An Event-Related Potential Study of Onset Primacy in Visual Change Detection

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Abstract

Onset primacy is a robust behavioural phenomenon whereby humans identify the sudden appearance of an object in the environment (onset) with greater speed and accuracy than other types of visual change, such as the sudden disappearance of an object from the environment (offset). The default mode hypothesis explains this phenomenon by postulating that onset detection is the default processing mode of the attentional system. The present study aimed to test this notion by investigating whether onset primacy is also reflected on a neural level, as indicated by the comparative efficiency of neural processing for onsets, using electroencephalography. It was hypothesised that this relative efficiency would be reflected in the P300 event-related potential as a greater amplitude across temporal, parietal, and occipital regions during onset detection, compared to offset detection. This prediction was tested through a change detection task in which participants were required to identify the location of onset or offset between paired images of naturalistic scenes. Results showed that P300 amplitude differed between onset and offset conditions in the anticipated direction, supporting the default mode hypothesis. These results suggest that the P300 is a neural marker of onset primacy in visual change detection.

Keywords: attention, attentional capture, EEG, P300, P3b

Impact Statement

This research identified a neural marker of onset primacy, a long-studied behavioural phenomenon in which appearance of new objects is detected more quickly and accurately than other types of change in visual scenes.

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The ability to direct attention within an environment provides an adaptive mechanism that is particularly useful for the detection of change. In the absence of effective visual change detection, it would be difficult to successfully navigate everyday life. Driving a car or crossing the road, for example, requires the ability to detect new obstacles as they appear in the visual field. Research involving visual search paradigms has indicated that humans are particularly adept at noticing new objects that abruptly enter their environment (Cole & Liversedge, 2006; Jonides & Yantis, 1988; Yantis & Jonides, 1984). Under certain conditions, however, even significant changes in visual scenes go unnoticed, through a phenomenon known as change blindness (Simons & Rensik, 2005). Behavioural studies have demonstrated that the sudden appearance of an object (object onset) is relatively robust to change blindness, while other types of change, such as the sudden disappearance of an object (object offset), are more likely to remain unnoticed (Cole & Kuhn, 2010; Yantis & Jonides, 1984). The comparative efficiency of onset over offset detection has been referred to in the literature as onset primacy (Cole, Kentridge, & Heywood, 2004).

The persistence of onset primacy across experimental paradigms led Donaldson and Yamamoto (2016) to propose that onset detection is the default processing mode of the attentional system. To process other kinds of change, a shift is required from this default mode, resulting in a less efficient response. While the robust nature of onset primacy may be functionally adaptive, given that onset detection is advantageous in most situations, there are other situations in which offset detection may be more beneficial. For example, a life guard monitoring a crowded beach needs to notice the disappearing swimmer; a parent watching over a group of children in the playground needs to notice if one goes missing. As such, it is important to understand how and why onset primacy occurs by investigating the processes that underlie onset and offset detection.

In pursuing this endeavour, the present study tested the validity of the default mode hypothesis (Donaldson & Yamamoto, 2016) by examining differences in neural activation across change detection tasks. If onset and offset detection do indeed recruit different neural mechanisms, in a manner in which onsets are processed with greater neural efficiency than offsets, it would lend support to the default mode hypothesis and offer a deeper insight into the operation of visual attention mechanisms. In particular, this study considered the P300 event-related potential (ERP) as a potential marker of the neural processes that underlie behavioural findings of onset primacy. Using electroencephalography (EEG) techniques, an experiment was conducted to investigate whether the amplitude of the P300 would reflect more efficient processing of onsets than offsets in the brain.

The P300 is a positive deflection that typically occurs between 300–400 ms after the onset of sensory stimuli, though it has been reported to range more widely, from 250 ms up to 900 ms (Polich, 2007). It is generally implicated in information processing that involves selective attention and may be evoked after exposure to auditory or visual stimuli. Given that the P300 varies in topographical distribution, it is often conceptualised as two separate subcomponents, the P3a, a frontal distribution associated with stimulus novelty, and the P3b, a temporal-parietal distribution associated with attention and memory processing (Polich, 2007). The latter component has also been observed across the occipital lobe in studies of selective attention (Koivisto & Revonsuo, 2007), presumably appearing as a marker of visual awareness (Singh-Curry & Husain, 2009). While the P3a novelty component may instinctively be of interest in a change detection paradigm, it is likely that novelty effects would quickly be habituated across the repetitive presentation of visual stimuli, making meaningful P3a components difficult to observe across averaged trials. The P3b component, however, remains of particular interest. As such, consequent discussion of the P300 is

focused on the P3b in this paper. For simplicity, the P3b component is referred to as P300 hereafter.

