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Scanning texts and orthographic proofreading as a measure for cognitive control?

A perspective on cognitive control in cognitive writing models

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Abstract:
Many cognitive models of the (academic) writing process integrate components of cognitive control, a concept which has mainly been scrutinized through psychological laboratory experiments. The question arises whether results obtained from such experiments are validly transferable to such models (i.e. if they are ecologically valid). In this perspective paper, I highlight similarities and differences between 1. tasks used to measure components of cognitive control (Stroop Word Colour (Switching) Task) and 2. activities that form part of the (academic) writing process (proofreading for orthographic errors and scanning a text for a keyword). Drawing from this comparison, I subsequently argue 1. for the ecological validity of the Stroop Word Colour (Switching) Task with respect to these activities and 2. encourage a stronger consideration of the ecological validity of experiments measuring components of cognitive control to better understand their relationship with activities relevant for the (academic) writing process. A better understanding of this relationship could further lead to the development of strategies to overcome difficulties in (academic) writing related to cognitive control.

Keywords: cognitive control, academic writing, writing, proofreading, selective search, inhibition, task switching

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Introduction

Cognitive control is understood as a broad concept which encompasses cognitive, affective, motivational and biological mechanisms underlying the regulation of goal-directed and habitual behaviour (for an overview see Kropotov, 2016). Although the further differentiation of cognitive control into its components is debated, work from Miyake and colleagues (2000) and a later elaboration by Friedman and Miyake (2004) resulted in distinguishing between 1. updating and monitoring information in working memory, 2. inhibiting prepotent responses (response inhibition), inhibiting interference through processing irrelevant information (interference inhibition), resistance to distractor interference and 3. shifting attention between different tasks (task switching) (but see Friedman & Miyake, 2017; Miyake & Friedman, 2012). These components of cognitive control – updating, inhibiting and switching – are crucial for higher order executive functions such as planning, reasoning and problem-solving (Diamond, 2013; Koole et al., 2023; Kuhl, 1984).

Although the concept of cognitive control, as it is defined here, has been extensively scrutinized in the fields of cognitive psychology and neuroscience (Cohen, 2017), it has also received considerable attention in the field of literacy studies. In their original model, Hayes and Flower (1980) elaborate on the process of cognitively controlling task-irrelevant thoughts when planning a writing project by "breaking associative chain[s] when [an] item is retrieved that is not useful for the task" (Hayes & Flower, 1980, p. 13). This 'breaking of associative chains' implies self-monitoring and regulating thoughts for the sake of fulfilling a goal or task. Further, in the process of reviewing the text written, the authors refer to maintaining focus on a specific goal while temporally ignoring another; the text written so far is read "[…] either as a springboard to further translating or with an eye to systematically evaluating and/or revising the text." (Flower & Hayes, 1981, p. 374).

Instead of implicitly considering components of cognitive control, in Hayes' most recent model (Hayes & Berninger, 2014), working memory and attention are explicitly included as components of cognitive control. However, these terms remain rather broadly defined. Graham (2018, 2021) proposed a more extensive model by elaborating on different aspects of working memory and attention as components of cognitive control. By giving examples of how components of cognitive control may relate to specific tasks in the writing process, he argues for the pertinence of components of cognitive control in writing tasks, but he does so without considering the degree of their empirical transferability (i.e. their ecological validity). Empirical transferability of tasks measuring components of cognitive control (e.g. interference inhibition) to tasks relevant for the (academic) writing process (e.g. proofreading) is especially important in the realm of cognitive control, because tasks once believed to measure the same components of cognitive control seem to have relatively weak correlations with one another i.e. they do not seem to measure the exact same thing (Gärtner & Strobel, 2021; Miyake et al., 2000; Shilling et al., 2002). Therefore, considering the exact operationalization of tasks measuring components of cognitive control when comparing them to tasks relevant for the (academic) writing process, may lead to more valid comparisons.

In his model, Graham (2018, 2021) focuses more strongly on integrating higher order executive functions, such as planning, reasoning and problem-solving, into the (academic) writing process instead of directly focusing on underlying components of cognitive control (see also Graham, 2006). This approach impedes making elaborate claims about which components of cognitive control are relevant for which activities in the (academic) writing process, because they are being considered indirectly. To make such claims, an examination of components of cognitive control underlying those higher executive functions in the context of (academic) writing activities would be necessary.

A more direct assessment of components of cognitive control could be achieved by identifying similarities and dissimilarities between tasks used to measure components of cognitive control and tasks of the (academic) writing process. Such similarities would suggest that similar latent variables (components of cognitive control) underlie the execution of both tasks i.e. they demand similar cognitive abilities. By clarifying the degree of transferability of findings of components of cognitive control to abilities relevant for the (academic) writing process, more light could be shed on the role of components of cognitive control in (academic) writing.

