Electrophysiological correlates of visually processing subject's own name

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Abstract

We investigated the electrophysiological correlates of the processing of subject's own name (SON) in comparison to familiar and unfamiliar names in the Chinese language. The three types of names were the deviants in an oddball paradigm among lexical and non-lexical phrases. All items consisted of three characters, and the non-lexical items were the targets. All names caused a clear N170 component of identity. Only SON elicited a large N250 component, reflecting attentional capturing of SON. Additionally, SON caused a larger P300 than the other two name stimuli which we interpret as a correlate of access to self-reference information.

Keywords: Event-related potential, SON, N250, P300

Because of its subjective importance and its frequency of occurrence in daily life, SON provides cues to the own identity. Due to this personal relevance SON should have an advantage in cognitive processing. Consistently, it has been demonstrated that SON automatically captures participant's attention, and disrupts ongoing processing. Consistently, it has been demonstrated that SON automatically captures participant's attention, and disrupts ongoing processing. This effect can even be traced back to the study of the cocktail-party phenomenon [4,14]. Neurological evidence showed that after general anesthesia, reactivity to the SON occurs first [11]. Researches also revealed that the search speed for a target stimulus was faster when SON was used than when a neutral stimulus was used as target (e.g., [5]). Also in dual tasks this effect was observed. Woldorf and Morrison found that the response latency was significantly prolonged when the SONs were used as interference stimulus [28]. It was also reported that individuals do not experience an attention blink for the SON as they do for either other name or noun [24]. Recently, a number of event-related potential (ERP) studies were reported that also support this perceptual priority. Hearing one's own name elicits a robust electrophysiological P300 response (e.g., [2,18]). Preserved P300 response to the SON has been obtained even in states of reduced consciousness, such as during certain sleep phases [19] or minimally conscious patients [12]. Attention related neural correlates (e.g., N2b and novelty P3) were larger for the spoken SON than for a non-vocal stimulus that was sensorial similar to the own name [7]. Only a few ERP studies used visual presentation but they also have reported an enhanced P300 component [13,20]. Obviously, SON has a processing priority in perception and attention [8,10].

Where in the processing stream is this priority established? A theoretical framework of name and face recognition has already been proposed that can be applied to perception of SON [3,25]. According to this model, a stimulus is initially structurally encoded to represent the name or face. These structural representations address a pool of stored representations or recognition units called face recognition units (FRU) or name recognition units (NRU) [3,25]. If the match is sufficiently high, the person corresponding identity node (PIN) is activated. The PINs are located at a post-perceptual (semantic) level and there also a judgment of familiarity takes place. The PINs act as the gateway to access further information about a person, such as biographic or semantic details. If a face was encoded the PIN allows retrieval of his or her name.

This model can explain the different electrophysiological components and their temporal order that were observed in the ERP studies. The first is the N170 component. It is assumed that it reflects a structural encoding process [21] because it is insensitive to repetition priming [23]. The second stage is related to the N250 component, which reflects a process of matching input information to stored representations. N250 appears in repetition priming paradigms as a negative component for familiar faces and names relative to unfamiliar faces and names over inferior temporal electrodes at latencies of around 200–300 ms. In fact, this ERP component may reflect a transient activation of perceptual recognition units for names (NRUs). The N250 can be considered as an index of familiarity. Correspondingly, we already found that SON can elicit larger N250 amplitudes than collective self-related
stimuli [30]. Recently, Herzmann et al. has also shown that N250 amplitudes are more pronounced in response to familiar-intimate faces than to familiar-famous faces [6]. This result suggests that the N250 is not only influenced by `general' familiarity – the stimulus is known – but also by `personal' familiarity, which corresponds to a feeling of belonging to my privacy, a kind of self-relevance of the stimulus. It is therefore debated whether the N250 is only a correlate of general familiarity or also of self-cognition. The P300 is considered a correlate of the final stage, the access to the person identity node and semantic processing. P300 is a well known component which represents the endogenous component at PIN level. This component is an index of self-relevant stimuli irrespective of their frequency [17]. The studies mentioned above suggest that the SON effect emerges at this stage.