There are several factors that have been reported to influence the amplitude of the P300 (for a review, see Patel & Azzam, 2005), though one of the most relevant factors to a change detection paradigm is discrimination difficulty. Many studies investigating P300 components have used variations of the oddball task, where participants are required to respond when they perceive an infrequent or deviant stimulus that is randomly presented among a series of standard stimuli (Donchin, Ritter, & McCallum, 1978). The P300 is modulated in these tasks when it is more difficult to distinguish between the standard stimuli and deviant stimuli. This increased difficulty is reflected in the P300 as a decreased amplitude, relative to easy discrimination trials (Kramer, Wickens, & Donchin, 1985; Polich, 2007). These findings have been replicated across other studies that manipulate task difficulty, suggesting that observed differences in P300 amplitude reflect neural processing, most notably relating to attention and working memory, that is required for successful task performance (Kok, 2001; Polich, 2007). Although the direction of this relationship may seem counter-intuitive, given that more difficult discrimination tasks may be thought to evoke a larger amplitude, the higher amplitude of the evoked potential found in easier discrimination tasks can be taken as an indicator of greater neural efficiency that allows observers to perform the tasks with relative ease. When applied to onset primacy, this framework leads to a prediction that the P300 would show a greater amplitude during detection of onset than offset, as behavioural studies indicate that onsets are detected with greater speed and accuracy than offsets (Donaldson & Yamamoto, 2012, 2016).

The P300 has also been subject to some investigation within a change detection paradigm. Rather than explaining differences in P300 amplitude through task difficulty, many of these studies infer that amplitude differences between conditions are the result of detected

versus undetected change (Koivisto & Revonsuo, 2003; Niedeggen, Wichmann, & Stoerig, 2001; Turatto, Angrillia, Mazza, Umilta, & Driver, 2002) and further, participants' confidence in their report of a detected change (Eimer & Mazza, 2005). Because it is possible that these factors interact, where more difficult tasks cause change to remain undetected and lower ratings of confidence in the participants' change response, it is not clear whether successful detection or participants' confidence itself has unique effects on the P300. Nevertheless, the fact that successfully and more confidently detected changes resulted in larger P300 amplitudes in these studies suggests that the P300 amplitude would be greater during onset detection than offset detection, as behavioural measures of onset primacy (i.e., quicker and more accurate detection of onsets than offsets) indicate that onsets are more prone to successful and confident detection than offsets.

In summary, in order to seek neural evidence for more efficient processing of onsets than offsets, the current study measured P300 amplitude while participants attempted to detect onsets and offsets. Given the behavioural findings of onset primacy, indicating that onsets are detected with greater speed and accuracy than offsets, onsets should be easier to discriminate in a visual scene than offsets. It then follows that the P300 should appear in a larger amplitude for onset than offset conditions in temporal, parietal, and occipital regions of the brain. This pattern of the P300, if actually observed, would provide new evidence for the default mode hypothesis of onset primacy.

Method

Participants

Twenty-five students (19 female, 6 male) aged 17–29 years (M = 20.88, SD = 3.25) participated in return for partial credit toward their course. Written informed consent was obtained prior to their participation. All were right-handed with no known history of neurological disorder, and had normal or correct-to-normal vision, as confirmed by a Snellen

eye-chart. The experiment was approved by the Human Research Ethics Committee of the Queensland University of Technology.

