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Allocation of attention to self-name and self-face: An ERP study

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ABSTRACT

Self-related information, due to its high social/adaptive value, seems to have a preferential access to our attentional resources (cf. the cocktail party effect). However, it remains uncertain whether this attention preference is the same for different kinds of self-related cues. In this ERP study we showed that self-name and self-face when compared with other names and faces, produced very similar patterns of behavioral and neural responses, i.e., shorter reaction times (RTs) and enhanced P300. The processing of the two self-related cues did not differ between each other, neither in RTs nor in P300 responses. In fact, the amplitudes of P300 to self-name and self-face were correlated. These results suggest that the adaptive value of different kinds of self-related cues tends to be equal and they engage attention resources to a similar extent.

1. Introduction

Attention allocation seems to be shaped in a large part by individual concerns, values and expectancies (Deutsch and Deutsch, 1963). Stimuli carrying a high social/adaptive value for a specific person (e.g., his or her own name) seem to automatically attract this person's attention, i.e., the so-called cocktail party phenomenon (Cherry, 1953; Moray, 1959; Wolford and Morrison, 1980; Wood and Cowan, 1995). Electrophysiological studies on the neural processing of self-related cues generally support this hypothesis. These stimuli showed enhanced P300 amplitude – the positive waveform occurring around 300 ms after the stimulus onset – which has been commonly attributed to attention allocation processes (see Polich, 2007, for review). For example, the amplitude was greater for the subjects' own name than for other names (Berlad and Pratt, 1995; Müller and Kutas, 1996; Folmer and Yingling, 1997; Gray et al., 2004), especially if spoken by a familiar voice (Holeckova et al., 2006). Perrin et al. (1999) found differential P300 responses to self-name even during sleep. Fischer et al. (2008), in turn, discovered such effects in comatose patients. As far as the neural processing of self-face is concerned, the P300 was also found to be higher for this stimulus than for famous and unknown faces (Scott et al., 2005). An analogous pattern of results was reported by Sui et al. (2006). Moreover, the enhanced P300 to self-face was absent in prosopagnostic patients (Eimer, 2000) and reduced in patients with autism (Webb et al., 2006).

However, none of these studies investigated more than one type of self-related cue at the same time, using the same experimental procedure, the same stimulus modality and with the same group of subjects. As a result, it remains uncertain whether different kinds of self-related cues engage human attentional resources to a similar or different extent.

Variations in the access to these resources would suggest that the cues differ in terms of adaptive/informative value. It might be assumed, for example, that in principle self-name carries more social relevance than self-face as in order to address a person, we call his or her name, not show them the image of their face. Consequently, human reaction to self-name should be more automatic and should engage more attentional resources. Still, faces inform us not only about a person's identity, but also about their age, sex, mood, direction of gaze, etc. The ability to extract this kind of information within a fraction of a second might have played a crucial role in the survival of our primate ancestors. Along these lines, the face-specificity hypothesis (Kanwisher and Yovel, 2006) suggests that humans have developed specialized cognitive and neural mechanisms dedicated specifically to the processing of faces. As an 'evolutionary privileged' stimulus, self-face might be likely to trigger stronger attention engagement than self-name.

Similar responses to self-name and self-face, in turn, would support the theory of late selection of attention which states that resource allocation is based on semantic characteristics of the stimuli (Deutsch and Deutsch, 1963). Once the recognition is completed, it is the denotation of a particular name or face, i.e., whose name or face it is, but not the physical characteristics of these stimuli, e.g., brightness, loudness, size, shape, etc., that determines the involvement of attention. As self-name and self-face denote the same person, they would engage attentional responses to a similar extent.

Considering the above, the aim of this study was to investigate similarities and/or differences in behavioral (reaction times, RTs)

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and neural (event-related potentials, ERPs) responses to both self-name and self-face vs. other famous and unknown names and faces (all stimuli were presented visually). Additionally, what is novel about this study, instead of the first names only, we used the full names of persons (still called names for the ease of reference). There are many life situations in which this stimulus, instead of just the first name, is used to attract our attention, e.g., a call for passengers at the airport, checking attendance at school, calling someone to have a public speech, etc. These situations might be less frequent but more formal, i.e., important for people, therefore, worth investigating.

