TOPICS
TOPICS IN COGNITIVE SCIENCE

Topics in Cognitive Science 3 (2011) 253–256

ISSN: 1756-8757 print / 1756-8765 online
DOI: 10.1111/j.1756-8765.2011.01137.x

The Other Side of Cognitive Control: Can a Lack of Cognitive Control Benefit Language and Cognition?

Evangelia G. Chrysikou,[a] Jared M. Novick,[b] John C. Trueswell,[a] Sharon L. Thompson-Schill[a]

[a]*Department of Psychology, University of Pennsylvania*
[b]*Center for Advanced Study of Language, University of Maryland*

Received 2 June 2010; received in revised form 24 September 2010; accepted 29 January 2011

Abstract

Cognitive control refers to the regulation of mental activity to support flexible cognition across different domains. Cragg and Nation (2010) propose that the development of cognitive control in children parallels the development of language abilities, particularly inner speech. We suggest that children's late development of cognitive control also mirrors their limited ability to revise misinterpretations of sentence meaning. Moreover, we argue that for certain tasks, a tradeoff between bottom-up (data-driven) and top-down (rule-based) thinking may actually benefit performance in both children and adults. Specifically, we propose that a *lack* of cognitive control may promote important aspects of cognitive development, like language acquisition and creativity.

Keywords: Cognitive control; Prefrontal cortex; Language comprehension; Language learning; Hypofrontality; Creativity; Cognitive flexibility

Cognitive control refers to the regulation of mental activity to guide and support flexible behavior across many domains, including attention, working memory, and language processing. The prefrontal cortex (PFC) has been associated with cognitive control functions that bias the selection of appropriate over inappropriate information during goal-directed tasks (Miller & Cohen, 2001).

The development of cognitive control in children parallels the maturation of PFC, which is among the last neuroanatomical regions to develop (Huttenlocher & Dabholkar, 1997; cf. Davidson, Amso, Cruess Anderson, & Diamond, 2006). Cragg and Nation (2010) propose that the developmental trajectory of cognitive control in children and young adults further coincides with the development of language abilities, particularly inner speech. They argue that inner speech, though not necessary for performance, can facilitate certain aspects of

Correspondence should be sent to Evangelia G. Chrysikou, Ph.D., Center for Cognitive Neuroscience, University of Pennsylvania, 3720 Walnut St., Philadelphia, PA 19104. E-mail: evangelg@psych.upenn.edu

cognitive flexibility. Specifically, an increase in the spontaneous use of inner verbal strategies during development may support aspects of top-down control in task-shifting, by selecting and maintaining task-relevant goals, remembering task order, or retrieving task-relevant information.

This interesting proposal for a developmental link between language development and cognitive control is reminiscent of another psycholinguistic account that emphasizes the importance of cognitive control for the processing and comprehension of language in real time (Novick, Trueswell, & Thompson-Schill, 2005). This account considers the incremental nature of language processing: As individuals perceive linguistic input, they assign interpretations ''on the fly'' with respect to accumulating syntactic and semantic evidence. Furthermore, as they provisionally commit to a particular sentence meaning, readers and listeners also anticipate what is likely to follow. However, a natural consequence of incremental parsing is temporary ambiguity; sometimes the interpretations individuals initially assign turn out wrong, as newer input provides evidence for an altogether different analysis. Readers and listeners must then override early processing commitments and recover a correct alternative. That is, the sudden detection of a misinterpretation triggers cognitive control processes to help resolve incompatible representations of sentence meaning, namely, the one assigned first and the one in need of recovery. Interestingly, 5-year-old children—compared to 8-year-olds and healthy adults—often fail to revise early parsing decisions, thus arriving at an incorrect interpretation (e.g., Trueswell, Sekerina, Hill, & Logrip, 1999). Young children's trouble overriding early interpretations may relate to their difficulty resolving interference during nonsyntactic cognitive control tasks like Go/No-Go (e.g., Durston et al., 2002; Mazuka, Jincho, & Oishi, 2009). Indeed, recent work illustrates a direct connection between children's cognitive control and language abilities. For example, performance on the Go/No-Go task predicts children's ability to inhibit contextually inappropriate meanings of ambiguous words (Khanna & Boland, 2010).

Children's broad inability to reverse automatic responses to stimuli might be rooted in the maturational lag of PFC regions hypothesized to support shared cognitive control functions. Interestingly, patients with damage to these very regions show a striking resemblance to 5-year-olds in their inability to override early parsing commitments. Moreover, this failure is related to the exaggerated effects of interference they show on general cognitive control measures (Novick, Kan, Trueswell, & Thompson-Schill, 2009).

Given the importance of cognitive flexibility for performing numerous tasks, it might be initially surprising that humans are not born with fully developed cognitive control abilities. Why is the ontogenetic development of cognitive control—from childhood to early adulthood—so slow? We propose that there might be some basic adaptive function to this protracted development. Particularly, we speculate that the lack of cognitive control during development may, in fact, support language *learning* (as opposed to performance, as sketched above), as well as other aspects of cognition like creative thought (see Thompson-Schill, Ramscar, & Chrysikou, 2009). Indeed, there might be a tradeoff between bottom-up (data-driven) and top-down (rule-based) thinking in development. For instance, during language acquisition, children's underdeveloped cognitive flexibility may allow them to master linguistic conventions (e.g., irregular plurals; *mouse* → *mice*) by absorbing the most frequent patterns they hear instead of deliberating about probabilistic rules (*mouse* → *mouses*), which is characteristic of top-down-guided adult learning (see Ramscar & Yarlett, 2007). That is, children's *lack* of cognitive flexibility may promote certain facets of cognitive development like convention learning.

