Acta Psychologica 115 (2004) 99–104

acta psychologica

www.elsevier.com/locate/actpsy

Editorial

Exorcizing the homunculus, phase two: editors' introduction

PsycINFO classification: 2300; 2500; 2800; 3200
Keywords: Executive functions; Frontal lobe; Action control

Research on executive functions aims at providing insightful answers to a seemingly simple yet fundamental question: How can we do what we want? Or, in other words, how can we make our body do the things our mind would like to happen? This question is of course older than academic psychology—not least because of its profound philosophical implications—and it falls into two subquestions that both have to with cognitive control: (a) What is controlled how and (b) who does the controlling?

Few authors have addressed the first, *what* question and the *how* question it implies as clearly as early ideomotor theorists like Lotze (1852), Harless (1861), and James (1890). How is it, so they asked, that you cannot only will to raise your arm or to get out of your bed (a question that seemed particularly interesting for James) but actually get the relevant limbs moving? The answer they provide (for a broader overview, see Prinz, 1987) makes use of the idea of a "mental cue": If you have established some association between a mental state of yours, such as the anticipation or image of a state of affairs (e.g., you out of the bed), and of the motor activities necessary to bring that state of affairs into being, you can use the former as a cue to activate and actually control the latter: mind can control body. According to this consideration, studying what sorts of mental cues people acquire and use to control their behavior, and how they do so, should increase our insights into the inner workings of cognitive control in particular and of the relationship between mind and body in general.

Most papers of this special issue address, in one way or another, the issue of how mental cues are acquired and/or used to exert cognitive control. Gruber and Goschke provide an overview of how the interplay between working memory, attentional systems, and language may translate our intentions into action. The role of language and inner speech is a particularly recent theme in executive research—a kind of Wygotskian renaissance. This role was further investigated by Miyake and Emerson in adults and by Kray, Eber, and Lindenberger in children, adults, and elderly people. Miyake

doi:10.1016/j.actpsy.2003.12.002

and Emerson show that articulatory suppression strongly impairs randomly switching from one task to another if the switch is signaled by a letter but not if it is signaled by a word. This suggests that word cues directly activate the task they are associated with whereas more arbitrary cues require active verbal mediation. Likewise, Kray et al. report beneficial effects of task-compatible verbal cues and interference from incompatible cues. Interestingly, the benefits are most pronounced in children, where the internal use of verbal cues is arguably still developing. In contrast, interference and distraction from incompatible cues are strongest in older people. As this was the case even under single-task conditions, it seems likely that elderly people have increasing problems to differentiate among potentially relevant task contents.

An inverted U-shaped age function related to cognitive control capacities was also obtained by Zelazo, Craik, and Booth, who found more perseverative errors after a rule change in a sorting task in children and elderly people than in young adults. However, by using the process-dissociation technique, Zelazo and colleagues demonstrate that this only holds for conscious contributions to performance, whereas estimates of unconscious, automatic influences were constant across the three age groups tested. This may indicate that both children and older adults have difficulty efficiently formulating hierarchical representations of task rules on the fly, accessing the appropriate levels of these representation, and maintaining the representations in working memory. Considering that inner speech is a conscious activity and that language is particularly suited to construct hierarchical representations (Zelazo, 1999), these conclusions fit nicely with the idea that language plays a central role in cognitive control: People seem to exert control over their actions by speaking to themselves, in a sense, by telling their own body what to do. If so, the efficiency of executive functions is likely to be strongly correlated with the level of one's verbal abilities and skills, which again opens new and interesting perspectives on the interpretation of trends in the development of action control and of the relationship between cognitive control and intelligence (Duncan, Emslie, Williams, Johnson, & Freer, 1996).

The important role of language and inner speech in the control of human action suggests a particularly tight association between verbal codes and the corresponding action plans, so that activating the verbal code spreads to the motor patterns it refers to. But action plans can also be addressed via other, nonverbal codes, as shown by Eenshuistra, Weidema, and Hommel. Their developmental study suggests that actions become more or less automatically associated with any temporally overlapping event, such as a meaningless sound pattern, which then can serve as a mental cue to activate that action. However, the ability to make efficient use of such action-cue associations seems to be still developing between 4 and 7 years of age. Considerable developmental changes are also the topic of the contribution from Zelazo, Craik, and Booth.

Acquiring reliable links between actions and their mental cues opens up a wealth of possibilities for both the individual and his or her social environment: People can now learn by observation, control each others action through verbal instruction, direct each others attention, and more. Even self-automatization is possible by establishing connections between a cue of a particular action and an anticipated environmental event: If one is prepared to "leave the train" (the verbal cue for an action pattern) whenever a particular station comes into sight (a perceptual cue), seeing the station is likely to make one move without even thinking (cf., Bargh & Gollwitzer, 1994). How automatic such stimulus-induced effects are is the topic of the study by Hübner, Kluwe, Luna-Rodriguez, and Peters. They analyzed whether effects of stimulus-induced response competition vary with the currently implemented task set, and they come to a surprising, negative conclusion: The degree to which a given stimulus activates an arbitrary, task-specific response does not depend on the degree to which this task is currently prepared and expected. Binding actions to stimuli apparently leads to considerable externalization of action control.