2. Methods

2.1. Participants

Thirty right-handed volunteers (15 male and 15 female) between 22 and 38 years of age (mean = 27.4; SD = 3.7) participated in this study. None of them had ever changed their first or last name. Handedness was confirmed with the Edinburgh Inventory (Oldfield, 1971). The participants were either Ph.D. students or employees of the Nencki Institute of Experimental Biology, Warsaw, Poland. They were free from any neurological dysfunctions and had normal or corrected-to-normal vision. None of the subjects had any previous experience with the task. Due to technical problems in data acquisition three of the subjects were excluded from the study. As a result, the total of 27 subjects were included in the analyses (13 male and 14 female).

The experimental protocol was approved by the Bioethics Committee of Warsaw Medical University and informed consents were obtained from all the subjects prior to the study. The subjects were paid PLN 100 (about $30) for their participation.

2.2. Stimuli

All the stimuli (names and faces) were presented visually. They were displayed in central vision on a 19-in. NEC MultiSync LCD 1990Fx monitor. For stimulus presentation and measurement of the subjects' responses we used Presentation® software (Neurobehavioral Systems, Albany, CA, USA).

The set of names consisted of 240 compounds of first and last names, written in white block capitals (Arial, 30 pt) against a black background. The size of the stimuli ranged from $2^\circ \times 2^\circ$ to $2^\circ \times 6^\circ$. They belonged to three categories: (1) the subject's own name (60 presentations), (2) names of famous people from various fields, e.g., politics, entertainment, sports (60 presentations), and (3) unknown names (120 presentations). Although there were three categories of names, the subjects performed a two-choice recognition task: familiar vs. unfamiliar, with self-name being treated as a familiar name. The number of the presentations was adjusted to make each type of response equally probable (i.e., 120 familiar and 120 unfamiliar names). In addition, the number of female and male names used for each participant was equal. The mean length of the famous names was 13 letters (SD = 2.8), of unknown ones—13 letters (SD = 2.5) and of the subjects' own names—14 letters (SD = 2.9).

The set of face stimuli also consisted of 240 images. They were grey-scaled pictures of faces (extracted from the original background so that only the face, ears and hair were visible) displayed against a black background. The size of the stimuli ranged from $4^\circ \times 4^\circ$ to $4^\circ \times 5^\circ$. Analogously, the stimuli belonged to three categories: (1) the subject's own face (60 presentations), (2) faces of famous people from various fields, e.g., politics, entertainment, sports (60 presentations), and (3) unknown faces (120 presentations). The photos of subjects' were taken three weeks before the study (participants have not seen these pictures before the experiment), whereas photos of other famous and unknown persons were downloaded from the Internet. Also in this part of the study, the number of female and male faces was equal. Possible differences in the luminance of pictures were addressed by matching the color (gray-scale) statistics of all images to the same image (arbitrarily chosen from the stimuli set).

In both parts of the experiment, we used names and faces of the same people (e.g., Albert Einstein's name and the image of his face). The order in which two parts were carried out was counterbalanced: half of the subjects were assigned the name-recognition task first while the other half were asked to begin with the face-recognition part. The pause between the two parts was 10 min. To prevent habituation, the order in which the stimuli were presented within one part was pseudo-randomized, so that no more than three names or faces of the same category were presented consecutively.

2.3. Experimental procedure

The participants were seated in an acoustically and electrically shielded dark room at a distance of 60 cm from the computer monitor. As mentioned earlier, they were asked to indicate whether they knew the identity of the person whose name/face was presented to them or not. They were to respond as quickly and accurately as possible by pressing one of two buttons on a Cedrus response pad (RB-830, San Pedro, USA). The participants used only the index and the third finger of the right hand to press the keys.

