The Contribution of Mere Recognition to the P300 Effect in a Concealed Information Test

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Abstract In two experiments, we investigated the role of mere recognition in a P300 based CIT. Mere recognition was isolated by having participants respond based on an irrelevant dimension of the stimuli. In Experiment 1 stimuli consisted of familiar and unfamiliar faces, with a dot placed on the left or the right cheek. Participants responded according to dot location. In the second experiment, participants were presented with autobiographical information, alternated with irrelevant stimuli, while instructed to respond based on the case of the stimuli. Results showed that with both familiar faces, and autobiographical information, mere recognition was sufficient to elicit a P300.

Keywords Recognition · P300 · Guilty knowledge test · Concealed information test · Lie detection

Introduction

The Guilty Knowledge or Concealed Information Test (CIT) is a psychological test that uses psychophysiological recordings to determine the presence or absence of certain information in someone's memory. Test questions concern details of which the testee claims to have no memory. Several answer alternatives to this question are presented serially, while physiological signals are recorded. These answer alternatives include the correct answer, but also several plausible but incorrect answers. In criminal investigations, for example, the test question may refer to guilty knowledge the defendant claims to be unknowledgeable of (e.g., "Was the victim killed with a … (a) gun, (b) knife, (c) rope, (d) bat, (e) ice pick?"). For an innocent suspect, all alternatives are equally plausible, and will elicit similar physiological responses. For the perpetrator, on the other hand, the correct alternative is salient, and will elicit an enhanced physiological response. Consequently, stronger physiological responding to the correct alternatives indicates intimate knowledge of the crime, from which guilt can be inferred.

The CIT originally described by Lykken (1959) used the Skin Conductance Response (SCR) as the dependent measure. This measure has by far received the most attention in CIT research, and has been shown to be reliable in discriminating between guilty and innocent participants (Ben Shakhar and Elaad 2003). Since the late eighties, the P300 component of the ERP has also received considerable attention as the dependent measure in a CIT (Farwell and Donchin 1991; Rosenfeld et al. 1991, 1988).

The rationale underlying the P300 based CIT is that rare, meaningful stimuli elicit a P300 (Donchin and Coles 1988; Johnson 1993; Rosenfeld 2002). Stimuli that are meaningful to the individual, like autobiographical information, have been shown to elicit a P300 waveform when presented infrequently in a series, intermixed with irrelevant stimuli (Berlad and Pratt 1995; Gray et al. 2004). Consequently, the P300 can be used to detect simulated amnesia for autobiographical facts (Rosenfeld et al. 1995). Similarly, when a crime has been committed, crime-related details are thought to be meaningful to the perpetrator, but not to an innocent suspect, and will therefore elicit a P300 only in guilty suspects.

The exact psychological mechanisms underlying the P300 in a CIT remain unclear, however. Several studies

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have shown that a P300 can also be elicited under passive conditions, i.e., without specific task instructions (Polich 1987, 1989), indicating that, at least to some extent, the P300 indexes automatic processing (Sommer et al. 1998). In line with this view, Meegan (2008) recently wrote that "P300 effects measure recognition rather than deception. Moreover, they can (and should) be measured without dishonest responding." (p. 18). Verschuere and colleagues (Verschuere 2009) recently tested this notion. These authors compared the P300 elicited by autobiographical information under specific deceptive instructions (by pressing the button you deny recognition of your name) with that elicited without deceptive instructions. Results showed no effect of instructions on P300 amplitude, and only a trend level significant effect on hit rates derived from the P300, indicating that the P300 in a CIT can indeed be largely be explained by automatic processing.

Data contradicting the automatic nature of the P300 effect in a CIT come from Meijer et al. (2007; Experiment 2). These authors found that, in absence of specific deceptive instructions, recognized faces did not elicit a P300. This, contrasting the view of Meegan (2008), indicates that mere recognition is not sufficient for successful detection of concealed information. Here, we report the results of two experiments in which we isolated mere recognition, in order to investigate its contribution to the P300 elicited in a CIT.

Experiment 1

Methods

Participants

Participants were 24 undergraduate students (four men) at Maastricht University (average age 23.1 years; range 18–35). They read and signed an informed consent, and received course credits for their participation. The experiment was approved by the ethical committee of the Faculty of Psychology.