In addition to Goschke and Gruber, the remaining papers focus more on the second issue of cognitive control and ask where control comes from. This *who* question has been largely neglected or explained away for many decades (Monsell & Driver, 2000). For introspectively working theorists like Lotze, Harless, and James, the analysis of the source of behavioral control posed a particular challenge and it seems fair to say that they did not get very far. The common strategy was to attribute executive control to *the will*, a not further specified instance that was introduced as metaphysically given; e.g., James writes that "desire, wish, will, are states of mind which everyone knows, and which no definition can make plainer" (1890, p. 486). However, until very recently modern theories of executive functioning were not much more specific—just think of Baddeley and Hitch's (1974) Central Executive or Norman and Shallice's (1980) Attentional Supervisory System, which basically served as mere placeholders for what we still fail to understand (Baddeley, 1986). In fact, the outdated term of the "will" was often simply traded for a less suspicious term taken from systems theory, such as "controller" or "executive", but how the underlying system works remained a mystery (Monsell, 1996).

The recent years have seen radical changes in both research strategies and theoretical accounts of executive control. With regard to research, the bygone decade of the brain was very successful in stimulating increasingly tight contacts between previously separated fields of research on control issues, such as behavioral investigations of working memory performance and task coordination, clinical case studies, research on cognitive development and aging, and brain imaging studies of healthy subjects and patient populations. This brought with it a rapid expansion of the methodological toolbox available for investigating cognitive control, including tasks, measures, models, and machines. Theoretically, the "homunculitis" bemoaned by Monsell and Driver (2000) is in the process of giving way to a more distributed view that conceives of control as emerging from multiple internal and external constraints (cf., contributions to Hommel, Ridderinkhof, & Theeuwes, 2002; Mayr, Spieler, & Kliegl, 2001). In contrast to the traditional unitary executive function view, recent approaches have emphasized its multifaceted nature and a complex interplay between a range of subcomponents, although there is as yet no consensus on a taxonomy (e.g., Smith & Jonides, 1999). Hence, research on executive control has entered phase two.

As Goschke's and Gruber's overview emphasizes, numerous functional systems and brain areas are involved in cognitive control—human will is a team player. As has been known for decades, important contributions come from areas residing in the frontal lobe, the prefrontal cortex in particular. Prefrontal function does, however, evolve in a complex interplay with a number of other systems, including the parietal lobe and, as emphasized by Heyder, Suchan, and Daum, subcortical systems. Heyder et al. provide an overview of neuropsychological findings that suggest a critical role of networks interfacing the prefrontal cortex, the basal ganglia, and the cerebellum via the thalamus. The critical issue relates to the question as to whether executive control is diffusely organized in fronto-subcortical networks leading to comparable impairments after damage to different network components or whether different components make a distinct contribution to executive control, leading to dissociable impairments.

How prefrontal contributions can be characterized functionally is addressed by Channon, who discusses cognitive and behavioral deficits in patients with frontal lesions and with neurodevelopmental disorders, such as Tourette's and Asperger's syndrome. Of particular interest, Channon considers the impact of frontal deficits on everyday problem-solving, which apart from cognitive-executive functioning includes social and emotional processes. Executive deficits in schizophrenic patients are the topic of Reuter and Kathmann's paper. They discuss how the analysis of unwanted saccadic movements can serve to tap into the mechanisms involved in the dysexecutive syndrome associated with schizophrenia. However, instead of the common interpretation of such effects in terms of inhibition failures, Reuter and Kathmann suggest that unwanted actions reflect the difficulty of schizophrenics to activate and maintain goal representations in prefrontal working memory.

Taken together, the contributions to this special issue converge on two central conclusions. The first relates to the what/how question of cognitive control. Task sets and the modules they comprise seem to be accessed via retrieval cues (e.g., Mayr & Kliegl, 2000), which include but are not confined to verbal labels. These cues can be activated endogeneously, as with a purely spontaneous action, or exogeneously, as with a preplanned, stimulus-linked action. Although not an issue in most of the present papers, more sources of cue-mediated task-set activation are conceivable, just think of emotional markers (Damasio, Tranel, & Damasio, 1991) or contextual cues that may affect the activation level of a task set. In other words, the activation of task sets may be multiply determined, and it may often be difficult to decide how "willed" a given activation and its impact on performance really was. The second conclusion relates to the who question of cognitive control. In line with recent developments in research and theorizing, the present papers provide strong evidence for a distributed view: many system (both functionally and anatomically defined) contribute to the executive control of human behavior. On the one hand, this complicates matters a lot, as apparently simple tasks and phenomena fall into a whole multitude of separable effects pointing at a whole number of processes subserving different functions—just think of the rapidly expanding field of task-switching research. Nailing down how all these processes work in detail takes time and effort, and often makes it difficult to relate it back to the main question of how intentional action is possible. Worse, most if not all of these processes may turn out to be disappointingly common and it may only be their concert that creates the emergent property of being "executive". On the other hand, however, cutting human performance into pieces that are simple enough for us to understand seems to be the only way to get rid of the homunculi still hiding behind our theories.

The papers making up this special issue on executive functions were authored by participants of a symposium on the same topic that was held in Leipzig, Germany, in November 2002, and funded by the Deutsche Forschungsgemeinschaft (DFG). This meeting took place in the broader framework of the also DFG-funded *Priority Program on Executive Functions* (cf., http://www.leidenuniv.nl/fsw/sppef/), in which many of the authors participate as members or collaborators.

Acknowledgements

The preparation of this special issue was supported by a grant of Deutsche Forschungsgemeinschaft, Priority Program on Executive Functions (SPP 1107).

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