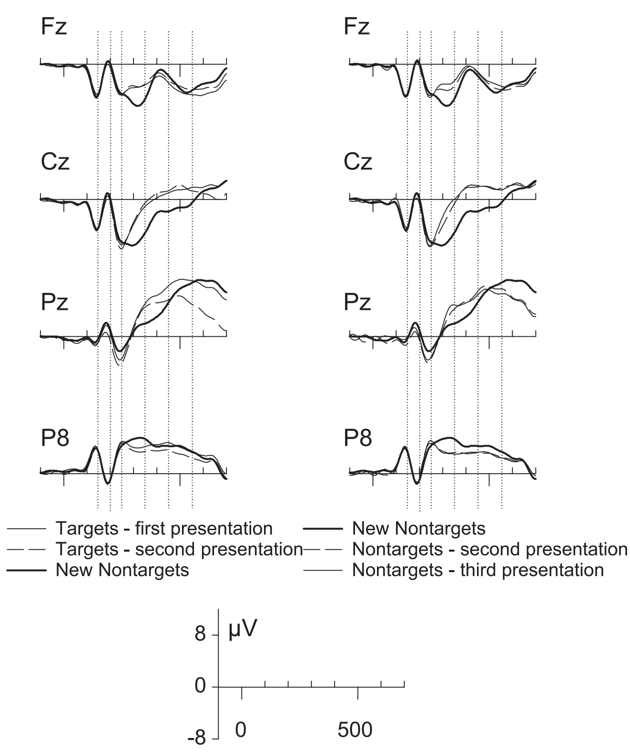

Fig. 4. ERPs at selected electrodes for intentional recognition (target face repetition) and incidental recognition (nontarget face repetition) in comparison to new nontarget faces, highlighting the main effects of face repetition. The time segments taken for ERP analyses are indicated by vertical lines.

or between target and nontarget faces), we tested for differences by contrasting the corresponding ERPs within separate ANOVAs with the additional factor of electrode site (24 levels). Because an average reference was used, setting the mean amplitude across all electrodes within any condition to zero, differences between conditions appear as interaction between condition and electrode site. Additional comparisons were conducted at single electrodes where the repetition effects were maximal: Pz for the 150–200 and 200–250-ms time segments; Cz, P7, P8 for the 250–350-ms time segment, and Cz for the 350–450 and 450–550-ms time segments (see Fig. 5).

With ERPs to new nontarget faces as baseline condition for the ERPs to repeated target (second presentations) and repeated nontarget faces (second presentations), significant repetition effects were found for all time segments and both *intentional* and *incidental recognition*, indicating memory-related ERP modulations starting at ~150 ms, i.e. about 100 ms before the ERE/N250r usually begins to develop (Tables 2 and 3). Similar ERP differences were also evident in the four last time segments for initially presented target faces (see Figs. 3 and 4), showing that this condition indeed cannot be regarded as unrepeated.

We then calculated difference waves between repeated targets (second presentations) and new nontargets for intentional recognition and between repeated nontargets (second presentations) and new nontargets for incidental recognition. In such difference waves, the ERPs to the baseline condition are removed and only the memory-related ERP modulations remain present. Calculating differ-

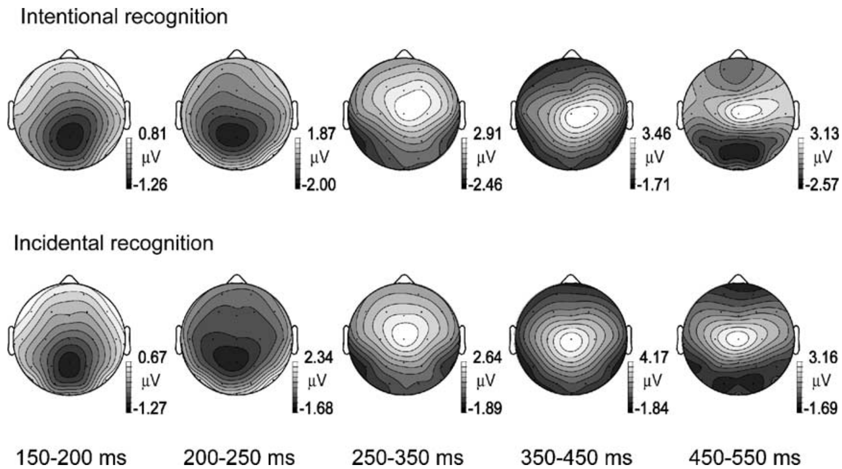

Fig. 5. Scalp topographies of memory-related difference wave amplitudes obtained by subtracting ERPs to new nontarget faces from ERPs to repeated target faces (second presentation) for *intentional recognition* and to repeated nontarget faces (second presentation) for *incidental recognition*. Topographies are shown as viewed from the top of the head with an extended view displaying all electrodes (indicated by dots). Intermediate amplitudes were obtained with a spherical spline algorithm.