Materials

This experiment used Donaldson and Yamamoto's (2012) change detection task, who modelled it from the earlier paradigm developed by Cole, Kentridge, Gellatly, and Heywood (2003). Stimuli depicted visual scenes, each of which included a small circular table-top (30 cm diameter) with a single supporting leg (38 cm height). A range of objects of approximately equal size (4 cm width, 3 cm height, 2 cm depth) were placed onto the table in sixteen different arrangements. The number of objects on the table was varied, ranging from six to nine, to minimise the potential to predict patterns of change. Images were presented at a central fixation point, with visual angle subtending approximately 7° horizontally and 4° vertically. Participants viewed the stimuli from an approximate distance of 60 cm on a monitor with a screen resolution of 1920 × 1080 pixels, via PsychoPy software (version 1.86; Peirce, 2007, 2009).

Design and Procedure

Participants were informed that they were going to view a series of paired photographs, and that a change would be identifiable on the appearance of the second image. They were instructed to indicate whether they observed the change on the left or right side of the stimulus by pressing either F or J on their keyboard, respectively. Participants were asked to keep their index fingers resting on the response keys throughout the experiment and to respond as quickly and accurately as possible. Participants were not informed of the nature of change (onset or offset) across trials and received no performance feedback throughout. The experiment was conducted in a darkened room and external sensory disturbances were minimised as much as possible.

The paired photographs were presented across a single block of trials. In onset trials, the second image contained one additional object on the tabletop; in offset trials, the second image removed one object from the tabletop (see Figure 1 for an example). The change occurred on each side of the table (left and right) an equal number of times and was counterbalanced across onset and offset conditions. To control for the potential influence of object properties, such as colour, location, or semantic salience, the same paired photographs were used for both onset and offset trails, in reversed order. Each photograph in the pair had either seven or eight objects on the tabletop, with each object acting as the change target an equal number of times. There were 64 trials for each change type, making a total of 128 experimental trials.

An additional 32 photograph pairs were created as filler trials. Across 16 filler onset trials, an eight-object display was followed by a nine-object display. Across 16 filler offset trails, a seven-object display was followed by a six-object display. These filler trials were included to discourage participants from anticipating the type of an upcoming trial on the basis of the first photograph alone. Without the filler trials, having a seven-object display in the first photograph could mean for certain that it would be an onset trial; similarly, having an eight-object display in the first photograph could mean that it would be an offset trial. The filler trials were randomly intermixed with experimental trials, creating a total of 80 onset and 80 offset trials. Each participant performed all of these trials (i.e., a within-participant design). Data from the filler trials were not included in the analysis. Participants also completed 16 practice trials (8 onset and 8 offset, randomised) to familiarise themselves with the task. Practice trials consisted of new photograph pairs that were not used in the filler or experimental trials.

The sequence of each trial is demonstrated in Figure 1. First, participants viewed a central fixation cross for 1000 ms. The first image then appeared for 1200 ms, followed by

blank grey screen for 100 ms. The second image, depicting the change (change stimulus), then appeared for 1200 ms, before a final grey screen lasting 2000 ms. Participants were able to provide a response any time after the appearance of the second image. When a response was provided, or when the final grey screen timed out, the fixation cross would reappear to indicate the start of the next trial.

EEG Data Acquisition and Analysis

Electrical activity was recorded across 64 channels, aligning with the International 10–20 system of electrode placement. Data were collected using a sampling rate of 1024 Hz and electrode impedance values were kept below 25 Ω throughout the recording. EEG data were recorded using the Biosemi ActiveTwo 64-channel amplifier version 7.06. Pre-

