Copyright © The British Psychological Society
Reproduction in any form (including the internet) is prohibited without prior permission from the Society

British Journal of Developmental Psychology (2005), 23, 517–521
© 2005 The British Psychological Society

The British Psychological Society
www.bpsjournals.co.uk

Commentary

Is inhibition impaired in ADHD?

Guido P. H. Band[1]* and Anouk Scheres[2]
[1]Department of Psychology, Leiden University, The Netherlands
[2]Department of Psychology, University of Arizona, USA

In the target paper, Wilding (2005) lists concerns about measures of attention and control that are used throughout the field of clinical developmental psychology. In particular, doubts are raised about the construct validity of the measures of attention that led Manly *et al.* (2001) to conclude that sustained attention is deficient in ADHD whereas selective attention is not. We support the criticism, but argue that Wilding's suggestion that executive dysfunction is the fundamental problem underlying ADHD symptoms does not bring us much closer to understanding ADHD. We illustrate this by evaluating the more specified claim that inhibitory deficiencies are the fundamental problem underlying ADHD.

Wilding makes the interesting observation about Manly *et al.*'s (2001) and other studies that whether or not a difference is observed between children with ADHD and controls depends on whether the dependent variable is speed or accuracy, and which of these is emphasized in the instruction. Children with ADHD display attentional deficiencies in the form of reduced accuracy and sensitivity to interference, rather than by speed measures such as search time. Wilding attributes the accuracy differences observed in a sustained attention task not to an attentional deficiency, but to a more fundamental deficiency in executive function of children with ADHD, that is involved in preventing errors. Although we do not object to this interpretation as such, we argue that not only the attentional constructs postulated by Manly *et al.*, but also the construct of executive function that Wilding proposes needs validation.

To start the quest for fundamental differences between children with ADHD and controls we should first define the building-blocks of cognition. Recent studies have made valuable contributions based on individual differences, by distinguishing between three latent variables underlying executive function; set shifting, working memory updating, and inhibition (Miyake *et al.*, 2000). Subsequent work along these lines has distinguished between two independent inhibitory functions; response-distractor inhibition and resistance to proactive interference (Friedman & Miyake, 2004; see below). Unfortunately, we are not aware of similar approaches to the varieties of

* *Correspondence should be addressed to Guido Band, Wassenaarseweg 52, 2333 AK Leiden, The Netherlands (e-mail: band@fsw.leidenuniv.nl).*

DOI:10.1348/026151005X58377

Copyright © The British Psychological Society
Reproduction in any form (including the internet) is prohibited without prior permission from the Society

attention that Manly *et al.* (2001) and Wilding discuss. The value of the latent variable approach is illustrated by the finding that commonly used neuropsychological tasks for the assessment of frontal cortex functions (e.g. Wisconsin card-sorting task) and executive function (Tower of Hanoi) loaded on multiple latent factors and they are, therefore, far from pure tasks.

To test the efficiency of a single control process, experiments should contrast conditions that differ only in the involvement of the associated factor. Although this seems like a truism, studies such as that of Manly *et al.* (2001) demonstrate a tendency to let go of task purity in favour of test convenience. In the literature, studies employing the Stroop colour-word test have been considered as providing evidence for poor interference control in ADHD. However, most studies that report poor Stroop task performance have reported performance on the interference condition without controlling for performance on the colour naming condition. A recent meta-analysis shows that when non-interference aspects of the task are taken into account, children with ADHD do not demonstrate poor interference control on this task (Van Mourik, Oosterlaan, & Sergeant, 2005).

Wilding disagrees with Manly *et al.*'s conclusion that children with ADHD have a deficiency in sustained attention. Instead, he suggests a list of alternative explanations. Weakness in executive function, Wilding argues, could affect preparation, response timing, stimulus-response organization, maintenance of focus, combining of target features, the definition of targets, and even more processes.

The fundamental role of executive functions in ADHD (Pennington & Ozonoff, 1996) is neither a new, nor a satisfying idea. As Wilding admits, the executive function system '[. . .] is so general as to explain everything or nothing'. Executive function is considered to be a system that balances activity in the nervous system by inhibition of pathways and adjusting thresholds. But is executive function more than a sum of its manifestations? Is it one fundamental factor that takes over the main role previously played by set shifting, inhibitory control, and working memory updating (cf. Miyake *et al.*, 2000)? We warn that peeling off the concept of executive function leaves us with a concept with homuncular properties that is neither observable, nor testable.