After reading instructions displayed on the computer screen, the participants started the experiment by pressing a button. After the presentation of a fixation point (a white '×' against a black background) a target item (a first and last name or an image of a face) was displayed for 300 ms. To prevent habituation, different inter-stimuli intervals (ISI) were used: 2100, 2200 or 2300 ms. One part of the experiment lasted about 9 min without pauses.

2.4. EEG recordings

EEG was continuously recorded from 62 scalp sites, plus two electrodes placed on the mastoids using a 136-channel amplifier (QuickAmp, Brain Products, Enschede, the Netherlands) and BrainVisionRecorder® software (Brain Products, Munich, Germany). Ag-AgCl electrodes were mounted on an elastic cap (ActiCAP, Munich, Germany) and positioned according to the extended 10–20 system. Electrode impedance was kept below 5 kΩ. The EEG signal was recorded against an average of all channels calculated by the amplifier hardware. The sampling rate was 500 Hz.

2.5. Data analysis

2.5.1. Behavioral data

Responses were scored as correct if the appropriate key was pressed within a 100–2000 ms period after the stimulus onset. Pressing the wrong key or pressing no key at all was treated as an incorrect response. To analyze the behavioral data statistically, we used a two-way repeated-measures MANOVA, where the type of stimuli (two levels: names and faces) and the type of name/face (three levels: own, famous and unknown) were the factors. *T*-tests with Bonferroni correction for multiple comparisons were applied on post hoc analyses. The results are reported, with significance at $p < 0.05$.

2.5.2. ERP analysis

Off-line analysis of the EEG was performed using BrainVisionAnalyzer® software (Brain Products, Gilching, Germany). The first step in data preprocessing was the correction of ocular artifacts using Independent Component Analysis, ICA (Bell and Sejnowski, 1995). After the decomposition of each data set into statistically maximally independent components, based on visual inspection of the component map, the components representing eye blinks were rejected (based on Jung et al., 2001). The ocular-artifact-free EEG data was obtained by back-projecting the remaining ICA components by multiplying them with the reduced component mixing matrix. Butterworth zero phase filters were then implemented: high-pass—0.5 Hz, time constant—0.3 s, 12 dB/oct; low-pass—30 Hz, 12 dB/oct; notch filter—50 Hz. Next, the EEG was segmented to obtain epochs extending from 200 ms before to 1000 ms after the stimulus onset (baseline correction from −200 to 0 ms). It is worth noting that we analyzed only the trials in which subjects correctly recognized a name or face that was presented (special 'macro' was run to select those epochs). In the automatic artifact rejection, the maximum permitted voltage step per sampling point was 50 μV. In turn, the maximum permitted absolute difference between two values in the segment was 300 μV. The minimum and maximum permitted amplitudes were −200 and 200 μV, respectively, and the lowest permitted activity was 0.5 μV. Finally, the EEG was re-referenced to the mean of the recordings from the left and the right mastoids.

In order to prevent the loss of statistical power of the MANOVA (Gevins et al., 1995, 1996), instead of 62 electrodes, we analyzed three midline electrodes (Fz, FCz and CPz), where the P300 is typically evaluated (Johnson, 1993). As a consequence, peak detection procedure (global maxima search) was run on the above-mentioned electrodes and it encompassed the interval between 350 and 850 ms after the stimulus onset. Peak amplitudes and latencies were analyzed using a three-way repeated-measures MANOVA, where the type of stimuli (two levels: names and faces), the type of name/face (three levels: own, famous and unknown) and the electrode (three levels: Fz, FCz and CPz) were the factors. *T*-tests with Bonferroni correction for multiple comparisons were applied on post hoc analyses. The results are reported, with significance at $p < 0.05$.

3. Results

3.1. Behavioral data

The accuracy of responses was very high: the rate for self-name recognition was 99 ± 1, for famous names: 95 ± 5 and for unknown names: 93 ± 7%, whereas, for self-face it was 98 ± 2, for famous faces: 96 ± 3 and for unknown faces: 95 ± 5%. No significant differences in the accuracy rate were found among experimental conditions.

Fig. 1 shows that reaction times to self-name and self-face were generally shorter than to other names and faces. The MANOVA car-