Stimuli

Every participant was asked to bring two passport photos: one of a sibling and one of a good friend. The persons on the two photos had to be of the same sex. These photos were scanned and converted to grayscale. Two additional versions of each picture were produced: one with a dot on the right cheek, and one with a dot on the left cheek (see Fig. 1 for an example). Stimulus size was 49 × 66 mm and viewing distance was 1 m.

Fig. 1 Example of a picture used in Experiment 1 with the original picture (*left*), with a *dot* on the *left cheek* (*center*), and with a *dot* on the *right cheek* (*right*)

Experimental Design and Procedure

Participants were allocated to groups of three. For each member of a group, stimulus material consisted of the two pictures they brought plus the four pictures the other two participants had brought. Each participant completed two conditions. In the *face* condition, participants had to classify each face based on familiarity. Participants were instructed to acknowledge recognition of one of the two familiar faces by pressing one of two buttons placed under their left and right index fingers, respectively, and pressing the other button for all unfamiliar faces. For half of the participants this entailed acknowledging recognition of their sibling, while for the other half it entailed acknowledging recognition of their friend. They were explicitly instructed to deny recognition the other familiar face, by classifying it as unfamiliar.[1] In the *dot* condition, we isolated mere recognition while ensuring that the faces were indeed processed. To achieve this, two versions of each picture were produced: one with a dot on the right cheek, and one with a dot on the left cheek (see Fig. 1 for an example). In this *dot* condition, the participants were instructed to press the left or right button in correspondence to the location of the dot. The order in which the participants completed the *face* and *dot* condition was counterbalanced.

Each trial started with the presentation of a picture, which was shown until the response button was pressed, with a maximum of 2,500 ms. Feedback was given if no response was given after 2,500 ms ('too slow!') or if the response was incorrect ('wrong!'). Each response was followed by a blank screen of a 2,100 ms duration, after which the next picture was presented. The *face* condition consisted of 12 practice trials that served to familiarize the participants with the procedure, and 432 trials that were presented in three blocks of 144, with a break in between blocks that could be terminated by the participant. Thus, each face was presented on 72 trials. In the dot condition, left and right button presses were matched to the *face*

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[1] This outcome of the *face* condition is published in detail in Meijer et al. (2007). Here, it only serves as a control condition.

condition, meaning that in 12 of these trials the dot was on one side, and in 60 on the other. The dot condition also consisted of one practice block with 12 trials and three blocks of 144 trials.

Data Acquisition, Reduction and Analysis

EEG data were recorded from four midline sites (Fz, Cz, Pz, Oz) and the right mastoid (A2), using Ag/AgCl electrodes, glued to the scalp with 10–20 conductive gel. All leads were online referenced to the left mastoid (A1). Horizontal and vertical electrooculograms (EOGs) were recorded using electrodes placed laterally to both eyes as well as below and above the left eye. EEG and EOG electrode impedances were below 5 and 10 kΩ, respectively. All signals were amplified using Contact Precision Instruments amplifiers. EEG was amplified 20,000 times, EOG 4,000 times. The signal was filtered online (0.1–30 Hz bandpass), and digitized at 200 Hz. All leads were off line re-referenced to an average of A1 and A2. Eye blink artifacts were reduced using a regression based method (Semlitsch et al. 1986) performed on the continuous data. After this, epochs were extracted from the continuous data, lasting from 100 ms before until 1,200 ms after stimulus onset. To ensure a reliable artifact rejection, these epochs were baseline corrected, after which all trials containing amplitudes exceeding ± 75 µV and all trials with an incorrect or too slow (>2,500 ms) behavioral response were removed. Remaining trials were then baseline corrected on the pre-stimulus interval, and averaged per stimulus type. All trials on which an unfamiliar face was presented were pooled into one average.

P300 was measured using the peak–peak method described by Rosenfeld (e.g., Rosenfeld et al. 2006). Firstly, the maximal positive 100 ms segment average was determined in the 300–800 ms window. This was defined as the peak P300 amplitude. Next, the maximal negative 100 ms segment average following this positive segment was determined. Peak–peak P300 amplitude was defined as the difference between these two segments. It has repeatedly been shown that this peak–peak method outperform a typical base-peak measure in a CIT paradigm (e.g., Soskins et al. 2001). Therefore, this peak–peak P300 measure was used as the dependent variable in an analysis of variance. As P300 is generally largest at Pz, we limited our analysis to this site.