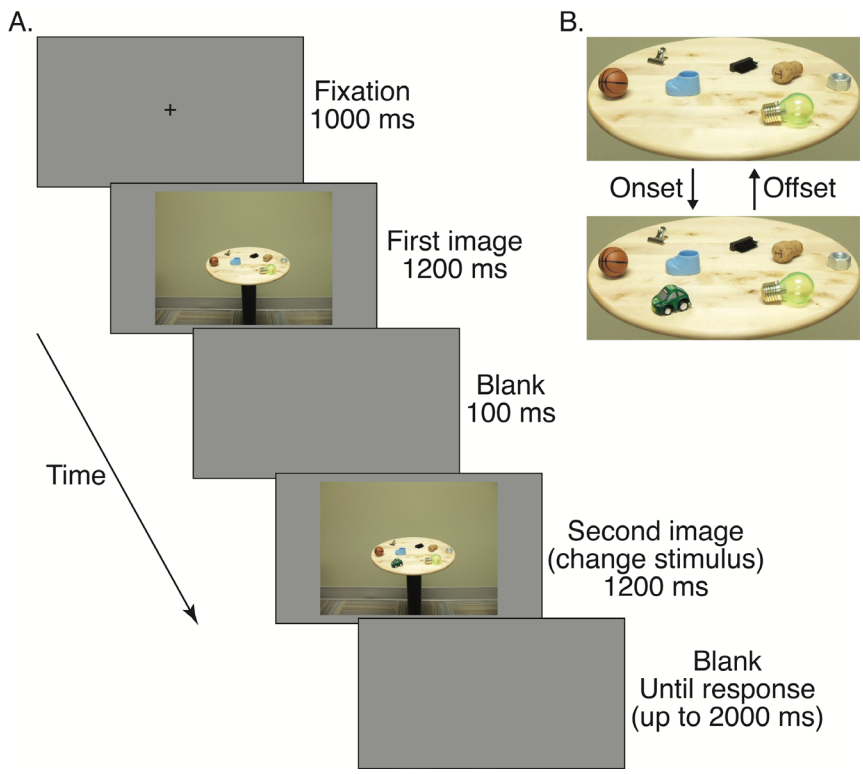

Figure 1. Experimental stimuli (adapted from Donaldson & Yamamoto, 2012). (A) Sequence of trials. (B) A closer view, demonstrating how the paired images changed between onset and offset trials. Here, the green car is the object of change.

processing was completed using BrainVision Analyzer 2.1 software. Amplitude data were analysed using MATLAB version R2019a and the statistical program R version 3.6.1.

During pre-processing, data were re-referenced to a common average based on all electrodes. A bandpass filter was then applied with a high pass filter of 0.1 Hz and a low pass filter of 30 Hz, with a notch filter set to 50 Hz as per Australia mains frequency. An ocular correction was applied using independent component analysis, with electrode Fp1 as the reference channel. Visual inspection of the data revealed channels with excessive noise, which were then removed and interpolated based on the mean of neighbouring electrodes. Data were then epoched into segments spanning from 100 ms preceding the onset of the change stimulus to 1000 ms after. Average ERPs were computed during the time window for onset and offset conditions separately within each participant for further analysis. Activity during the inter-stimulus period (−100 ms to 0 ms) was used to baseline the data.

Outcome Measures

Behavioural Measures. Reaction time was measured as the time that elapsed between the appearance of the change stimulus and the participant's response. Accuracy of the change location judgement, as indicated by the keyboard button press, was also measured. Trials where participants failed to provide a response before the end of the final grey screen were considered incorrect. When incorrect responses were made, associated reaction time data were excluded from analysis.

P300. The region of interest (ROI) for the P300 included the cortical surface of the temporal, parietal, and occipital lobes. Electrodes in these regions were grouped into clusters corresponding to their topographical location (Figure 2): left (CP1, CP3, CP5, TP7, P1, P3, P5, P7, PO3, PO7, and O1), centre (CPz, Pz, POz, Oz, and Iz), and right (CP2, CP4, CP6, TP8, P2, P4, P6, P8, PO4, PO8, and O2). Mean amplitude measures were calculated across the P300 time window of interest, defined as 275–500 ms after the presentation of the change

stimulus (Eilmer & Mazza, 2005; Turatto et al., 2002). Peak amplitude, as defined by the largest amplitude peak within the time window, was also measured and analysed. However, results from this analysis are not reported below because they were consistent with those from the mean amplitude analysis.

Results

Behavioural Results

Accuracy. Accuracy scores were defined as outliers if they were more than two standard deviations away from the mean of all participants, considering onset and offset conditions separately. This resulted in the exclusion of three participants from all further analyses (adjusted $N = 22$). The mean accuracy of excluded participants was 77.08% (onset) and 78.65% (offset). The mean accuracy of the remaining participants was 95.81% (SD = 3.62%, onset) and 94.39% (SD = 3.33%, offset). Although participants detected onsets with slightly greater accuracy, this difference was not statistically meaningful, $t(21) = 1.57$, $p = 0.13$, $d_{rm} = 0.41$ (for the definition of d_{rm}, see Lakens, 2013). This is not contrary to prediction, as previous studies demonstrated that accuracy is not as sensitive to onset primacy as reaction time (Donaldson & Yamamoto, 2012, 2016).

