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Do You Know Him? Gaze Dynamics Toward Familiar Faces on a Concealed Information Test

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Can gaze position reveal concealed knowledge? During visual processing, gaze allocation is influenced not only by features of the visual input, but also by previous exposure to objects. However, the dynamics of gaze allocation toward personally familiar items remains unclear, especially in the context of revealing concealed familiarity. When memorizing four pictures of faces on a short term memory task, participants' gaze was initially directed toward a personally familiar face, followed by a strong avoidance from it. This avoidance was evident even when participants were instructed to conceal their familiarity and direct their gaze equally to all faces. On the other hand, participants were partially able to control the initial preference to fixate on the familiar face. By exploiting these patterns, a machine learning classification algorithm and signal detection analysis revealed impressive detection efficiency estimates, suggesting practical applications of recent theoretical insights from the domains of eye tracking and memory.

General Audience Summary

The ability to detect concealed information, and specifically familiarity with other people, is highly important for both security and law enforcement purposes. By combining simple eye tracking and a short term memory task, we describe a technique that can be applied easily and efficiently to detect concealed information about personally familiar faces. When several faces are displayed, people tend to look less at a familiar face, even when they are asked to conceal recognition of the faces that were familiar to them. Moreover, this pattern is observed even when subjects are instructed to look equally at all faces. Based on these findings, a machine learning classification algorithm and signal detection analysis revealed impressive detection efficiency estimates, suggesting practical applications when there is a need to detect concealed familiarity in security and forensic settings.

Keywords: Attention, Memory, Eye movements, Information detection

A few days before the terror attack in Brussels in 2016, one of the accomplices was interrogated about his association with terrorist groups. Photos of the terrorists were shown to him, but he denied knowing them at all (Vincent, 2016). Clearly, a simple method of detecting concealed information could have saved many lives. The Concealed Information Test (CIT) is a theory-based method designed to detect concealed information (e.g., Verschuere, Meijer, & Ben-Shakhar, 2011). Typically, the test measures physiological responses (such as heart rate and skin conductance responses) during a serial presentation of items.

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One of the items is significant to a knowledgeable participant (e.g., a photo of a familiar terrorist) and the other items are neutral alternatives (e.g., photos of unfamiliar people). The CIT effect is the differential response elicited by the significant items. This effect has been traditionally accounted for by the orienting response (OR) theory, which posits that the differential response is evoked by a shift in attention toward an unexpected or significant stimulus (Ben-Shakhar, 1977; Lykken, 1974; Sokolov, 1963). Suspects who are familiar with a significant crime-related item are expected to exhibit a larger OR toward this item than to the neutral alternatives. In contrast, naïve subjects who are not familiar with any of the items will not show differential response to any of the items. However, applying the CIT with physiological measures is challenging in ecological settings (e.g., airports) since it requires a laboratory setup and direct contact with the examinee. Hence there is a need for a scientifically valid method to detect concealed information in real time, which can be applied quickly and easily. Eye tracking is one such promising tool since current video based eye trackers enable recordings of eye movements without restraining the head (Ohno & Mukawa, 2004). Moreover, novel calibrations techniques are being developed to enable eye tracking without the participants awareness (Pfeuffer, Vidal, Turner, Bulling, & Gellersen, 2013).[1]

A handful of studies have shown that gaze behavior is modulated by familiar items (for a review, see Hannula et al., 2010). However, the efficiency of this modulation in detecting concealed information has not been assessed (Devue, Van der Stigchel, Brédart, & Theeuwes, 2009; Hannula, Baym, Warren, & Cohen, 2012; Millen, Hope, Hillstrom, & Vrij, 2017; Ryan, Hannula, & Cohen, 2007; Van Belle, Ramon, Lefèvre, & Rossion, 2010) or has emerged as weaker than physiological measures. This weaker detection efficiency is evident when comparing between eye movements studies (Peth, Kim, & Gamer, 2013; Proudfoot, Jenkins, Burgoon, & Nunamaker, 2016; Schwedes & Wentura, 2012) and physiological measures studies (Meijer, Selle, Elber, & Ben-Shakhar, 2014). Moreover, a recent study by Peth, Suchotzki, and Gamer (2016) directly compared eye movements and physiological measures, demonstrating a lesser detection ability by ocular measures.

