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The relevance of the irrelevant: Attention and task-set adaptation in prematurely born adults

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HIGHLIGHTS

- This study investigated ERP components in a group of adults born preterm with very low birth weight.
- The preterm group allocated excessive attention to irrelevant stimuli as reflected in P3 amplitudes.
- Unlike term-born controls, the preterm group persisted in attending to irrelevant stimuli over time.

ABSTRACT

Objective: To investigate attention and task-set adaptation in a preterm born very low birth weight (PT/VLBW) population by means of event-related potential components from an adapted cued go/no-go task.
Methods: P3 components after target and non-target cues, as well as target, no-go and non-target imperative stimuli were compared in 30 PT/VLBW young adults and 33 term-born controls. Changes in P3 amplitudes as a function of time-on-task were also investigated.
Results: The PT/VLBW group had larger P3 amplitudes to non-target cues and non-targets compared with controls. There were no significant group differences in the P3s to target or no-go stimuli. Moreover, the amplitude of the P3 to non-target cues and non-targets decreased significantly over time in the control group but not in the PT/VLBW group.
Conclusions: PT/VLBW young adults allocate more attention to behaviorally irrelevant information than term-born controls, and persist in attending to this information over time.
Significance: This is the first study to investigate ERP components in an adult population born preterm with very low birth weight.

1. Introduction

Being born preterm (PT, before week 37 of gestation) with very low birth weight (VLBW, <1500 g) is associated with increased risk of perinatal brain injuries and compromised brain development that can have negative long-term consequences for cognitive function (Løhaugen et al., 2010; Nosarti et al., 2012). Increased prevalence of problems in the domains of executive attention and learning are particularly notable in PT/VLBW populations (Mulder et al., 2009; Murray et al., 2014; van der Weijer-Bergsma et al., 2008). Processes of attention and learning are interactive, and a central aspect of learning is to prioritize to which aspects of the environment attention should be allocated. Some

Abbreviations: ADHD, attention deficit hyperactivity disorder; VLBW, very low birth weight; ERP, event-related potential; PT, preterm; S–R, stimulus–response.

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studies indicate that attention problems in PT/VLBW infants are related specifically to excessive attention to distractors (van de Weijer-Bergsma et al., 2008). Furthermore, inflexible and persistent gazing as well as unusual and random errors involving responses to previously non-rewarded stimuli characterizes young PT/VLBW populations (Espy et al., 2002; Kittler et al., 2011; Woodward et al., 2005). Whether or not the described characteristic of excessive attention to irrelevant information still characterizes PT/VLBW populations in adulthood has not previously been investigated.

Earlier studies on PT/VLBW populations, have primarily investigated attention problems by means of behavioral measures and clinical interviews. Behavioral measures, however, represent the end-point of many sensory, perceptual and cognitive processes. In contrast, event-related potentials (ERPs) have exquisite temporal resolution and give insight into neural processes underlying behavior. The method also enables the study of cognitive processes in task conditions where no overt responses are made. Previous cognitive ERP studies on PT/VLBW populations are limited, and have only investigated oddball paradigms in children, not finding any significant differences in the target P3 component (e.g. Lindgren et al., 2000; Potgieter et al., 2003). To date, no studies of cognitive ERPs have been conducted in adult VLBW populations.

1.1. P3 Components and the cued go/no-go task

Cued go/no-go tasks can be used to study ERP components related to attention and executive processes (Aasen and Brunner, 2016; Brunner et al., 2015; Checa and Rueda, 2011; Wiersema and Roeyers, 2009). The different conditions in such tasks elicit variants of the P3 ERP component, with different timing, amplitude and topography, reflecting different cognitive processes. Importantly, the amplitudes of all P3s are modulated by the amount of attentional resources allocated to specific cognitive operations (Polich, 2007). The different P3 components therefore reflect both specific cognitive processes, as well as the degree of attention allocated to these processes.