Reaction time. Reaction time data were defined as outliers if they were more than two standard deviations away from the participant's individual mean, considering onsets and offsets separately. This resulted in 116 outlier trials, constituting 4.33% of the correctly performed trials. Outlier reaction times were not removed from accuracy calculations. The mean reaction time across remaining trials was 548 ms (SD = 72 ms, onset) and 609 ms (SD = 49 ms, offset). These data indicate that participants detected onsets faster than offsets, $t(21) = 6.02$, $p < .001$, $d_{rm} = 0.89$. These data align with prediction and show that onset primacy was present.

EEG Results

The mean P300 amplitude values were calculated for each participant, at each electrode in the ROI, for onset and offset trials separately. They were analysed by a 2 (onset, offset) × 3 (left, centre, right) repeated measures analysis of variance (ANOVA). The Greenhouse-Geisser correction for non-sphericity was applied when appropriate.

Descriptive statistics for the mean amplitude data are displayed in Table 1. Consistent with prediction, the mean P300 amplitude was higher in onset conditions than offset conditions. Mean amplitude values also suggest that amplitude varied with electrode location, with the highest mean amplitude occurring in the right electrode cluster. These patterns can be seen in Figure 2 that shows the topographic distributions of the mean P300 amplitude. Figure 3 displays mean ERP waveforms from each cluster separately. Figure 3C, visualising the right cluster, demonstrates the expected pattern of the P300 most fittingly, where the

Table 1

Mean Amplitude of the P300 as a Function of Change Type and Electrode Location

	Mean Amplitude (μV)			
	Onset		Offset	
Location	*M* (*SD*)	95% CI	*M* (*SD*)	95% CI
Left	1.26 (1.34)	[0.67, 1.86]	0.79 (0.78)	[0.44, 1.13]
Centre	1.01 (1.55)	[0.32, 1.70]	0.92 (1.32)	[0.33, 1.50]
Right	2.14 (1.46)	[1.49, 2.78]	1.33 (0.98)	[0.90, 1.77]