Ryan et al. (2007) showed that prior exposure to faces influenced the total duration of fixations on these faces when they appeared together with unfamiliar faces. Importantly, the direction of these differences in terms of overall fixation duration was tightly linked to the task demands: whereas instructions to recognize the familiar face elicited longer fixation durations on the familiar face, instructions to avoid the familiar face resulted in preferential fixation on the unfamiliar faces. Interestingly, the effect of memory on eye movements emerged at different time points on the two tasks. Whereas preferential gaze toward the familiar face on the recognition task emerged during the first second, in the avoidance task, preferential viewing of unfamiliar faces was observed only later.

The Ryan et al. (2007) study did not involve deception of any kind. By contrast, Millen et al. (2017) tested whether lying about recognition of a familiar face influenced gaze behavior. They found that even during deception, personally familiar and famous faces had fewer fixations, fewer returns to observed regions and fewer sampling of face regions, as compared to unfamiliar faces. Although the authors highlighted the potential contribution of their research to forensic psychology, they did not attempt to detect knowledgeable individuals based on their eye movement (as has been traditionally done in concealed information tests). Schwedes and Wentura (2012) confronted this issue using a modification of previous CIT tasks that were based on a familiarity judgment. In their task, participants were initially familiarized with several faces and were later asked to observe a display of six faces. Some displays included a learned face and the participants were requested to conceal their familiarity with that face. The researchers considered the displays without a familiar face as a concealed information test of a virtual "innocent" participant, and the displays including a familiar face as a concealed information test of a "guilty" participant. For each participant, the distribution of fixation duration was created by a simulation based on the data of fixation duration on the distractors (i.e., the other, non-familiar faces in the display). The authors defined a cutoff point for classifying participants as guilty versus innocent—if the fixation duration for the learned faces exceeded the 95% percentile of the distribution, this participant was identified as guilty. By this procedure, 65% of the knowledgeable participants were correctly classified. However, in this study, the vulnerability of eye movements to countermeasures was not explored. Countermeasures are steps taken by the examinees to avoid detection and are a major threat to the validity of the CIT (for a review of countermeasures' effects on CIT outcomes, see Ben-Shakhar, 2011). A recent study by Peth et al. (2016) investigated how countermeasures influence the detection efficiency of eye movements. Countermeasures were found to decrease detection ability (the area under the receiver operating characteristic [ROC] curve dropped from a range of 0.59–0.83 to a range of 0.5–0.74). This pattern of results echoes classical physiological studies in which countermeasures lowered and sometimes even eliminated detection ability. Thus, CIT based on eye movements appears susceptible to deliberate countermeasures, similar to autonomic nervous system measures (Honts, Devitt, Winbush, & Kircher, 1996). However, it is worth noting that the countermeasures employed by Peth et al. (2016) were designed to alter the typical physiological responses used in the CIT, which are not necessarily appropriate for ocular measures.

The current study was designed to introduce several improvements to this field by incorporating a novel short term memory task. In this task, after seeing a display of four faces, participants see a single face and are asked to decide whether this face appeared in the previous display. This task exploits the advantages of eye tracking and enables the use of simultaneous presentation of stimuli, unlike the classic CIT procedure which relies on a serial presentation of single items. This short term memory task has two major advantages. First, in contrast to most

[1] This method is based on moving an item in a continuous manner. When the camera captures a gradual change in the eye measures, the system assumes that the subject is looking at the item (smooth pursuit cannot take place voluntarily without a continuous movement). The association between the eye measures and the item trajectory enables fast and unnoticeable calibration.