What we do encourage, on the other hand, is to further our understanding of executive deficits in ADHD by identifying distinguishable control functions and by subjecting them to the same type of validation process as Wilding argues for in attention. Needless to say, such an undertaking is too large for a commentary. Therefore, we will illustrate our point by focusing on inhibitory control. Researchers have suggested that deficient inhibitory control is a key characteristic of children with ADHD (e.g. Barkley, 1997; Nigg, 2001; Quay, 1997). How valid is this conclusion?

The first problem is that inhibition as such is not a singular concept. Latent variable analyses have shown that resistance to proactive interference as measured by the Brown-Petersen task and cued-recall task is unrelated to response-distractor inhibition as recorded by, among others, stop-signal inhibition, Stroop interference, and Eriksen interference (Friedman & Miyake, 2004). Children with ADHD may have deficits with certain forms of inhibition but not with other forms. Little research has focused on investigating various domains of inhibition within one sample (but see Geurts, Oosterlaan, Roeyers, & Sergeant, 2005; Scheres *et al.*, 2004). Most studies have used the stop-signal task (Logan, 1994), and although findings vary across studies, meta-analyses have indicated that children and adults with ADHD do demonstrate slow prepotent response inhibition (Lijffijt, Verbaten, & Van Engeland, 2005; Oosterlaan, Scheres, &

Copyright © The British Psychological Society
Reproduction in any form (including the internet) is prohibited without prior permission from the Society

Sergeant, 2005). Studies using the Stroop colour-word test, however, show no deficit in interference control in ADHD (Van Mourik *et al.*, 2005).

Second, the involvement of active inhibition in performance is in many cases uncertain. An example is negative priming; the finding that subjects are slower at classifying a stimulus feature that previously had to be ignored (Tipper, 1985). Although inhibitory accounts of this effect prevail, MacLeod, Dodd, Sheard, Wilson, and Bibi (2003) have proposed a plausible non-inhibitory explanation of this effect, based on the learned association between the feature and its previous irrelevance. In addition, MacLeod *et al.* have argued that what is often interpreted as inhibition in conflict paradigms, such as Stroop, Eriksen, and Simon tasks actually refers to the objective observation of interference. Whether an inhibitory theory explains the effect better than a non-inhibitory theory remains to be seen.

Doubts even exist about the involvement of active inhibitory processes in stop-signal inhibition, while this is a direct manifestation of the act of control that interrupts a response. However, successful stopping may be the result of a non-response replacing a response, or the discontinuation of support for finishing a response (Band & van Boxtel, 1999). In sum, if the role of inhibition as an explanatory construct is questionable, so is the fundamental role of inhibition in ADHD.

Third, the finding that inhibition is deficient in children with ADHD does not necessarily imply that it is a deficit that underlies other cognitive problems, nor that it is the most important problem. Based on research so far, the most striking and robust characteristic of children with ADHD seems to be within-subject variability of responding and not poor inhibition. Effect sizes for group differences on variability are larger than those for response inhibition (Lijffijt *et al.*, 2005). Studying the pattern of within-subject variability will help increase our understanding of the nature of this observed variability (Castellanos *et al.*, 2005).

Another process that may be more strongly related to ADHD than poor inhibition is delay aversion. A recent study that used the stop-signal paradigm and a delay-aversion paradigm found that performance on the delay-aversion task accounted for much more of the variance in ADHD group than performance on the stop-signal paradigm (Solanto *et al.*, 2001).

Fourth, the finding that inhibition is deficient in ADHD does not mean that it is a deficit that is uniquely related to symptoms of ADHD. Poor inhibitory control has also been observed in other clinical conditions such conduct disorder (Oosterlaan, Logan, & Sergeant, 1998).

Fifth and finally, it is extremely unlikely that a heterogeneous diagnostic category such as ADHD is associated with a single underlying pathophysiology. It is much more likely that there are multiple independent causal pathways leading to different subtypes of ADHD (Castellanos & Tannock, 2002; Sonuga-Barke, 2002). Therefore, the search for a single underlying deficit in ADHD leading to symptoms, be it at the cognitive, neural, or genetic level, is too restricted. Instead, studying various endophenotypes and looking at how each of these may contribute in a unique way to different symptom-clusters of ADHD will be a more promising approach for future research (Castellanos & Tannock, 2002; Sonuga-Barke, 2002; Solanto *et al.*, 2001).

In conclusion, we support Wilding's call for valid measures of attention in ADHD and his doubts about the fundamental role of sustained attention. However, we bring to mind that there is currently insufficient support for his alternative view – that executive dysfunction is the fundamental problem in ADHD.

Copyright © The British Psychological Society
Reproduction in any form (including the internet) is prohibited without prior permission from the Society

Acknowledgements

This research is supported by a fellowship from the Royal Netherlands Academy of Arts and Sciences to the first author.

