ADHD RESEARCH

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A research summary from the School of Psychology and the Brain & Behaviour Research Institute at the University of Wollongong (visit www.uow.edu.au/health/psyc/research/bbri)

The School of Psychology at the University of Wollongong would like to thank everyone who has participated in this ongoing research project. As you may be aware this project has been made possible due to an Australian Research Council grant received for 3 years. The studies have been examining brain mechanisms underlying symptoms and problems in Attention-deficit Hyperactivity Disorder (ADHD). The research is specifically focusing on a particular process known as *inhibition* – this process allows us to focus attention and ignore distracting information, as well as "stop and think" before acting.

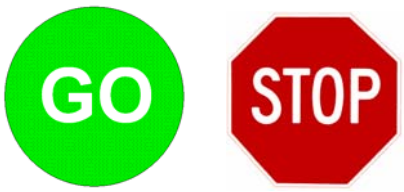
ADHD and Inhibition

Current influential theories of ADHD suggest that many of the symptoms that are observed stem from a deficiency in the inhibition process. Inhibition is vital for the performance of everyday tasks that we often take for granted. For example, in adults, inhibition allows us to 'stop' ourselves from blurting out an inappropriate comment in a social setting. In children with ADHD, this process is believed to be activated at a weaker level, resulting in an inability to stop inappropriate behaviours or to ignore distracting information, making it more difficult to focus attention on the task at-hand.

While inhibition is seen as a contributing factor to ADHD symptoms, there is also some evidence that motivational or energetic factors may play a role. This large-scale research project is making it possible to obtain much-needed information about (a) group differences in task performance b) optimal workload rates, c) effort levels, and d) the influence of external feedback for children with ADHD. Such investigations will assist to further identify the contributing role of these factors to the behaviours observed in children with ADHD.

In the laboratory

In the lab, we try to mimic real-life situations requiring inhibition by developing computer tasks that will evoke an inhibitory, or "stopping" response. We use the Go/Nogo task to do this - the children are asked to press a button to a green "Go" sign but not to press the button (i.e. withhold or inhibit the response) to the presentation of a red "Stop" sign.



More Go than Stop signs are presented, which means there is lots of button pressing. This makes it more difficult to inhibit the response when a 'STOP' sign is presented. In one of the tasks that children participated in during 2006 the rate of presentation of the GO and STOP shapes was varied from fast to slow to determine how this would affect performance. It was expected that children with ADHD would perform better when the shapes were presented at a medium rate, but that their performance (and effort) levels would deteriorate when the task was either fast or slow and required sustained attention.

Summary of results

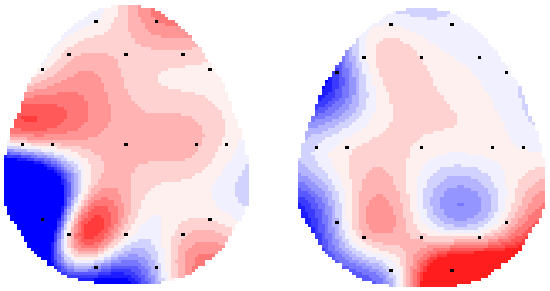
Children with ADHD aged from 7 to 14 years were compared with children without ADHD in performance and electrical brain activity. We found that:

1. *Children with ADHD made more errors during the fast presentation rate.* This indicates that, while children without ADHD were able to inhibit fairly consistently across the different rates, children with ADHD were more impulsive during the fast rate. This result has been related to difficulties in maintaining appropriate arousal levels.

2. *Children with ADHD process inhibition faster at fast presentation rate.* The ERP to the stop sign was found to occur earlier in children with ADHD during the fast rate. This brain wave is indicative of the inhibition process. As more errors were made at the faster rates, this is evidence that faster processing may have led to increased errors in the children with ADHD.

Electroencephalography

To carry out the research outlined above, we measure brain activity using the electroencephalogram (EEG) while the child performs the task. We then average together slices of EEG to obtain clearly-defined brain potentials. These are called *event-related* potentials (ERPs) because they show the flow of neural processing that is evoked by a specific event. In the Go/Nogo task of the present study we examined the ERPs to the "Stop" sign. Therefore, the ERPs show the brain activation associated with stopping the response (aka inhibitory processing).



Control **ADHD**

Figure 1: These maps look down on top of the head, and show brain activation related to inhibition/stopping. The darker areas indicating stronger brain activity. The figure shows reduced brain activity in children with ADHD, most noticeably in the frontal part of the brain (top of pic).

Conclusions

As a result of preliminary analysis, we were able to identify the following differences in children with ADHD.

a). Children have a reduced ability to inhibit at fast presentation rates, implicating the role of arousal in ADHD.

b). Children process inhibition faster at fast presentation rates, potentially leading to increased errors.

Recent Research

In the most recent phase of our research we examined what happens when we vary the difficulty of the Go/Nogo task, to influence effort levels. It has been suggested that children with ADHD perform better when they are able to apply more effort in completing the task and that their performance levels deteriorate when the task is easy and requires less effort. This investigation will help to identify what role motivational factors play in ADHD and provide greater understanding of the disorder. This data should be analysed over the next few months and we hope to provide a summary in the next newsletter.

Current research is also incorporating a pilot study testing the effectiveness of a computer-based game as an alternative treatment for ADHD. This is the first investigation of its type in Australia and we are looking for children with a diagnosis of ADHD (combined subtype) to be involved. Additionally, we are always keen to test children without a diagnosis of ADHD or any other problems. Contact details below.

For your information, below are a few references to articles that may be of interest to you in this area. If you would like a photocopy of any of these articles, please email us.

• Johnstone, S.J., Dimoska, A., Smith, J. L., Barry, R. J., Pleffer, C.B., Chiswick. D., Clarke, A. R. (2007). The development of stop-signal and go/nogo response inhibition in children aged 7-12 years: Performance and event-related potential indices. *International Journal of Psychophysiology*, 63, 25-38.

• Lawrence, C. A., Barry, R. J., Clarke, A. R., Johnstone, S. J. McCarthy, R., Selikowitz. M. & Broyd., S. J. (2005). Methylphenidate effects in Attention-Deficit/Hyperactivity Disorder: Electrodermal and ERP measures during a Continuous Performance Task. *Psychopharmacology*, 183, 81-91.

• Broyd, S. J., Johnstone, S. J., Barry, R. J., Clarke, A. R., McCarthy, R., Selikowitz, M. & Lawrence, C. A. (2005). The effect of methylphenidate on response inhibition and the event-related potentials of children with Attention-Deficit/Hyperactivity Disorder. *International Journal of Psychophysiology. 58,* 47-58.

• Johnstone, S. J., Pleffer, C. B., Barry, R. J. Clarke, A. R. & Smith, J. (2005). Development of inhibitory processing during the Go/Nogo task: A behavioural and event-related potential study of children and adults. *Journal of Psychophysiology, 19*, 11-23.

• Smith J. L., Johnstone, S. J., Barry, R. J. (2004). Inhibitory processing during the Go/NoGo task: An ERP analysis of children with Attention-Deficit/Hyperactivity Disorder. *Clinical Neurophysiology, 115*, 1320-1331.

• Dimoska, A., Johnstone, S. J., Barry, R. J. and Clarke, A. R. (2003). Inhibitory motor control in children with attention-deficit/hyperactivity disorder: Event-related potential in the stop-signal paradigm. *Biological Psychiatry, 54*, 1340-1349.

Dr Stuart Johnstone
sjohnsto@uow.edu.au

Val Markovska
valm@uow.edu.au