Obviously, behavioral and ERP studies have shown that the SON is processed more efficiently than other names. However, there are still some issues that need to be clarified. First, it is not shown that a SON effect can be clearly observed in the visual domain. Previous ERP studies have mainly investigated aural SON effect only a few studies had ever addressed the SON effect with visual input. They also did not use the whole name as stimulus even though this provides the strongest personal input [13,20]. Second, the relationship of the N250 to processing of self-relevant information is still disputed. Until now, only one study has demonstrated that sub-salient of the N250 to processing of self-relevant information is still disputed. Until now, only one study has demonstrated that sub-

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EEG signals were sampled at 1 kHz from 64 Ag/AgCl electrodes referenced to Cz and placed according to the extended 10–20 convention. Impedances were kept below 5 kΩ. Signals were filtered on-line between 0.01 and 40 Hz. Ocular artifacts were mathematically corrected using Scan 4.3.1 (Neuroscan, Inc.). Remaining artifacts were manually rejected upon visual inspection. EEG epochs ranging from −200 to 1000 ms relative to stimulus onset were baseline corrected in reference to pre-stimulus activity before ERP averaging. In order to test lateralization, 15 electrode sites were selected for statistical analysis: F3, FC3, C3, CP3, P3 (left sites); Fz, FCz, Cz, CPz, Pz (5 midline sites); and F4, FC4, C4, CP4, P4 (5 right sites). The peak amplitude and latency of the N170 (130–220 ms), N250 (220–300 ms) and P300 (300–500 ms) were extracted. A three-way repeated measures analysis of variance (ANOVA) on the amplitude and latency of each component was conducted. The corresponding factors were stimulus type (SON, familiar name, and unfamiliar name), laterality (left, midline and right sites) and spatiality (front, front-central, central, front-parietal, and parietal sites). Degrees of freedom were corrected according to the Greenhouse–Geisser method when necessary. In this case the original degrees of freedom are reported together with the correction factor ε.

The results are shown in Fig. 1. For the N170 component, no effect of stimulus type was observed [R(2,34) = 1.38, p = 0.27, ε = 0.94]. The main effects of laterality [R(4,68) = 54.99, p < 0.001, ε = 0.41] and laterality [R(2,34) = 21.68, p < 0.001, ε = 0.92] were both significant. The mean amplitudes went more negative from frontal (−0.70 µV), over central (−3.31 µV), to centro-parietal (−7.43 µV) and parietal sites (−12.80 µV). Bonferroni-corrected pairwise comparison within laterality revealed that N170 in the parietal sites was larger than all other sites [all Fs(1,17) > 5.16, all ps < 0.05]. The mean amplitudes of the laterality factor (from left to right) were as follows: −6.15 µV, −3.87 µV, and −5.22 µV. Pairwise comparison within laterality revealed that N170 was more pronounced in the left than at other sites [all Fs(1,17) > 2.99, all ps < 0.05]. For latency of N170, there was no significant effect.

The amplitude and latency measures of N250 for all electrodes are presented in Table 1. A significant main effect of stimulus type was observed [R(2,34) = 15.54, p < 0.001, ε = 0.56]. Bonferroni-corrected pairwise comparisons within stimulus type revealed that N250 amplitude elicited by SON was larger than those elicited by familiar name [R(1,17) = 5.07, p < 0.05] and unfamiliar name [R(1,17) = 3.89, p < 0.05]. The latter two were not significantly different from each other [R(1,17) = 1.35, p > 0.05]. The amplitudes elicited by familiar names were comparable to those for unfa-
Fig. 1. Grand average of ERPs at F3, Fz, F4, C3, Cz, C4, P3, Pz, P4 for subject’s own name, familiar name and unfamiliar name cognition. Vertical timelines indicate the areas of SON effect, which were used in ANOVA (130–220 ms, 220–300 ms and 300–500 ms). For the sake of space we dropped the FC and CP row because they were exactly in between the presented ones.