ence waves allows direct comparisons of the memory-related ERP modulations across different experimental conditions and time segments in graphical displays as topographic maps (see Fig. 5) and are a prerequisite for corresponding statistical analyses, for example for shape comparisons of these topographies.

For every time segment, these difference waves were compared by ANOVAs with recognition intention (intentional, incidental) and electrode site as factors and at single electrodes with recognition intention as the only factor. When tested at all electrodes, significant interactions were found only for the 450–550-ms time segment corresponding to the LRE/N400 (Table 2), but for none of the earlier time segments, $Fs(23, 345)<=1.52$, $ps>=0.2277$, $1100<=\varepsilon<=0.1665$; when tested at single electrodes, none of the comparisons was significant, $Fs(1,15)<=2.98$, $ps>=0.1049$ (Table 3). The memory-related ERP modulations thus differ between intentional and incidental recognition only when all electrodes are taken into account and after about 450 ms, that is, within the time range of the LRE/N400. There was, however, no indication for differences of the ERE/N250r or in the preceding time segments.

The findings above indicate that recognition intention had a differential influence on memory-related ERP modulations in the 250–350-ms time segment, corresponding to the ERE/N250r, compared to the 450–550-ms time segment, corresponding to the peak of the LRE/N400. This suggests qualitative differences in the neural generation that underlies the two repetition effects. A common approach to substantiate this conclusion is the comparison of the scalp

Table 2
F ratios and Greenhouser–Geisser epsilon for the main ERP effects between and across intentional and incidental recognition conditions tested at all electrodes

Condition	Time segment				
	150–200 ms	200–250 ms	250–350 ms	350–450 ms	450–550 ms
	F (ε)	*F* (ε)	*F* (ε)	*F* (ε)	*F* (ε)
Intentional recognition (targets)					
First presentation—new nontarget		6.20*** (0.18)	14.56**** (0.12)	18.59**** (0.20)	6.30**** (0.21)
Second presentation—new nontarget	4.11** (0.17)	6.50** (0.12)	10.39**** (0.11)	8.23**** (0.19)	7.38**** (0.19)
Third presentation—new nontarget		3.01* (0.14)	11.61**** (0.10)	9.15**** (0.19)	7.98**** (0.18)
Incidental recognition (nontargets)					
Second presentation—new nontarget	3.37* (0.12)	6.68** (0.11)	8.36*** (0.10)	14.72**** (0.13)	8.83**** (0.14)
Third presentation—new nontarget		4.26* (0.13)	11.08*** (0.09)	11.19*** (0.09)	8.41**** (0.16)
Intentional vs. incidental recognition (unscaled)					
Second presentation—new nontarget					3.09* (0.19)
Third presentation—new nontarget					

All nonsignificant effects were omitted. Uncorrected degrees of freedom for all comparisons: 23, 345. ε—Greenhouse–Geisser epsilon.

* $p<0.05$.

** $p<0.01$.

*** $p<0.001$.

**** $p<0.0001$.

Table 3
F ratios for the main ERP effects between and across intentional and incidental recognition conditions tested at specific electrodes

Condition	Time segment (electrodes)				
	150–200 ms	200–250 ms	250–350 ms	350–450 ms	450–550 ms
	(Pz)	(Pz)	(Cz, P7, P8)	(Cz)	(Cz)
Intentional recognition (targets)					
First presentation—new nontarget		23.73***	>=14.72**	38.62****	29.86****
Second presentation—new nontarget	12.51**	33.02****	>=15.23**	19.10***	20.44***
Third presentation—new nontarget		14.73**	>=10.03**	21.16***	23.86***
Incidental recognition (nontargets)					
Second presentation—new nontarget	22.72***	22.75***	>=11.68**	34.05****	24.64***
Third presentation—new nontarget		17.28***	>=11.04**	25.00***	31.93****
Intentional vs. incidental recognition (unscaled)					
Second presentation—new nontarget					
Third presentation—new nontarget					

All nonsignificant effects were omitted. Degrees of freedom for all comparisons: 1, 15.
* $p<0.05$.
** $p<0.01$.
*** $p<0.001$.
**** $p<0.0001$.

topographies of these ERP modulations (Fig. 5) between the two time segments when confounding amplitude differences were removed after normalization by vector length [15]. These comparisons revealed indeed a significant difference between the two time segments for intentional recognition and a trend for incidental recognition (Table 4).