The most studied P3 component is the parietal P3b, which increases in amplitude as the behavioral significance of the preceding stimulus is learned (Rose et al., 2001). Although a matter of long-standing debate, there is accumulating evidence that the P3b reflects a bridge between stimulus evaluation and response selection, referred to as a stimulus–response (S–R) link (Verleger et al., 2005; Verleger et al., 2014a,b). Most often, the P3b is studied in the target condition where an active response is given immediately. In addition to targets, however, cue stimuli that provide essential information for response selection following the imperative stimulus, will also elicit a P3b-like component. This component has been interpreted as a pre-activation of the P3b (Verleger et al., 2015), thereby primarily reflecting the same process as the target P3b. Alternatively, the cue-P3 has been interpreted as a process is somewhat different from the target P3, reflecting the resolution of response uncertainty regarding what S–R mappings that should be prepared (Barceló et al., 2007). In some types of tasks, two cue-P3 components with differing latencies can be identified (Barceló et al., 2007; Nicholson et al., 2006). In those tasks, it has been hypothesized that the later latency component reflects more detailed, or in depth preparatory processes, whereas the earlier latency component reflects more automatized activation of well-learned, and readily available task rules.

1.2. Task-setting, S–R links, and the P3b

One possible explanation for the elevated rates of random and unusual errors in PT/VLBW populations is problems related to task-setting. Task-setting, or the forming and selection of task relevant rules, is fundamental to all learning (Stuss and Alexander, 2007). The task-set can be regarded as the sum of all the S–R links in a task that are regarded as relevant for task performance.

The relative weighting of the different S–R links is adapted during task performance, as the participant understands the relevance of the different links. This process selectively drives attention to relevant task characteristics while reducing attention to irrelevant information. These adaptations lead to corresponding changes in P3 amplitudes (Rose et al., 2001). The amplitude of the P3 elicited by stimuli that do not require any type of active (mental or behavioral) response is significantly reduced over the course of the first few stimulus presentations (Verbaten et al., 1986), whereas a large number of trials is needed before a reduction in P3 amplitude is detected for stimuli that have a significant *signal value* (Polich and McIsaac, 1994; Romero and Polich, 1996). In accordance with the S–R link hypothesis of the P3b, the initial P3 activation following non-targets could be interpreted as non-targets (S) being linked with a non-response (R). After some practice, however, attention is selectively allocated to the S–R links that are regarded as relevant for task performance. Investigating changes in P3 amplitude as an effect of time-on-task may therefore elucidate how being born preterm can affect how the task-set is adapted during task performance.

In this study, ERP components from a cued go/no-go task was used to investigate attentional allocation and task-set adaptation in a population of PT/VLBW adults. The results will be interpreted in the framework of the S–R link hypothesis of the P3b. P3b amplitudes elicited by stimuli with significant behavioral relevance (target cues and targets) as well as P3b amplitudes elicited by behaviorally irrelevant stimuli (non-target cues and non-targets) were investigated. The more anteriorly distributed no-go P3 was also included in the analysis, as this component has been found to be of reduced amplitude in other populations with attention problems (Johnstone et al., 2013; Woltering et al., 2013). To investigate dynamics of task-set adaptation, changes in these P3s as an effect of time-on-task were analyzed. It was hypothesized that the PT/VLBW group would demonstrate significantly larger P3b amplitudes to behaviorally irrelevant stimuli, compared with controls. The PT/VLBW group was also expected to exhibit smaller reduction of these P3 amplitudes over time compared with controls. Correlation analyses were performed in order to explore whether group ERP differences were related to birth weight or gestational age.

2. Materials and methods

2.1. Participants

The PT/VLBW group consisted of 30 young adults (18 female) born preterm (before 37th week of gestation) with very low birth weight ($\leqslant$1500 g). At 14 years of age, 63 adolescents met for examination. At 23 years, seven of these young adults were untraceable and two were not testable due to severe quadriplegic cerebral palsy. The remaining 54 PT/VLBW young adults were contacted for participation in the study. Of these young adults, 21 (39%) did not consent, leaving 33 (61%) young adults for examination. The recording of one participant was excluded due to excessive artifacts in the EEG, and two were excluded because of technical difficulties that terminated the recordings prematurely.

At the time of testing, 16 (53%) of the PT/VLBW participants had completed high school and/or started higher education, whereas the remaining 14 (47%) participants had chosen vocational training rather than ordinary high school or had not completed high school. Three of the PT/VLBW participants had cerebral palsy as assessed through a neurological examination at age 23. Removing these three participants from the analyses did not significantly alter