familiar names at each site [all $F$s(1, 17) < 1.97, all $p$s > 0.15]. In addition, the stimulus type $\times$ caudality interaction was significant [$F(8, 136) = 3.21$, $p < 0.05$, $\varepsilon = 0.36$]. Simple effect analysis revealed that SON evoked a larger N250 than other stimuli at all sites [all $F$s(1, 17) > 8.86, all $p$s < 0.05]. These effects, however, were largest in parietal sites [$F(1, 17) = 22.77$, $p < 0.01$] and smallest in frontal sites [$F(1, 17) = 8.86$, $p < 0.01$]. The stimulus type $\times$ laterality interaction was also significant [$F(4, 68) = 3.93$, $p = 0.02$, $\varepsilon = 0.61$]. Simple main effects analysis revealed that SON evoked larger N250 than other stimuli at all sites [all $F$s(1, 17) > 12.04, all $p$s < 0.01]. However, these effects were large in the left [$F(1, 17) = 17.81$, $p < 0.01$] and right sites [$F(1, 17) = 14.75$, $p < 0.01$] and smaller at the midline [$F(1, 17) = 12.04$, $p < 0.01$]. All results of the three-way ANOVA were confirmed when we analyzed the data in individual one way analyses using stimulus type as factor separately for each electrode. Effects were strongest at lateral parietal sites ($\eta_p^2$ around 0.65) and somewhat smaller at

Table 1

<table>
<thead>
<tr>
<th>SON</th>
<th>Amplitude</th>
<th>Latency</th>
<th>Familiar name</th>
<th>Amplitude</th>
<th>Latency</th>
<th>Unfamiliar name</th>
<th>Amplitude</th>
<th>Latency</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3</td>
<td>-2.43 (4.20)</td>
<td>264 (21.81)</td>
<td>2.35 (3.63)</td>
<td>255 (27.43)</td>
<td>0.25 (5.05)</td>
<td>268 (27.75)</td>
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<tr>
<td>Fz</td>
<td>-3.12 (3.97)</td>
<td>264 (22.96)</td>
<td>1.61 (3.68)</td>
<td>261 (25.77)</td>
<td>0.31 (4.20)</td>
<td>266 (28.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F4</td>
<td>2.25 (3.31)</td>
<td>262 (21.79)</td>
<td>-1.62 (3.14)</td>
<td>261 (28.38)</td>
<td>0.48 (3.62)</td>
<td>161 (30.70)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FC3</td>
<td>-2.28 (3.76)</td>
<td>256 (19.46)</td>
<td>2.71 (3.56)</td>
<td>251 (28.27)</td>
<td>1.41 (4.93)</td>
<td>251 (33.56)</td>
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<td></td>
</tr>
<tr>
<td>FCz</td>
<td>-1.51 (4.35)</td>
<td>255 (22.36)</td>
<td>1.97 (4.17)</td>
<td>253 (30.16)</td>
<td>0.37 (5.61)</td>
<td>256 (33.34)</td>
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</tr>
<tr>
<td>FC4</td>
<td>-1.54 (4.05)</td>
<td>256 (21.43)</td>
<td>1.87 (4.12)</td>
<td>243 (26.53)</td>
<td>-1.12 (4.79)</td>
<td>254 (34.03)</td>
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<tr>
<td>C3</td>
<td>-1.85 (4.14)</td>
<td>248 (16.12)</td>
<td>2.19 (3.57)</td>
<td>238 (24.57)</td>
<td>1.87 (4.65)</td>
<td>227 (12.04)</td>
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<tr>
<td>Cz</td>
<td>-1.50 (4.51)</td>
<td>251 (20.22)</td>
<td>2.29 (3.87)</td>
<td>246 (26.56)</td>
<td>1.74 (4.59)</td>
<td>253 (31.62)</td>
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<tr>
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<td>-5.43 (6.53)</td>
<td>246 (18.87)</td>
<td>-0.53 (4.62)</td>
<td>238 (24.63)</td>
<td>-0.01 (4.86)</td>
<td>244 (31.30)</td>
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<tr>
<td>CP3</td>
<td>-3.59 (4.84)</td>
<td>239 (13.74)</td>
<td>1.25 (3.71)</td>
<td>238 (21.51)</td>
<td>0.39 (4.91)</td>
<td>227 (12.43)</td>
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<td>CPz</td>
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<td>246 (19.67)</td>
<td>1.63 (4.14)</td>
<td>241 (24.96)</td>
<td>1.19 (3.82)</td>
<td>239 (25.16)</td>
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<td>0.47 (3.08)</td>
<td>231 (15.58)</td>
<td>0.35 (4.12)</td>
<td>227 (12.10)</td>
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<td>234 (11.78)</td>
<td>-1.69 (4.67)</td>
<td>233 (18.53)</td>
<td>-0.21 (5.91)</td>
<td>231 (20.70)</td>
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<tr>
<td>Pz</td>
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<td>0.43 (4.27)</td>
<td>242 (28.48)</td>
<td>0.25 (4.60)</td>
<td>250 (32.59)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>-5.64 (6.41)</td>
<td>239 (18.04)</td>
<td>-1.06 (5.26)</td>
<td>236 (25.14)</td>
<td>-0.75 (6.25)</td>
<td>241 (31.04)</td>
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</table>