To further substantiate that the difference of the LRE/N400 between intentional and incidental recognition reflects distinct scalp topographies rather than a pure amplitude change, as indicated above, a similar comparison using scaled scalp topographies of the difference waves was calculated for the LRE/N400 between intentional and incidental recognition. This comparison was significant (Table 4), indicating that the neural generation of the LRE/N400 may vary with recognition intention. Similarly, as suggested by Fig. 5, the early ERP modulation in the time range of the N170 (time segment 150–200 ms) showed a scalp topography that differed from that of the ERE/N250r for both incidental and intentional recognition (Table 4).

Table 4
F ratios and Greenhouser–Geisser epsilon for ERP scalp topography comparisons (scaled) for intentional and incidental recognition conditions at all electrodes across and within time segments

Condition	*F*	(ε)
250–350 vs. 450–550 ms		
Intentional recognition		
Second presentation—new nontarget	5.77**	(0.14)
Third presentation—new nontarget	8.30****	(0.16)
Incidental recognition		
Second presentation—new nontarget	2.78[a]	(0.09)
Third presentation—new nontarget	3.64*	(0.12)
150–200 vs. 250–350 ms		
Intentional recognition		
Second presentation—new nontarget	9.25****	(0.14)
Incidental Recognition		
Second presentation—new nontarget	7.71***	(0.13)
Intentional vs. incidental recognition (second presentation—new nontarget)		
450–550 ms	2.98*	(0.19)

Uncorrected degrees of freedom for all comparisons: 23, 345. ε—Greenhouse–Geisser epsilon.
[a] $p<0.10$.
* $p<0.05$.
** $p<0.01$.
*** $p<0.001$.
**** $p<0.0001$.

The ERPs to third presentations of targets (intentional recognition) and third presentations of nontargets (incidental recognition) also differed from the baseline ERP to new nontargets. Firstly, there were reliable differences for the four later time segments for intentional and incidental recognition (Tables 2 and 3). There were, however, no significant differences within the first time segment, neither when all electrodes were taken into account, Fs(23, 345)<=1.50, ps>=0.2193, 0.1409<=ε<=0.1536, nor for the comparison at single electrodes, Fs(1, 15)<=4.26, ps>=0.0568, indicating that reliable memory-related differences for further repetitions start around 200 ms, that is, about 50 ms earlier than the ERE/N250r, but 50 ms later than for second presentations of target and nontarget faces. Secondly, for these four later time segments the corresponding difference waves for intentional recognition (repeated targets minus new nontargets) and incidental recognition (repeated nontargets minus new nontargets) did not differ significantly with recognition intention, Fs(23, 345)<=1.93, ps>=0.1482, 0.1134<=ε<=0.1418 (all electrodes), Fs(1, 15)<=2.06, ps>=0.1717 (single electrode comparisons). Thirdly, the comparison of scaled scalp topographies of the difference waves, when compared between the 250–350-ms and the 450–550-ms time segments, resulted in significant differences (Table 4), indicating two distinct subeffects corresponding to ERE/N250r and LRE/N400 for both intentional and incidental recognition. In brief, the memory-related ERP modulations to subsequent repetitions of targets and nontargets showed the expected pattern of an ERE/N250r followed by a LRE/N400 and—again—did not indicate a modulation of the ERE/N250r by recognition intention.

The finding of an ERP modulation for both first repeated targets and first repeated nontargets in the 150–200-ms time segment corresponding to the occurrence of the N170 opens the question whether this modulation reflects amplitude changes in the N170. We therefore tested the mean amplitudes between repeated faces and new nontarget faces at the temporo-parietal electrode sites P7 and P8 where the N170 usually is most pronounced, and at Pz where the modulation appears strongest (Fig. 5). None of the contrasts at the temporo-parietal sites was significant, $Fs(1, 15)<=1.65$, $ps>=0.2182$, whereas significant differences were revealed at Pz (Table 3), suggesting that the modulation in the 150–200-ms time segment does relate to strength variations of processes other than those reflected mainly in the N170.