References

Band, G. P. H., & Van Boxtel, G. J. M. (1999). Inhibitory motor control in stop paradigms: Review and reinterpretation of neural mechanisms. *Acta Psychologica*, *101*, 179–211.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65–94.

Castellanos, F. X., & Tannock, R. (2002). Neuroscience of attention-deficit/hyperactivity disorder: The search for endophenotypes. *Nature Reviews Neuroscience*, *3*(8), 617–628.

Castellanos, F. X., Sonuga-Barke, E. J. S., Scheres, A., Di Martino, A., Hyde, C., & Walters, J. R. (2005). Varieties of attention-deficit/hyperactivity disorder-related intra-individual variability. *Biological Psychiatry*, *57*(11), 1416–1423.

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent-variable analysis. *Journal of Experimental Psychology: General*, *133*, 101–135.

Geurts, H. M., Verte, S., Oosterlaan, J., Roeyers, H., & Sergeant, J. A. (2005). ADHD subtypes: Do they differ in their executive functioning profile? *Archives of Clinical Neuropsychology*, *20*(4), 457–477.

Lijffijt, M., Kenemans, J. L., Verbaten, M. N., & van Engeland, H. (2005). A meta-analytic review of stopping performance in attention-deficit/hyperactivity disorder: Deficient inhibitory motor control? *Journal of Abnormal Psychology*, *114*(2), 216–222.

Logan, G. D. (1994). On the ability to inhibit thought and action: A users' guide to the stop signal paradigm. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 189–239). San Diego: Academic Press.

MacLeod, C. M., Dodd, M. D., Sheard, E. D., Wilson, D. E., & Bibi, U. (2003). In opposition to inhibition. *Psychology of learning and motivation*, *43*, 163–214.

Manly, T., Anderson, V., Nimmo-Smith, I., Turner, A., Watson, P., & Robertson, H. (2001). The differential assessment of children's attention: The test of everyday attention for children (TEA-Ch), Normative sample and ADHD performance. *Journal of Child Psychology and Psychiatry*, *44*, 1065–1081.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex Frontal Lobe tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100.

Nigg, J. T. (2001). Is ADHD a disinhibitory disorder? *Psychological Bulletin*, *127*(5), 571–598.

Oosterlaan, J., Logan, G. D., & Sergeant, J. A. (1998). Response inhibition in AD/HD, CD, comorbid AD/HD + CD, anxious, and control children: A meta-analysis of studies with the stop task. *Journal of Child Psychology and Psychiatry*, *39*(3), 411–425.

Oosterlaan, J., Scheres, A., & Sergeant, J. A. (2005). Which executive functioning deficits are associated with AD/HD, ODD/CD and comorbid AD/HD + ODD/CD? *Journal of Abnormal Child Psychology*, *33*, 69–85.

Pennington, B., & Ozonoff, S. (1996). Executive functions and developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *37*, 51–87.

Quay, H. C. (1997). Inhibition and attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology*, *25*, 7–13.

Scheres, A., Oosterlaan, J., Geurts, H., Morein-Zamir, S., Meiran, N., Schut, H., Vlasveld, L., & Sergeant, J. A. (2004). Executive functioning in boys with ADHD: Primarily an inhibition deficit? *Archives of Clinical Neuropsychology*, *19*, 569–594.

Solanto, M. V., Abikoff, H., Sonuga-Barke, E., Schachar, R., Logan, G. D., Wigal, T., Hechtman, L., Hinshaw, S., & Turkel, E. (2001). The ecological validity of delay aversion and response

Copyright © The British Psychological Society
Reproduction in any form (including the internet) is prohibited without prior permission from the Society

inhibition as measures of impulsivity in AD/HD: A supplement to the NIMH multimodal treatment study of AD/HD. *Journal of Abnormal Child Psychology*, *29*(3), 215–228.

Sonuga-Barke, E. J. (2002). Psychological heterogeneity in AD/HD–a dual pathway model of behaviour and cognition. *Behavioural Brain Research*, *130*(1–2), 29–36.

Tipper, S. P. (1985). The negative priming effect: Inhibitory priming by ignored objects. *Quarterly Journal of Experimental Psychology*, *37A*, 571–590.

Van Mourik, R., Oosterlaan, J., & Sergeant, J. A. (2005). The stroop revisited: A meta-analysis of interference control in AD/HD. *Journal of Child Psychology and Psychiatry*, *46*(2), 150–165.

Wilding, J. (2005). Is attention impaired in ADHD? *British Journal of Developmental Psychology*, *23*(4), 487–505.