

*A research review by the University of Wollongong Department of Psychology  
and the Brain & Behaviour Research Institute  
<http://www.psy.uow.edu.au/research/bbri>*

The Department of Psychology at the University of Wollongong would like to say thank you to everyone who has participated in our current research project. In 2005, Dr Stuart Johnstone successfully obtained a grant from the Australian Research Council to fund ADHD research for the next 3 years. The aims of the research project are to examine brain mechanisms underlying symptoms and deficiencies in Attention-deficit/Hyperactivity Disorder (ADHD). Specifically, we will be focusing on a particular process known as *inhibition* - this process allows us to amend thoughts and behaviours, as well as to inhibit attention directed at distracting information. It is anticipated that this large-scale project will provide much-needed information about (a) ADHD brain mechanisms, (b) optimal workload rates and effort levels, and (c) the effect of positive/negative feedback.

## **ADHD and Inhibition**

Current theories of ADHD suggest that many of the symptoms that we observe in children with ADHD stem from a deficiency in the "inhibition" process. This process is located in the frontal lobes and is vital for the performance of everyday tasks that we take for granted. For example, in adults, inhibition allows us to STOP from blurting out an inappropriate comment in a social setting. In children with ADHD, this process is deficient, resulting in an inability to stop inappropriate behaviours or to inhibit distracting information in order to focus attention on the task at-hand.

## **In the Laboratory**

Researchers attempt to mimic real-life situations requiring inhibition by developing laboratory tasks that will evoke an inhibitory response. The Go/Nogo task is one such task, requiring participants to respond with a button press to a green "GO" sign and to not press the button (i.e. inhibit the response) to the presentation of a red "STOP" sign.



As there are a greater number of Go's than STOP's, participants are more likely to prepare a button press and find it difficult to inhibit when a "STOP" occurs.

## **Performance in the Present Study**

Children with ADHD ranging in age from 8 to 14 years were compared with children without ADHD (controls) in performance and electrical brain activity. We found that:

1. *Children with ADHD showed greater variability in their response times.* What this means is that, while children without ADHD showed fairly consistent response times across the task, children with ADHD varied between fast and slow response times. This effect has often been attributed to difficulties in maintaining an appropriate level of arousal.
2. *Children with ADHD showed a tendency towards inhibiting fewer responses.* This means that children with ADHD were less likely to inhibit a button-press upon the presentation of a "STOP" sign. However, a reduced ability to inhibit responses may not necessarily be due to a deficiency in the inhibition process. For example, two individuals may have a similar inhibition process but a faster response will be more difficult to inhibit than a slower response. An examination of the electrical brain activity will tell us whether poorer inhibitory control was due to a deficient inhibition process or not.

## **Electroencephalography**

Electroencephalography (EEG) was measured during task performance. Slices of EEG were then averaged together to obtain noise-free brain potentials. We call these *event-related* potentials

(ERPs) because they show the flow of neural processing that is evoked by a specific "event". In the present study ERPs were time-locked to the "STOP" sign, thereby reflecting inhibitory processing (see below Figure 1). Once the inhibition process is triggered by the presentation of the "STOP" sign, it takes approximately 200 ms to inhibit a response. Figure 1 shows a positive brain potential (i.e. pointing downwards) that peaks around 200 ms after the "STOP" sign. This brain potential appeared to be smaller in children with ADHD (dotted line) compared to control children (solid line), indicating reduced or weaker activation of the inhibition process.

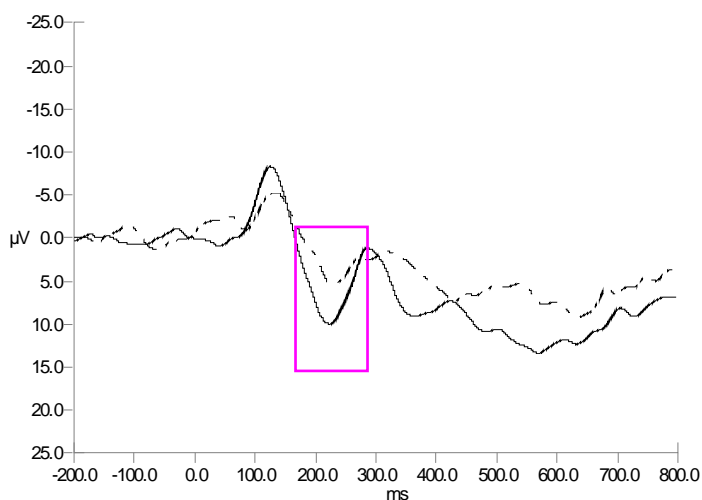


Figure 1. The ERP to the "STOP" sign shows a smaller positive brain potential (shown in pink box) in children with ADHD indicating a weak inhibition process.

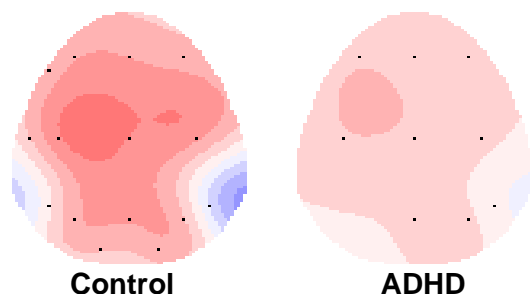


Figure 2. Head maps showing the distribution of activation at 200 ms after the presentation of the "STOP" sign. Darker areas indicate stronger brain activity. Children with ADHD showed reduced activation of this fronto-central process suggesting weaker inhibitory activation.

We can also graph brain activity a different way. Figure 2 maps the spread of brain activity across the entire scalp. These head maps show reduced activation of processing across the entire scalp in the ADHD group. However, this reduction was most evident in the fronto-central region.

### Conclusions

After a preliminary analysis of the data, we were able to identify a number of deficiencies in children with ADHD, including:

- (a) variable responding - which may be due to an inability to maintain an appropriate level of arousal....we will further examine this issue in future research
- (b) a reduced ability to inhibit responses, and
- (c) reduced activation of the inhibition process, particularly in the fronto-central region.

### Future Research

In the next phase of our research we will be examining what happens when we manipulate motivation, workload and effort levels. It has been suggested that presenting stimuli at very fast rates cause children with ADHD to become over-aroused, but that very slow rates result in under-arousal and a severe deterioration in performance. These studies will provide an insight into which presentation rates may be optimal for children with ADHD, which will eventually help develop more effective methods of behavioural treatments.

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