Results and Discussion

Analysis of the behavioral data in the *dot* condition revealed no difference between the familiar and unfamiliar faces in terms of error rates ($F(1,23) = 1.1$, $p = .31$; M familiar = .96, SD = 0.03, M unfamiliar = .97, SD = 0.03) or reaction times ($F(1,23) = 1.2, p = .30$; M familiar = 736.5, SD = 103.6, M unfamiliar = 754.0, SD = 130.9). The ERP waveforms elicited by the familiar and the unfamiliar faces in the *dot* condition are given in Fig. 2 (left panel). A repeated measures ANOVA comparing the two familiar faces including order as a between subjects factor revealed no significant effects, meaning both familiar faces elicited a comparable P300. These two were therefore averaged. Comparison of this average P300 with that elicited by the unfamiliar faces showed that familiar faces elicited a larger P300 than unfamiliar faces ($F(1,23) = 37.1$, $p < .001$). These results indicate that mere recognition was sufficient to elicit a P300.

To contrast the P300 elicited by mere recognition with that elicited by active concealment of recognition, it is also of interest to compare the P300 elicited by the familiar faces in the *dot* condition with that elicited by the familiar face of which recognition was denied in the *face* condition. P300 amplitudes for familiar and unfamiliar faces for both conditions are plotted in Fig. 3 [for the ERP waveforms of this condition see Meijer et al. (2007; Experiment 1)]. A repeated measures ANOVA on these values with condition (face, dot) and type (familiar, unfamiliar) as within factors and order as a between factor revealed no significant effect of order. This factor was therefore dropped from the analysis. The subsequent ANOVA revealed a significant interaction ($F(1,23) = 13.2$, $p = .001$). Post hoc testing showed that the P300 to the recognized face was smaller in the condition where participants classified according to dot placement compared to classification based on familiarity ($F(1,23) = 11.1$, $p = .003$), and no difference between the irrelevant stimuli.

The results indicate that, even under the instructions to respond to an irrelevant dimension, familiar faces still elicit a P300. This means that in this case, mere recognition was sufficient to elicit a P300. This P300 was, however, smaller than when participants were instructed to classify based on familiarity. To replicate the finding of a P300 due to mere recognition, we conducted a second experiment using autobiographical stimuli, again instructing the participants to respond to an irrelevant dimension.