Note: Amplitude values are in microvolts (SD). Latencies are in milliseconds (SD).
According to the saliency of SON. Therefore, our result suggests that SON automatically captures attention when the stimulus was salient enough to trigger a switch of attention wave. In passive conditions, an N2b/P3a was observed when the attention-switching mechanism and is followed by a positive P300. The P300 amplitude elicited by familiar name did not significantly differ from those elicited by unfamiliar name (F[1,17] = 0.20, p > 0.05). The amplitude elicited by familiar names did not differ from those elicited by unfamiliar names at any site in the right sites (F[1,17] < 0.24, all ps > 0.27). In addition, the stimulus type × caudality interaction was significant (F[8,136] = 4.55, p = 0.02, ε = 0.24). Simple main effect analysis revealed that SON evoked larger P300 than other stimuli at all sites (F[1,17] > 7.05, all ps < 0.05). These effects were at the central site (F[1,17] = 22.73, p < 0.01) stronger than at the parietal site (F[1,17] = 7.05, p = 0.01). The stimulus type × laterality interaction was also significant, (F[4,68] = 8.37, p = 0.001, ε = 0.77). Simple main effect analysis revealed that SON evoked larger P300 than other stimuli at all sites (F[1,17] > 16.71, all ps < 0.05). These effects were largest in the right sites (F[1,17] = 18.94, p < 0.01) at an intermediate level in the midline sites (F[1,17] = 17.59, p < 0.01) and smallest in the left sites (F[1,17] = 16.71, p < 0.01). Again, these results were confirmed in one-way ANOVAs of individual electrodes. The largest effects (n^2 = 0.65) were now obtained at frontocentral electrodes and right lateralized, why the effect at the left parietal electrode was small (n^2 = 0.23). As for the latency of P300, a significant main effect of stimulus type was found (F[2,34] = 7.62, p = 0.004, ε = 0.92). The average latencies were as follows: 424 ms for SON, 386 ms for familiar name and 394 ms for unfamiliar name. Bonferroni-corrected pairwise comparison revealed within the stimulus type revealed that P300 latency for SON was longer than other stimuli, all (F[1,17] > 3.05, all ps < 0.05). However, the P300 latency of familiar name was not significantly different from the latency of unfamiliar name (F[1,17] = 0.69, p > 0.05).