From this perspective, I will point out conceptual similarities between selected components of cognitive control (interference inhibition and task shifting) and how they are operationalized (Stroop Word Colour (Shifting) Task) with activities occurring in the (academic) writing process (proofreading a text written and scanning a text for keywords). I chose to focus on the components named, because they are being assessed via the Stroop Word Colour (Switching) Task (from now on SWCT and SWCST respectively), which, as I will argue, are comparable to the mentioned activities occurring in the (academic) writing process. Because the theoretical arguments made in this paper are empirical testable, I encourage conducting research comparing more and less ecologically valid tasks measuring components of cognitive control regarding their explanatory power of activities which are relevant for the (academic) writing process. Both fields of research could profit from such interdisciplinary work, with possible consequences being new pedagogic applications for the (academic) writing process, which in turn could shed new light on the underlying components of cognitive control.

Interference inhibition

Inhibiting interference through processing irrelevant information is commonly measured by tasks in which two stimuli are simultaneously presented, whereby one is relevant, the other disruptive for task fulfilment. To fulfil the task, one needs to react to the relevant stimulus while neglecting the disruptive stimulus. The two stimuli are therefore conflicting, because they are competing for attention.

To swiftly and correctly react to the relevant stimulus and not to the disruptive one, focusing on former while neglecting latter is necessary (Gratton et al., 2018).

A widely used example of such a task is the SWCT (but see Friedman and Miyake (2004), who argue that the task rather measures response inhibition) . While the task exists in some variation (e. g. in Penner & Calabrese, 2012 or Shilling et al., 2002), the scheme underlying all word colour tasks remains the same and will be presented here. The conflicting stimuli presented are 1. a written word symbolizing a colour (e.g. “blue”) and 2. the font colour of the word (which differs from the colour symbolized by the word). Latter stimulus is the relevant one that needs to be reacted to, former the disruptive one that needs to be neglected. The reaction to the font colour is usually a key press (e.g. the key “G” if the font is green, “R” if red and “B” if blue), thus a motor reaction. The words written represent the same colours as represented by the font colour (“green”, “red” and “blue”), although they do not have to overlap. The challenge for the participants therefore is to neglect the word meaning (semantic properties) while focusing on a specific visual property (font colour), in order to perform the correct motor action (key press).

Although this procedure is not seamlessly transferable, there seem to be similarities to scanning a text for information when reviewing literature, e.g. when searching for a specific keyword (e.g. “cognition”) in a text. While doing this, the goal is to only perform the action of reading the word, sentence or paragraph (motor action) in response to the occurrence of a specific visual stimulus or stimuli (e. g. the word “cognition”, an assembly of letters such as “cog…”, the initial letter “c”). While scanning a text for a specific keyword, the focus lies more strongly on its visual properties (e.g. constellation of letters, initial letter, number of letters) rather than on its semantic properties (Dampuré & Vibert, 2014; Vibert et al., 2019, 2023; Wang & White, 2019). Likewise, when running the SWCT, a motor reaction (key press) follows a stronger focus on and subsequent registration of a visual stimulus of a word (font colour) at the cost of neglecting the words’ meaning (semantic properties).

A similar procedure can be recognized when proofreading a text for orthographic errors. Although empirically less well secured, it seems that a weaker focus on word meaning through explicit instructions or forced interruption of the natural reading flow, improves spelling error recognition by shifting the focus from meaning to visual characteristics of the word (Bean & Bouffler, 1987; Larigauderie et al., 2020; Porte, 2001). To once again point out procedural parallels with the SWCT, proofreading seems more efficient with an increased focus on visual characteristics of a word (e.g. letter constellation, type of letters) at the cost of neglecting word meaning (semantic properties) to subsequently enable error correction (motor action) .

Task switching

In task-switching tasks the ability to flexibly switch between tasks is assessed. Although there exist different setups, one variant consists of presenting a specific stimulus that a participant reacts to under changing circumstances. More precisely, while the reaction (e. g. pressing certain keys) remains the same throughout the task, the conditions under which the reaction is supposed to be executed differ (for a review of setups see Kiesel et al., 2010; Vandierendonck et al., 2010).

This task has been applied by using the already discussed stimuli of the SWCT. For this, words representing different colours (e. g. “red”, “green” and “blue”) written in font colours not matching the colour they are representing (e. g. “red” written in blue font) are being displayed. The task consists of alternately naming the colour represented by the current word and the colour of the words’ font (Allport et al., 1994; Wylie & Allport, 2000; for different setups see Monsell et al., 2000).

