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Research report

The experiential blink: Mapping the cost of working memory encoding onto conscious perception in the attentional blink

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ABSTRACT

The attentional blink (AB) represents a cognitive deficit in reporting the second of two targets (T2), when that second target appears 200–600 msec after the first (T1). However, it is unclear how this paradigm impacts the subjective visibility (that is, the conscious perception) of T2, and whether the temporal profile of T2 report accuracy matches the temporal profile of subjective visibility. In order to compare report accuracy and subjective visibility, we asked participants to identify T1 and T2, and to rate the subjective visibility of T2 across two experiments. Event-related potentials were also measured. The results revealed different profiles for the report of T2 versus the subjective visibility of T2, particularly when T1 and T2 appeared within 200 msec of one another. Specifically, T2 report accuracy was high but T2 visibility was low when the two targets appeared in close temporal succession, suggesting what we call the *Experiential Blink* is different from the classic AB. Electrophysiologically, at lag-1, the P3 component was modulated more by subjective visibility than by report accuracy. Collectively, the data indicate that the deficit in accurately reporting T2 is not the same as the deficit in subjectively experiencing T2. This suggests that traditional understandings of the AB may require adjustment and that, consistent with other findings, working memory (WM) encoding and conscious perception may not be synonymous.

1. Introduction

A key objective in the study of mind and brain is to characterise the temporal dynamics of cognitive and perceptual functions. For example, researchers have sought to answer questions concerning how long attention has to be engaged on an item in order to be reported (Duncan, Ward, & Shapiro, 1994; Ward, Duncan, & Shapiro, 1996), and what the temporal profile of working memory (WM) encoding is. One

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phenomenon that has been frequently employed to study the temporal dynamics of cognition is the Attentional Blink (AB) (Raymond, Shapiro, & Arnell, 1992). The AB refers to a deficit in correctly reporting the second of two targets when that second target (T2) appears 200–600 msec after the first (T1). Most major theories of the AB maintain that it indexes the temporal cost of encoding a stimulus into WM (Bowman & Wyble, 2007; Chun & Potter, 1995; Olivers & Meeter, 2008). However, it is unclear whether the cost associated with encoding T1 is specific to *encoding* T2 into WM, or whether it impacts other functions, such as the conscious perception of T2. The current study was designed to examine this.

This topic is particularly pertinent because it has the potential to throw light on whether WM encoding and conscious perception are synonymous. Within the AB domain, many researchers (including ourselves) have previously assumed that the correct report of T2 (which requires WM encoding) suggests that T2 was consciously perceived (Bowman & Wyble, 2007; Kranczioch, Debener, Maye, & Engel, 2007; Pincham & Szucs, 2012). The assumption that T2 is consciously perceived when (and, indeed, only when) it is correctly reported therefore implies that WM encoding and conscious perception are synonymous: what is consciously perceived enters WM, and everything that enters WM is consciously perceived. In other words, this position suggests that conscious perception is necessary and sufficient for entry into WM. Even though it might be intuitively plausible to view conscious perception and report accuracy as synonymous, the current study provides evidence to the contrary.

Only a small number of AB studies have distinguished between WM encoding and the conscious perception of T2. In those studies, the conscious perception of T2 has been operationalized using subjective visibility measures, and WM encoding of T2 has been operationalized using T2 identity (report) accuracy (Nieuwenhuis & de Kleijn, 2011; Sergent & Dehaene, 2004). For example, Sergent and Dehaene (2004) collected subjective visibility measures of T2 and suggested that the distribution from non-conscious to conscious perception is bimodal. In that study, it appeared that T2 was either ‘seen’ (high subjective visibility rating) or ‘not seen’ (low subjective visibility rating). By contrast, Nieuwenhuis and de Kleijn (2011) collected subjective visibility and report accuracy measures for T2 and revealed that the conscious perception of T2 could be a more gradual distribution between low and high subjective visibility ratings. Importantly, neither of these existing studies asked whether conscious perception and accuracy are synonymous in the AB. Further empirical work is needed to uncover the relationship between WM encoding and subjective visibility in the AB.

Outside of the AB, the relationship between conscious perception and WM encoding has been frequently debated in terms of the notion of phenomenological awareness (Block, 2007). This debate really considers whether conscious perception is *sufficient* to ensure WM encoding, and the existence of phenomenological awareness would suggest it is not. Although the current investigation is related to Block's work, it is distinct from that body of literature because we focus on the dual concept – whether conscious perception is *necessary* for WM encoding, and we will argue our findings suggest it is not.

To examine the relationship between WM encoding and conscious perception in the AB, we presented two targets in a Rapid Serial Visual Presentation (RSVP) stream, and asked participants to report the identities of T1 and T2. Participants were also asked to provide a subjective visibility rating for T2. Across lags, these data can generate two temporal profile curves: report accuracy across lags versus subjective visibility across lags. The accuracy profile represents the (classic) AB curve. We argue that if WM encoding and conscious perception are equivalent in the AB, then the report accuracy curve and the subjective visibility curve would have the same shape.

In addition to examining behavioural data, the current study employed the temporal resolution of electroencephalography (EEG) to help contrast the temporal profiles of WM encoding and conscious perception in the AB. The P3 event-related potential component has been frequently viewed as an electrophysiological correlate of WM encoding (Polich, 2007; Vogel, Luck, & Shapiro, 1998). Studies have consistently found that P3 amplitude is reduced or even absent altogether on trials where T2 is reported incorrectly or not at all (Craston, Wyble, Chennu, & Bowman, 2009; Kranczioch, Debener, & Engel, 2003; Kranczioch, et al., 2007; Martens, Elmallah, London, & Johnson, 2006; Pincham & Szucs, 2012; Robitaille, Jolicoeur, Dell'Acqua, & Sessa, 2007; Vogel, et al., 1998). More importantly, the timing of the P3 component has been taken to be the temporal profile of the AB deficit. A demonstration of this was provided by McArthur, Budd, and Michie (1999), who matched the temporal profile of the T2-P3 to the temporal profile of the T2 report accuracy deficit observed in the AB.

Given that previous AB work has rarely separated subjective visibility from report accuracy, it is not clear whether, in this context, the P3 indexes conscious perception, WM encoding or both. To that end, we examined how the amplitude and topography of the P3 is modulated by subjective visibility versus report accuracy. In a related study, Lamy, Salti, and Bar-Haim (2008) measured ERPs in the context of a backwards masking paradigm to investigate the role of consciousness in online responding. To examine the neural correlate of awareness, Lamy et al. contrasted P3 amplitudes across high subjective visibility and low subjective visibility trials, while holding report accuracy constant. To examine the neural correlate of unconscious perception, P3 amplitude was contrasted across accurate and inaccurate trials, while holding subjective awareness constant (low visibility). In that study, both report accuracy and subjective visibility were shown to modulate P3 amplitude, but the impact of subjective visibility on the P3 was larger and topographically more widespread. Whereas Lamy et al. examined online responding, our study was designed to uncover the relationship between conscious perception and WM *encoding* (where responding is later and offline).

To summarise, the current study contrasted the temporal profile of WM encoding and conscious perception in the AB. To achieve this, two experiments were conducted. In Experiment 1, we aimed to sample the entire AB curve. Behavioural data were collected while T2 appeared at lags 1, 2, 3, 4, 6 or 8. In Experiment 2, behavioural and EEG data were collected, while T2 predominantly appeared at lags 1 and 3 (only two lags were used to enhance EEG signal strength). Following Lamy et al.