In this study, we used a three-stimulus oddball paradigm to explore the visual SON effect. Consistent with previous studies, we obtained a N170 component, which was completely independent of the type of name. This result replicates the results of earlier studies and supports that N170 could be seen as an index of early structural encoding. That this effect is left lateralized and strongest over left parietal sites is probably due to the verbal nature of the stimulus. It is assumed that word form encoding is mainly provided by the visual word form area in the left hemisphere where also SON processing might happen [16].

The following N250 behaved differently. A clear negative going component was observed restricted to SON. Familiar and unfamiliar names did not elicit this component and both did not differ from each other. This effect was not found in previous aural SON studies [7,12,19]. However, it is consistent with the results of our previous study using the same material [30]. Recently, Herzmann et al. also demonstrated that subject’s own faces can elicit larger N250 amplitudes than control stimuli [6]. The N250 component is usually described as a nonspecific component that corresponds to an attention-switching mechanism and is followed by a positive P300 wave [9]. In passive conditions, an N2b/P3a was observed when the stimulus was salient enough to trigger a switch of attention [15]. Therefore, our result suggests that SON automatically captured attention even though it was not a target as is to be expected according to the saliency of SON.

Another possibility is that this negativity is caused by enhanced neural activity. SON activates a larger neural network that facilitates information processing and access to the NRU and the PIN. Because this does not happen for familiar names, the processing enhancement might be a consequence of the attention grabbing quality of SON. The presence of stored information seems not to be sufficient to enlarge the N250 because familiar and unfamiliar names did not differ. This is probably due to the specific paradigm of this experiment. A left temporal ‘N250’ component around 250 ms is modulated by immediate repetitions [1] or repetitions across a very small number of intervening items [21]. This effect has been related to the facilitated access to stored name representations or NRUs [22]. However, in our study the repetition lag was long, probably too long for such a transient effect.

In terms of laterality, the SON evoked larger N250 amplitude than familiar and unfamiliar names at the left sites. The result is consistent with Schweinberger’s prediction, which claimed that the left hemisphere plays a critical part in the processing of SON [16]. Therefore, our result suggests that the SON might possess a unique processing pathway in the left brain.

Moreover, a conspicuous P300 component was observed in each of the three-stimulus conditions but the amplitude elicited by SON was larger than for familiar and unfamiliar names. This is consistent with previous studies on face as well as name processing [6,17]. This supports the hypothesis that P300 is an indicator of processes at the PIN level. P300 amplitude has been shown to reflect allocation of information-processing resources [27]. It is thus conceivable that the larger P300 to SON reflects an increased allocation of attention causing a more elaborated and deep processing. Consistently the peak latency for the P300 to SON is clearly later than for the other stimuli.

In terms of laterality, we found that the largest amplitude was elicited in the right brain. This is consistent with previous studies suggesting that self-relevant stimuli are preferably processed within the right hemisphere [26]. This result supports the theory of right dominance in the recognition of personal names at this stage. Please remember that the left hemisphere had a more dominant role for SON processing earlier in time. This indicates a shift of SON processing from left to right. In the early stage of SON processing the left brain is dominant probably providing access to NRU, whereas in the later stage the right brain is dominant providing access to personal information via PIN.

The present study investigated the electrophysiological correlates of the psychological processing of subject’s own name (SON). The N170 was not modified by the type of stimulus suggesting that this has its origin in structural processing. The N250 and P300 amplitudes were larger for SON than for familiar and unfamiliar names. This is a consequence of the priority of processing self-referenced information. The N250 was left lateralized whereas the P300 was right lateralized. We interpreted this as a shift from verbal surface processing (access to NRU) to semantic processing (retrieval of personal information attached to the PIN). This study extended previous research; it did not only testify the superior effect for SON processing in the later component, but it also discovered this effect in early stages.

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References