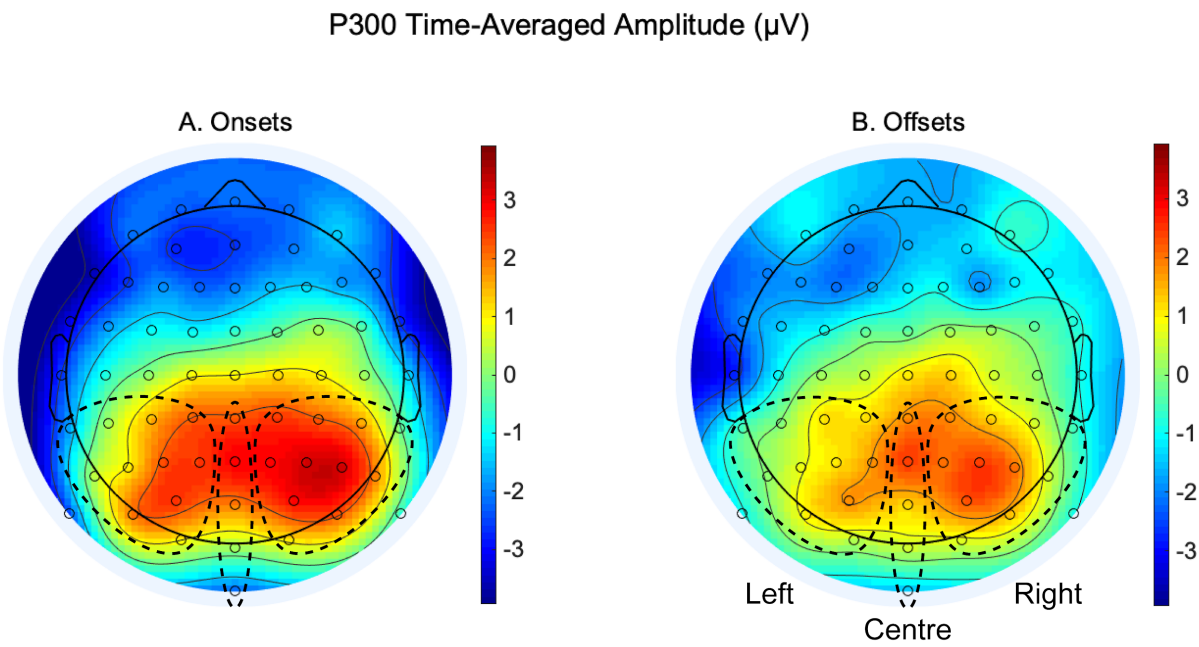

Figure 2. Grand average topographic plots collapsed over participants ($N = 22$), showing the distributions of the voltage in the P300 time window (275–500 ms post change stimulus) separately for each change type (A: onsets; B: offsets). Broken lines indicate electrode clusters that constituted the region of interest: left (CP1, CP3, CP5, TP7, P1, P3, P5, P7, PO3, PO7, and O1), centre (CPz, Pz, POz, Oz, and Iz), and right (CP2, CP4, CP6, TP8, P2, P4, P6, P8, PO4, PO8, and O2).

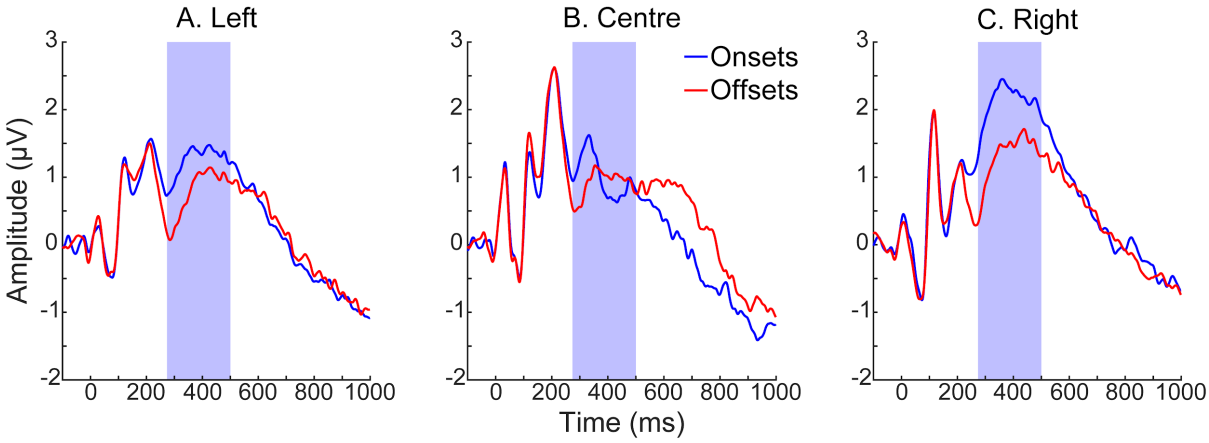

Figure 3. Mean P300 amplitude time series collapsed over participants ($N = 22$) are displayed for each change type and each electrode cluster (A: left; B: centre; C: right). The shaded area indicates the time window across which amplitude was averaged for analyses (275–500 ms post change stimulus).

amplitude was consistently higher in onset trials than in offset trials.

The ANOVA examining amplitude data revealed a significant main effect of change type, $F(1, 21) = 9.21$, $p = 0.006$, $\eta_G^2 = 0.033$, where onsets ($M = 1.46$ μV, $SD = 1.24$ μV) were greater than offsets ($M = 1.01$ μV, $SD = 0.84$ μV). There was also a significant main effect of electrode location, $F(2, 42) = 6.57$, $p = 0.004$, $\eta_G^2 = 0.074$. Follow-up pairwise comparisons (each with a Bonferroni-corrected α of 0.016) suggested that this main effect was driven by the right cluster ($M = 1.73$ μV, $SD = 1.29$ μV), which yielded significantly larger amplitude than the left cluster ($M = 1.03$ μV, $SD = 1.11$ μV) and the centre cluster ($M = 0.96$ μV, $SD = 1.42$ μV), $t(21) = 2.69$, $p = 0.014$, $d_{rm} = 0.65$ (right vs. left) and $t(21) = 3.43$, $p = 0.002$, $d_{rm} = 0.60$ (right vs. centre). There was no significant difference in mean amplitude between the left and centre clusters, $t(21) = 0.29$, $p = 0.77$, $d_{rm} = 0.05$. The ANOVA showed a significant interaction between change type and electrode location as well, $F(2, 42) = 6.21$, $p = 0.005$, $\eta_G^2 = 0.014$, indicating that the effects of change type on mean amplitude varied according to the electrode location. The interaction was followed up by a contrast that compared the effects of change type in the right cluster against those in the left and centre clusters. This contrast was significant, $F(1, 21) = 6.92$, $p = 0.016$, $\eta_G^2 = 0.14$, suggesting that the difference in mean amplitude between onsets and offsets was more pronounced in the right hemisphere.

