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The effect of countermeasures against the reaction time based concealed information test on the P300 index of knowledge recognition: A combined RT and P300-based test☆

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ABSTRACT

Behavioral reaction time (RT) to key (probe) stimuli in a concealed information test (CIT) is usually greater than RT to irrelevant stimuli, and this difference has been utilized as a sign of recognition of concealed information. The ability to voluntarily increase irrelevant RT would appear to be an obvious countermeasure to the RT-based CIT. This study examined the effect of such countermeasure use on the simultaneously recorded P300 event related potentials. There were two blocks of trials in the present study, based on the 3-stimulus protocol. On the first trial block, half the participants were tested on concealed recognition of their phone numbers without a countermeasure. In the second block, this subset of participants were tested on their birth dates, while they applied a countermeasure consisting of the mental statement of the phrase "yes sir" prior to the button press signaling irrelevant stimulus. The other half of the subjects received the reverse order of stimulus categories. Results were that probe RT exceeded irrelevant RT in the first block, but that this relationship was reversed on the second block. In contrast, although the probe P300 exceeded the irrelevant P300 in the first block, this difference significantly increased in the second (RT countermeasure) block, leading to more detections based on P300. Thus, there was a differential effect of this novel countermeasure (directed at countering RT) on RT and P300, which actually led to improved detection with P300, suggesting that both measures might be profitably used in field applications.

1. Introduction

The Concealed Information Test (CIT, Lykken, 1959, also called the Guilty Knowledge Test or GKT) has been studied for > 50 years; (for reviews, see Verschuere et al., 2011; Meijer et al., 2014; Rosenfeld et al., 2012). In this protocol, there are minimally two kinds of stimuli presented in a random order to participants: The 1) *probes* are the expected, to-be-remembered items—often from a crime scene—such as a stolen necklace. The 2) *Irrelevant* stimuli are other similarly valuable items (a watch, a bracelet, a ring, etc.) which are in the same category (jewelry) as the probe, but are not equivalent to it, so are not recognized by the thief as the stolen item. The probe is recognized, and thus evokes an enhanced physiological response in only the knowledgeable subject. To unknowledgeable (innocent) suspects, the probe is also irrelevant and evokes a much smaller or no physiological response.

Traditionally, the responses examined are autonomic (ANS) responses such as SCR, respiration pattern, and cardiac responses. In more recent years, the P300 component of the event-related potential (ERP) and fMRI have been frequently utilized (for review, see Rosenfeld, 2011; Rosenfeld et al., 2012). Also recently utilized is the behavioral reaction time (RT), which, as pointed out by Seymour et al. (2000), Suchotzki et al. (2017) and others, may be less expensive and simpler to utilize as a sign of concealed information recognition in the CIT. That is, the RT to the probe is typically larger than that to the irrelevant, and indeed, other characteristics of the probe distribution (besides means) differ from those of the irrelevant distribution in knowledgeable but not in unknowledgeable persons (Seymour et al., 2000; Seymour and Kerlin, 2008). Nevertheless, Farwell and Donchin (1991) speculated that RT had the disadvantage of easy voluntary manipulation (countermeasures), although Seymour et al. (2000) showed that the behavioral index showed some resistance to some countermeasures.

RT is also utilized as a recognition sign in a more complex and highly reliable CIT protocol called the autobiographical implicit association test (aIAT, Sartori et al., 2008), which was adapted from the

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Implicit Association Test (IAT) of Greenwald et al. (1998). In this protocol, congruent or incongruent response pairings are mapped to the same response key, and RTs to the latter are expected to exceed those to the former. However, clearly successful (if well-practiced) countermeasures have been shown to be effective against the aIAT, involving both the slowing of congruent responses (Verschuere et al., 2009), as well as the speeding of incongruent responses (Hu et al., 2012). Although the former countermeasures are detectable (thus less effective), the latter are not (Hu et al., 2012).

The most direct strategy for defeating the simple RT protocol (which is based on the notion that probe RTs will exceed and otherwise differ from irrelevant RTs) involves subjects learning to recognize and slow responses to irrelevant stimuli. Although providing general information to subjects about how the test works does not defeat the RT-based CIT (Seymour et al., 2000), we hypothesize that providing subjects with a simple but specific and robust technique for delaying the irrelevant response will defeat the RT-based CIT. However, the major hypothesis of the present report is that the same countermeasure that slows the irrelevant RT will have the effect of increasing the simultaneously recorded probe P300 response, which will then even more readily detect knowledgeable subjects. That is because the present countermeasure involves mentally speaking the phrase "yes sir" to irrelevants prior to behavioral response, but not to the probe. This should have the effect of adding salience to the probe via the "Omit effect" (Meixner and Rosenfeld, 2010): the probe then becomes the only stimulus requiring inhibition of the countermeasure response. Increased salience (meaningfulness) increases the P300 (Johnson, 1988).

We note that the countermeasure used here (against the delayed RT index of probe recognition) is not the same as that used in Rosenfeld et al. (2004). In that report the countermeasure used was directed against the P300 index of recognized information, such as a P300 elicited by a probe stimulus in comparison to the P300 elicited by an irrelevant item in a knowledgeable participant. This countermeasure was effective against P300 indices of concealed information in the 3-stimulus protocol which led to our development of the newer complex trial protocol (Rosenfeld, 2011).