Experiment 2

Methods

Participants

Participants were 26 undergraduate students (seven men) at Maastricht University (average age 21.4 years; range 18–27). They read and signed an informed consent, and received course credits for their participation. The experiment was approved by the ethical committee of the Faculty of Psychology, Maastricht University.
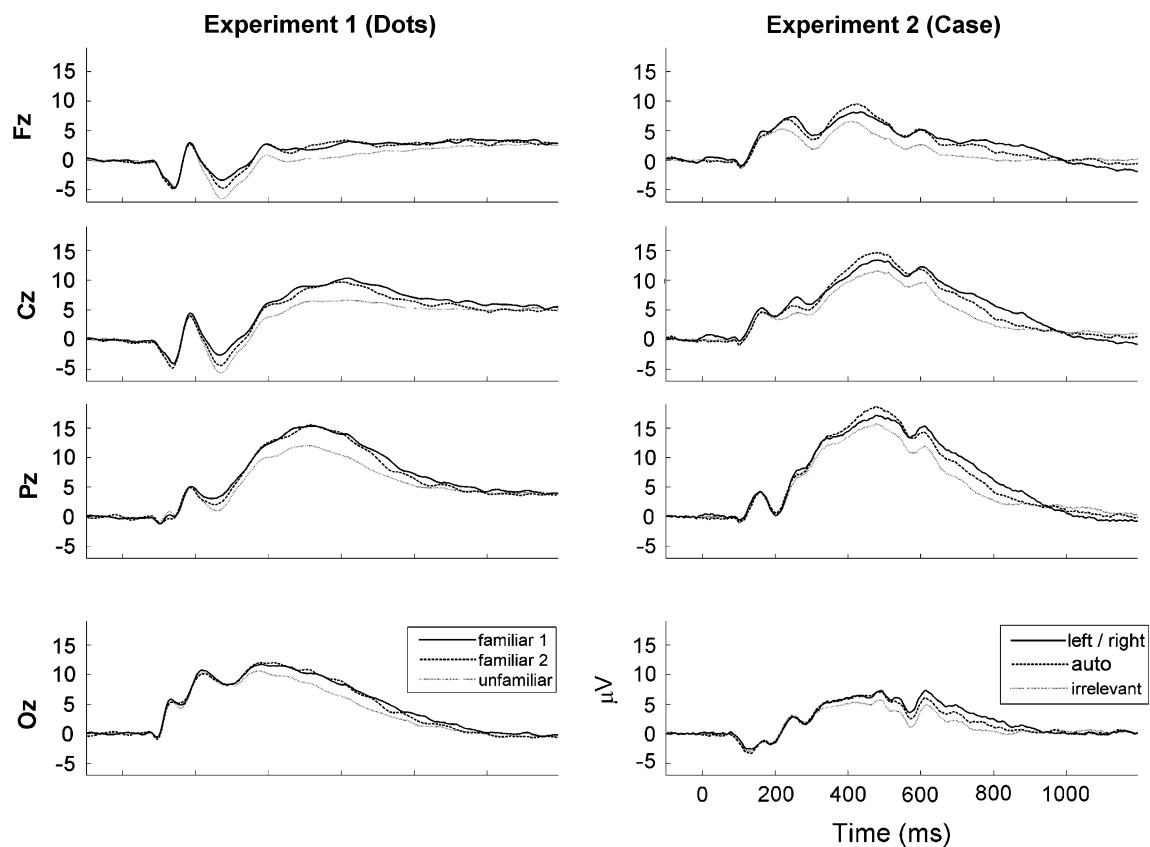
Fig. 2 Grand average ERPs at Fz, Cz, Pz, and Oz as a function of familiar and unfamiliar faces in Experiment 1 (*left panel*), and as a function of stimulus type (*left/right*: word *left* or *right*; Auto: autobiographical stimuli; irrelevant: irrelevant information) in Experiment 2 (*right panel*)
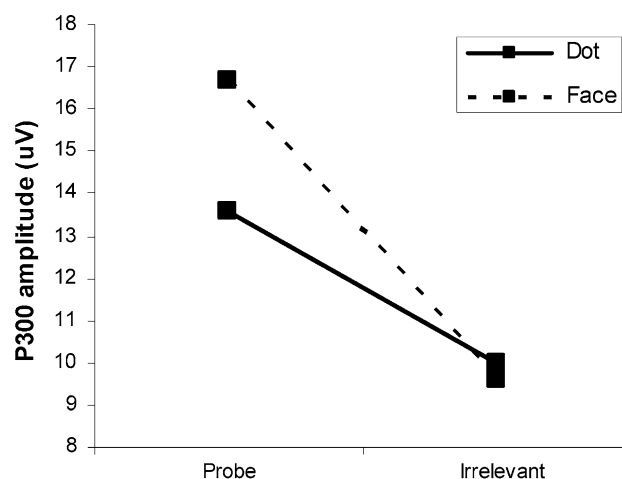

Fig. 3 P300 amplitude to faces classified based on familiarity (*face*) or dot placement (*dot*) for familiar and unfamiliar faces. From the face condition, only the face of which recognition is denied is included

Stimuli

Stimuli consisted of words either referring to autobiographical information (first name, last name, father's name, mother's name, and birth date of the participant), or to

unfamiliar names and dates. Font size was 1 cm, and stimuli were presented on a computer monitor with a viewing distance of 1 m.

Experimental Design and Procedure

Participants were instructed to respond based on the case of the stimuli. If stimuli were written in upper-case, one of two buttons placed under their left and right index fingers was pressed while the other button was pressed for all stimuli written in lower case. To ensure processing of the stimuli, on some of the trials the words 'left' and 'right' were presented instead of names or dates, upon which the participants pressed the left and right button, respectively, regardless of case. Each trial started with the presentation of a stimulus for 400 ms. Feedback was given if no response was given after 2,500 ms ('too slow!') or if the response was incorrect ('wrong!'). The intertrial interval varied randomly between 2,250 and 2,750 ms.