Although most aspects of human performance benefit from top-down influences on information processing, there may be notable exceptions in the domain of creative (or unconventional) behavior. For example, German and Defeyter (2000) have shown that children younger than 5 years old appear immune to functional fixedness during problem solving. When asked to retrieve a toy from a high shelf, young children escaped from the demonstrated use of a box (as a container for smaller items) and used it as a platform to reach the toy and accomplish the goal. In contrast, older children were more likely to follow the ''rule'' regarding the box's conventional use, thus failing to solve the problem.

Consistent with this, a recent fMRI study suggests that healthy adults may benefit from a tradeoff between perceptually based and rule-based thought for optimal performance during creative thought. When generating creative uses for common objects (e.g., using a shoe as a hammer), participants exhibited lower PFC activity, reflecting reduced cognitive control, and increased activity in perceptual (object processing) regions, compared to participants who generated typical uses for the objects (Chrysikou & Thompson-Schill, in press). Thus, under demands of an open-ended, creative thinking task, healthy adults sometimes benefit from a state of lower cognitive control.

Overall, although immature cognitive control can hinder performance on various tasks, we interpret the above evidence as indicating that a *lack* of cognitive control may benefit certain aspects of cognitive development, like language acquisition and creativity. Though more experimental evidence is necessary to support this proposal, emerging findings suggest that under certain circumstances, a tradeoff between bottom-up (data-driven) and top-down (rule-based) thinking can benefit performance in both children and adults.

Finally, the above findings could further indicate that cognitive control processes might be the result of dissociable component subsystems, each supported by different brain regions. For example, recent research studying healthy adults and patients with neurological diseases shows that cognitive flexibility depends on the independent and dissociable contributions of both cortical (e.g., PFC) and subcortical (e.g., basal ganglia) systems (e.g., Leber, Turk-Browne, & Chun, 2008). Although behavioral and neuroimaging findings suggest domain-general mechanisms in PFC that support regulatory functions under a variety of circumstances (Thompson-Schill, Bedny, & Goldberg, 2005), complex tradeoffs between PFC and subcortical regions modulate performance across different cognitive control tasks (e.g., Cools, Sheridan, Jacobs, & D'Esposito, 2007). Differences in the development of these regions may therefore be associated with differences in learning versus cognitive control performance during development. Future research should explore relationships between the development of specific brain regions, inner speech (Cragg & Nation, 2010), and cognitive control.

References

Chrysikou, E. G., & Thompson-Schill, S. L. (in press). Dissociable brain states linked to common and creative object use. *Human Brain Mapping*, *32*.

Cools, R., Sheridan, M., Jacobs, E. J., & D'Esposito, M. D. (2007). Impulsive personality predicts dopamine-dependent changes in fronto-striatal activity during component processes of working memory. *Journal of Neuroscience*, *27*, 5506–5514.

Cragg, N., & Nation, K. (2010). Language and the development of cognitive control. *Topics in Cognitive Science*, *2*, 631–642.

Davidson, M. C., Amso, D., Cruess Anderson, L., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*, 2037–2078.

Durston, S., Thomas, K. M., Yang, Y., Uluğ, A. M., Zimmerman, R. D., & Casey, B. J. (2002). A neural basis for the development of inhibitory control. *Developmental Science*, *5*, F9–F16.

German, T. P., & Defeyter, M. A. (2000). Immunity to functional fixedness in young children. *Psychonomic Bulletin & Review*, *7*, 707–712.

Huttenlocher, P. R., & Dabholkar, A. S. (1997). Regional differences in synaptogenesis in human cerebral cortex. *Journal of Comparative Neurology*, *387*, 167–178.

Khanna, M. M., & Boland, J. E. (2010). Children's use of language context in lexical ambiguity resolution. *The Quarterly Journal of Experimental Psychology*, *63*, 1.

Leber, A. B., Turk-Browne, N. B., & Chun, M. M. (2008). Neural predictors of moment-to- moment fluctuations in cognitive flexibility. *Proceedings of the National Academy of Sciences*, *105*, 13592–13597.

Mazuka, R., Jincho, N., & Oishi, H. (2009). Development of executive control and language processing. *Language and Linguistics Compass*, *3*, 59–89.

Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, *24*, 167–202.

Novick, J. M., Kan, I. P., Trueswell, J. C., & Thompson-Schill, S. L. (2009). A case for conflict across multiple domains: Memory and language impairments following damage to ventrolateral prefrontal cortex. *Cognitive Neuropsychology*, *26*, 527–567.

Novick, J. M., Trueswell, J. C., & Thompson-Schill, S. L. (2005). Cognitive control and parsing: Reexamining the role of Broca's area in sentence comprehension. *Cognitive, Affective, & Behavioral Neuroscience*, *5*, 263–281.

Ramscar, M., & Yarlett, D. (2007). Linguistic self-correction in the absence of feedback: A new approach to the logical problem of language acquisition. *Cognitive Science*, *31*, 927–960.

Thompson-Schill, S. L., Bedny, M., & Goldberg, R. F. (2005). The frontal lobes and the regulation of mental activity. *Current Opinion in Neurobiology*, *15*, 219–224.

Thompson-Schill, S. L., Ramscar, M., & Chrysikou, E. G. (2009). Cognition without control: When a little frontal lobe goes a long way. *Current Directions in Psychological Science*, *18*, 259–263.

Trueswell, J. C., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition*, *73*, 89–134.