Discussion

The current study aimed to test the default mode hypothesis by examining whether behavioural findings of onset primacy were reflected on a neural level, as indicated by EEG recordings during a change detection task. If the default mode hypothesis is true, trials involving the detection of onsets should be processed with greater neural efficiency than trials involving the detection of offsets. That is, detection of offsets should entail an alteration of the attentional priority that goes against the default ‘onset detection’ mode, and this

alteration should be reflected in neural activity that differentiates between onset and offset detection. On the basis of previous studies on visual discrimination tasks (Kramer et al., 1985; Polich, 2007), the P300 ERP was hypothesised to be an index of this activity. Specifically, it was hypothesised that the P300 would have a higher mean amplitude across onset trials compared to offset trails, across the specified time-window (275–500 ms post change stimulus) and ROI (temporal, parietal, and occipital regions), reflecting the relative difficulty of discriminating offsets in change detection tasks.

The hypothesis was supported, as mean amplitude of the P300 component was larger in onset conditions than offset conditions. This finding is consistent with previous research, which has implicated the P300 in processes of visual awareness, attention, and memory (Polich, 2007). More specifically, the current finding provides further support for research suggesting that discrimination difficulty moderates P300 amplitude in change detection tasks (Kok, 2001; Patel & Azzam, 2005). These studies typically reported a larger amplitude in response to visual stimuli that were easy to discriminate, compared to those that were more difficult. Reaction time and P300 data of the present study indicated the comparative efficiency of onset detection, supporting the default mode hypothesis on both behavioural and neural levels.

Although no predictions were formed about the effect of electrode location, differences in amplitude did emerge as a function of electrode location for the P300 component. Specifically, the amplitude was overall higher across electrodes in the right hemisphere than those in the midline and in the left hemisphere, regardless of change type. Moreover, the electrodes in the right hemisphere revealed the effects of change type on P300 amplitude more clearly than the other electrodes. These amplitude patterns most likely reflect the generally accepted view that the right hemisphere tends to be dominant in the performance of tasks involving visuospatial attention (Corballis, 2003; Mesulam, 1999;

Shulman et al., 2010). This account is supported by EEG studies that examined performance across visuospatial tasks and identified similar P300 lateralisation (Makeig et al., 1999).

An important implication of the current experiment is the potential insight it provides into the debate within visual search and change detection literature as to the origin of onset primacy. As the visual properties of a stimulus, such as its luminance, shape, or motion compared to its surroundings, can influence attentional capture, it is often argued that the primacy of onset detection can be attributed to these sensory transients created by an appearing object, rather than the mere appearance of the object itself (Franconeri & Simons, 2003; Miller, 1989; Theeuwes, 1994). An alternative view is that object onset engages higher-order cognitive processes such as creation of a new mental representation of the object and implementation of an attentional set that gives preference to detection of onsets over other types of change, and these cognitive operations constitute a primary source of onset primacy (Cole et al., 2004; Donaldson & Yamamoto, 2016; Yantis, 1993). If the sensory account were true, then early sensory ERP components (e.g., those that occur within the first 100 ms) should reveal clear differences between onset and offset conditions. On the other hand, if the cognitive account were true, then onsets and offsets should evoke similar sensory responses in these early components, and begin to differ in later components that represent the cognitive processes. The significant effects of change type on P300 amplitude suggest that the cognitive processes made a major contribution to giving rise to onset primacy in this experiment, lending support to the cognitive account.