4. Discussion

The present study assessed the question whether the intention to recognize a well-known person would modulate processes within the person recognition system. The intention to recognize a person was induced by defining a particular famous face as target for a modified Sternberg recognition task. These intentionally recognized faces were contrasted to other famous faces that appeared as nontargets during the recognition test; any recognition of a nontarget face was unrequired by the task and would therefore be purely incidental. In order to assess the extent to which intentional and incidental recognition relate to similar processing, we measured ERPs to these familiar faces. The analyses focused on the ERE/N250r and the LRE/N400, which have been linked to processing at different stages within the person recognition system [22,27,28,32]. First of all, our results replicate these two temporally and topographically distinct ERP modulations. The LRE/N400 showed some evidence of a modulation by recognition intention. Importantly, the ERE/N250r did not differ between intentional and incidental recognition. Varying across conditions, an additional ERP modulation preceded the ERE/N250r; this modulation was similarly unaffected by recognition intention. Additionally, the N170 showed no evidence for an amplitude modulation for repeated faces.

What can be concluded from these results for the person recognition system? The earliest modulation before 250 ms may relate to repetition of pictorial codes [22,32], a hypothesis that could be evaluated in future research by employing repetitions across different images of the same faces, for which this modulation should disappear. Note that a similar pattern of three consecutive modulations, with the first modulation related to stimulus-specific repetition, were recently found in the verbal domain [23]. Pictorial codes are outside of the core of the person recognition system and the early modulation is therefore not further considered here.

The ERE/N250r, which is commonly discussed as electrophysiological indicator of facilitated access to FRUs due to repetition [22,28,32], was expressed indistinguishably for target and nontarget faces. That is, there was no indication that incidental access to FRUs differs from intentional access in either the involved brain circuits (as measured by means of scalp topographies) or in the activation strength of these brain circuits. These result indicate that access to FRUs does not vary with recognition intention. According to current models of person recognition, access to an FRU does not correspond to the recognition of the corresponding person, but these models assume that in healthy observers sufficient activation of an FRU eventually leads to a corresponding activation of the subsequent PIN, allowing the recognition of the person seen [28]. In other words, though the recognition of a (nontarget) face may not be required by the task at hand, or may be actually detrimental for achieving the goal in the present task by interfering with the memory trace for the target face, a face that is encountered incidentally is nevertheless likely to be recognized.

When discussing the modulation of the LRE/N400 by recognition intention, one should keep in mind that the contrast between repeated target faces and new nontarget faces reflects both (1) facilitation due to prior processing of target faces and (2) differences in processing the expected vs. the nonexpected face. The modulation of the LRE/N400 by recognition intention may thus be related to either a different amount of facilitation from prior processing due to recognition intention or to processing differences between the expected versus an unexpected face. The similarity of ERP repetition effects within the first ~450 ms between intentional and incidental recognition despite this possible confound, however, strengthens our conclusion of equal amount of facilitation as indicator of similar access to FRUs and similar recognition of persons at initial presentation. Moreover, the existence of the LRE/N400 for incidental recognition clearly indicates that also other knowledge related to these persons was accessed.

To our knowledge, incidental recognition of familiar persons upon seeing their faces was reported only once in a purely behavioral study, when incidental access to FRUs and PINs was demonstrated during expression or gender judgments [9]. Going beyond current cognitive models of person recognition [4,5], which propose parallel processing routes for face recognition and gender or expression recognition, our results suggest that, when seeing a face of a familiar person, this person is recognized incidentally even when a different person's face is kept in mind/memory. Note that in this case, the person recognition system is challenged to a much higher degree as in case of gender or expression judgments because processing takes part only inside the face recognition route. Importantly, our results show no indication that under this extreme condition incidental and intentional recognition relate to different processing. Taken together, the available behavioral and ERP evidence implies an almost automatic recognition of the identity of known persons when their faces are seen, possibly a result of the expertise humans gain in the recognition of faces as a reflection of the amount of practice with and the high importance of faces for social interaction and communication.

To summarize, we introduced a modified Sternberg task that allows assessing memory-related ERP modulations for intentional and incidental recognition of familiar faces within a single task. We measured several temporally and topographically distinct modulations, some of which have been shown in prior research as being related to distinct stages of person recognition. These modulations were similar for intentional and incidental recognition within the first 450 ms, indicating that intentional and incidental recognition relate to similar processing within this time range; only thereafter differences start to emerge. In particular, these results support the idea of a mandatory-like recognition of a person when seeing his/her face, even while a different face is kept in mind.

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