2. Methods

2.1. Participants (Ps)

Five members of an advanced laboratory course at Northwestern University and their volunteering friends participated in the experiment, a total of 15 persons, aged 18–22, 7 male. These participants were all sophomore, junior or senior undergraduates. All signed informed consent forms for this IRB-approved study. Three data sets were dropped for excessive artifact (n = 1) and response errors (n = 2).

2.2. Procedures

The Ps were run through two blocks of a 3-stimulus protocol version of the P300-CIT (Rosenfeld, 2011). In this protocol, in addition to probe and irrelevant stimuli, there is also a special class of irrelevant stimuli called targets. Ps are required to press the left mouse button (defined as "No, I do not recognize the stimulus") for both probe or irrelevant stimuli (thus, lying to probes). They press the right mouse button to target stimuli (defined as "Yes I recognize this stimulus"). Targets are initially irrelevant, then assigned and learned by participants prior to their CIT blocks. Stimulus categories were either birthdates (e.g., "March 9") or last four digits of phone numbers (e.g., "3570"). Half the Ps saw date stimuli in the first block and phone numbers in the second. The remaining Ps had the reverse block order. It should be noted that each block contained a unique set of probe and irrelevant stimuli, either dates or 4-digit number strings.

In each block, one probe and one target was each presented 30–60 times, as was each of 6 irrelevants. The three stimulus types were presented in a random sequence. In the first baseline block Ps, all Ps were simply instructed to press response buttons as quickly as possible to all stimuli. As in Seymour et al. (2000), trials with responses later than 1500 ms were dropped. The inter-trial interval, equivalent here to the inter-stimulus interval, was 3 s. In order to assure proper recovery of the ERP from one trial to the next, it was necessary to utilize an interval between response and subsequent stimulus that randomly varied typically between 1500 and 1900 ms depending on RT. In the second block, Ps were taught countermeasures for the RT index of concealed information. Specifically, Ps were instructed to say "yes sir" to one-self prior to the button press for all irrelevants. They were warned to keep these responses entirely mental, without whispering, so as to avoid artifacts related to orofacial movements. The countermeasure block was always given second so as to avoid carryover of countering tendencies from first to second block if the countermeasure block had been given first.

2.3. Data acquisition

P300, measured P300 peak to the subsequent negative peak ("peak to peak" or p-p as in Soskins et al., 2001) from Fz, Cz, and Pz, was recorded, filtered, artifacted, and averaged as in most of our previous papers (e.g., Rosenfeld et al., 2015):

EEG recording was taken using tin electrodes attached to the scalp at sites Fz, Cz, and Pz. Only these electrodes were attached. The electrodes were referenced to linked mastoids. EOG was recorded with a Tin electrode above the right eye and also referenced to the linked mastoids. Eyeblinks were removed using an algorithm of Semlitsch et al. (1986). Remaining eye movement artifacts were detected, marked, and all trial data containing ± 90 uV (or more) signals in any EEG or EOG channel were dropped. The forehead was connected to the chassis of the isolated side of the amplifier system ("ground"). Signals were passed through a Mitsar 19 channel (model 201) amplifier with a 0.16 Hz high pass filter setting, and low pass filters at 30 Hz. Output was passed to a 16-bit Mitsar A/D converter sampling at 500 Hz. For all analyses and displays, single sweeps and averages were digitally filtered off-line to remove higher frequencies; the filter passed frequencies from 0 to 6 Hz using a *Kaiser* filtering algorithm.

P300 amplitude was measured at Pz using both the "base-to-peak" (b-p) and the "peak-to-peak" (p-p) methods. The p-p method, exclusively analyzed here, has repeatedly been confirmed as the most sensitive in P300-based deception investigations (See Meijer et al., 2007; Soskins et al., 2001). Both b-p and p-p methods search from 300 to 750 ms for the maximally positive 100 ms segment; this is the b-p P300, and the midpoint of this maximum positive segment is defined as the P300 latency. The average amplitude difference of the segment from the pre-stimulus baseline is the base-peak (b-p) value. For p-p, the algorithm also searches for the maximally negative 100 ms segment between P300 latency and 1300 ms and then subtracts the average absolute amplitude of that segment from that of the maximally positive segment described above. Although other (but similar) search windows have been used in other studies, we, and other researchers, believe it a poor idea to choose a window for novel studies with novel protocols based on those used in previous studies with different protocols and P300 latencies. Our present choice of a search window was made based on a grand average of all present subjects in all conditions, a procedure recommended by Keil et al. (2014).

2.4. Within individual analysis: bootstrapped amplitude difference method

To determine whether or not the P300 evoked by one stimulus is greater than that evoked by another *within an individual*, the bootstrap method (Efron, 1979) was used on the Pz. Consider a probe response being compared with an irrelevant response. The bootstrap method answers this question: Is the probability > 90 in 100 that the true difference between the average probe P300 and the average irrelevant