To elaborate on this point, it is worth noting that when onsets and offsets are presented as non-informative and task-irrelevant stimuli so that observers have no reason to direct their attention to them (i.e., the onsets and offsets are perceived largely in a stimulus-driven fashion), they do not elicit the P300 at all (Hopfinger & Maxwell, 2005). This finding corroborates the notion that the P300 observed in the present study represented higher-order

cognitive processes involved in the change detection task. Given that the P300 waveforms differed in amplitude but resembled in overall shape between onset and offset trials (see Figure 3; this was particularly the case in the left and right hemispheres), it was probable that the P300 ERPs were generated from cognitive processes that were commonly at play during onset and offset detection, and the two change types only varied in the extent these processes were engaged. It then follows that creation of a new mental representation of an appearing object was not the primary cause of the evoked P300 because only the detection of onsets entailed this operation. Instead, a more likely possibility is that the P300 stemmed from top-down deployment of attention to onsets and offsets, which were necessary for detecting both onsets and offsets, and the P300 amplitude difference reflected the fact that this deployment was more effectively done when to-be-attended targets were onsets than offsets. In other words, the current results suggest that as a neural correlate of onset primacy, the P300 chiefly captures a component process in which attention is preferentially given to onsets over offsets in an endogenous manner.

Given the current findings that the P300 amplitude reflects neural processes underlying onset primacy, future research can utilise this ERP pattern as a neural index of how firmly observers' attentional priority is set to the default onset-detection mode. For example, by measuring this ERP component while observers are being trained to prioritise detection of non-onset events (e.g., offsets), it may be possible to quantify the degree to which this training is effective (Donaldson & Yamamoto, 2016). Similarly, the same approach can be taken for exploring whether the default mode hypothesis persists in populations that may already be well practiced in alternate modes of change detection, such as lifeguards or child-care workers. A novel study by Laxton and Crundall (2017) suggests that lifeguards do indeed differ from the general population in their ability to detect change, as indicated by an experiment that required the detection of 'drownings' in a crowded

swimming pool. Measuring the P300 while these experts detect offsets can be useful from both theoretical and practical points of view—it not only helps further examine whether the P300 works as a neural marker of onset primacy, but also has a potential for providing an objective measure of how well the experts adopt a non-default attentional mode for performing their professional duties.

Finally, future research could also explore other differences that were observed between onset and offset conditions, which were not investigated in the present study. Averaged ERP waveforms, visualised in Figure 3, revealed possible additional differences that may be of interest. For example, there appears to be an early negativity for onsets compared to offsets 150–200 ms post change stimulus across the occipital, temporal, and parietal lobes. A similar trend was observed when participants in the Hopfinger and Maxwell (2005) study passively viewed task-irrelevant onsets and offsets. A negativity that resembles these ERPs is known to be evoked in the occipitotemporal areas by a variety of visual perception tasks (i.e., the N170 component; Bentin, Allison, Puce, Perez, & McCarthy, 1996; Levita, Howsley, Jordan, & Johnston, 2015; Tanaka & Curran, 2001). Although the N170 has traditionally been associated with processes specific to perception of human faces (Eimer, 2000; Itier & Taylor, 2004), an emerging view is that it more generally reflects the extent to which a visual stimulus appears in an unexpected manner (Johnston et al., 2017; Robinson, Breakspear, Young, & Johnston, 2018). In this view, the N170 is an error signal whose amplitude indicates the degree of mismatch between predicted and actual stimuli. Within this framework, the potentially larger N170 in the onset than offset conditions leads to an interesting hypothesis about how the brain prioritises the detection of onsets: It is possible that the brain treats onsets as greater errors of prediction, thereby triggering the allocation of more resources to the processing of onsets. This hypothesis might sound counterintuitive because one way of detecting onsets with enhanced speed and accuracy would be to expect,

rather than be surprised by, the appearance of new objects. However, if supported, this hypothesis will clarify what is in ‘default’ in the default attentional mode—it is not observers’ expectation of possible onsets but the setting of the prediction-error mechanisms in which onsets constitute major deviation from prediction. If further differences were established between onset and offset conditions in the N170 and other ERPs, they would have the potential of providing additional evidence that refines the default mode hypothesis as an explanation of onset primacy.

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