The task consisted of one practice block, and five experimental blocks. Within each experimental block all stimuli referred to the same category, e.g., first names. In each block, 96 trials were presented. Sixteen of these trials contained an autobiographical stimulus, 64 contained one

of four unfamiliar stimuli, eight contained the word 'left' and eight contained the word 'right'. Each stimulus was presented equally often in lower and in upper case. Half of the participants were instructed to press the left button for uppercase stimuli and the right button for lowercase stimuli, while for the other half button assignment was reversed.

Data Acquisition, Reduction and Analysis

Data acquisition, reduction and analysis were identical to experiment 1.

Results

Analysis of the behavioral data revealed no difference between the autobiographical and unfamiliar stimuli in terms of error rates ($F(1,25) = 2.0$, $p = .17$; M autobiographical = .95, SD = 0.05, M unfamiliar = .96, SD = 0.05). Participants did, however, respond significantly slower to the autobiographical stimuli ($F(1,25) = 12.7$, $p = .002$; M autobiographical = 714.3, SD = 116.4, M unfamiliar = 696.9, SD = 103.0). The grand average ERP waveforms elicited by the three types of stimuli are given in Fig. 2 (right panel). A repeated measures ANOVA comparing the P300 elicited by the autobiographical stimulus with that elicited by the unfamiliar stimuli revealed a main effect ($F(1,25) = 48.6$, $p < .001$), showing that stimuli referring to autobiographical information elicited a larger P300 ($M = 18.1$, SD = 7.3) than stimuli referring to unfamiliar information ($M = 14.9$, SD = 6.2). In line with the results from experiment 1, these results indicate that mere recognition elicits a P300.

General Discussion

In two experiments we investigated the role of mere recognition on the P300. Mere recognition was isolated by instructing the participants to respond to an irrelevant dimension of the stimulus (placement of a dot in Experiment 1 and case of the stimuli in Experiment 2). The results show that in both experiments mere recognition was sufficient to elicit a larger P300.

The results of Experiment 1 further show that the P300 elicited by familiar faces is smaller when participants were asked to respond to an irrelevant dimension than when asked to respond to face familiarity. This finding is in line with the theory of resource allocation (Kok 1997). According to this theory, a limited pool of attentional recourses is available, and when attention is shifted from one task or feature to another, less attention is available for the original task or feature. Consequently, measures thought to index this attention, such as the P300, diminish,

and the P300 elicited by attended stimuli is smaller if participants divide their attention (for examples see Allison and Polich 2008; Ruiter et al. 2006; see also Rosenfeld et al. 2008). On a practical level, this finding of a smaller P300 when attention is allocated to an irrelevant dimension means the adaptation of the CIT used in the experiment reported in this manuscript is less suitable for field use, as it does not maximize detectability.

At first glance, the elicitation of a P300 by mere recognition may seem at odds with a previous study in which we showed that, in absence of deceptive instructions, recognized faces did not elicit a larger P300 than unfamiliar faces (Meijer et al. 2007; Experiment 2). One potential explanation for this is that stimuli in both experiments reported in this paper referred to information that is highly significant to the participant (faces of siblings and good friends in Experiment 1, and autobiographical information such as the participant's first and last name in Experiment 2), whereas the stimuli in Experiment 2 of Meijer et al. (2007) depicted university teachers whom the participants had only incidentally met. Several studies have shown that stimuli referring to (self) relevant information elicit a larger P300 than stimuli referring to incidentally acquired information (Rosenfeld et al. 2006, 2007).

The results reported in this paper are in line with those reported by Verschuere et al. (2009). These authors showed that deceptive instructions were not necessary for successful application of the P300 based CIT, and the effect of these instructions on P300 amplitude was limited to the hit rates, and absent in the continuous P300 data, the measure reported in this paper. It is important to note, however, that these authors also used highly significant stimulus material (the participant's first name). Whether mere recognition of stimuli referring to less significant information is also sufficient for the elicitation of a P300 should be answered by future research.

In sum, the current data show that mere recognition of familiar faces and autobiographical information suffices to elicit a larger P300, indicating that recognition indeed plays an important role in the P300 based CIT.

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