Alternating between focusing on the meaning of a word (the colour it is representing) and its specific visual properties (the font colour) to subsequently react to it adequately (naming the colour of the respective characteristic) seems to have similarities with approaches to reviewing a text. Text review can encompass considering the content of the text written and considering orthographic rules (Dengscherz, 2019; Dockrell & Connelly, 2021). These two different reviewing approaches necessarily draw on information from different stimuli. When reviewing the content of a sentence or chapter, word meaning seems to be crucial while visual characteristics of a written word appear to be neglectable (given that the word is decodable). For an orthographic review of a text, it seems to be the other way around (Bean & Bouffler, 1987; Larigauderie et al., 2020; Porte, 2001), although, as noted before, I admit that there can be exceptions.

Furthermore, there seem to be similarities between SWCST and the activity of scanning a text for keywords to subsequently read it. As already examined above, when searching for a specific word in a text, paying attention to the words’ visual features rather than to its meaning, seems to be the strategy intuitive to humans (given that the word and its visual features are known) (Dampuré & Vibert, 2014; Vibert et al., 2019, 2023). In the context of (academic) writing, scanning a text for specific key words, especially during literature research, in order to identify relevant passages of the text at hand is a common practice. This procedure implies a task switch in transition from scanning a text for a keyword to reading the relevant passage in which it is embedded. Similarly, in the SWCST, it is necessary to flexibly switch between focusing on visual properties of a word (colour) and its meaning to subsequently set the right motor action for task fulfilment (keypress).

Ecological Validity of experiments

There is evidence that task switching tasks using verbal stimuli (such as the SWCST) measure different abilities when compared to tasks not using verbal stimuli (e.g. numbers or pictures) (Cartwright, Lee, et al., 2020; Cartwright, Marshall, et al., 2020). More precisely, the skill of reading comprehension was shown to be more accurately predicted by verbal task-switching tasks throughout different age groups (Cartwright, Lee, et al., 2020; Cartwright, Marshall, et al., 2020). Additionally, training task switching with verbal stimuli in children improved reading comprehension significantly while training with non-verbal stimuli did not (Cartwright, 2002).

Similar evidence has been found for tasks measuring cognitive components of working memory: Tasks using verbal stimuli to measure working memory span better predicted reading comprehension compared to tasks using spatial or numeric stimuli (Shah et al., 1996).

Further, the ability to decode written words seems to be predicted by working memory tasks using verbal stimuli (Arrington et al., 2014; Christopher et al., 2012) whereas this was not the case for working memory tasks using non-verbal stimuli (Kieffer et al., 2013).

Regarding interference inhibition, there does not seem to exist such an effect on reading comprehension (Borella et al., 2010; Nouwens et al., 2021) or different syntactic abilities (Kaushanskaya et al., 2017). However, a relatively recent study suggests that verbal interference inhibition tasks are better predictors of reading comprehension in individuals diagnosed with ADHD than non-verbal tasks (Avramovich & Yeari, 2023). Although the findings of this study still need to be replicated, it suggests that, under specific circumstances, interference inhibition tasks using verbal stimuli are better suited to assess reading related abilities such as reading comprehension.

Although these studies do not refer to the relevance of components of cognitive control for activities involved in the (academic) writing process such as proofreading for orthographic errors or scanning for keywords (they rather refer to the ability of semantically understanding a text), they suggest that tasks measuring components of cognitive control are better applicable to some abilities involved in text processing if verbal stimuli are being used. Without treating tests measuring e.g. reading comprehension and the activities of proofreading and scanning (as described above) as interchangeable, I interpret the increased accuracy in predicting reading comprehension by components of cognitive control as an increase in ecological validity of tasks measuring them, which may also be the case for other text related activities such as proofreading and scanning. In other words, if using verbal stimuli increases ecological validity of tasks measuring components of cognitive control for specific text related abilities, leading to more accurate predictions than tasks using non-verbal stimuli, then using verbal stimuli for such tasks to assess other text related abilities may also lead to more accurate predictions.

Therefore, I argue to more strongly consider the exact setup of tasks measuring components of cognitive control when referring to them as abilities relevant for activities in the (academic) writing process. This is important, because using more ecologically valid tasks leads to more accurate predictions in general and potentially to a better understanding of the role of components of cognitive control in the (academic) writing process in particular.

Conclusion

In prominent cognitive models of (academic) writing, components of cognitive control are being integrated without considering the ecological validity of the experiments they were assed with (Hayes & Berninger, 2014; Graham, 2018, 2021). Further, it is argued for the relevance of components of cognitive control in the (academic) writing process by referring to studies measuring the influence of higher order executive functions, such as planning, reasoning and problem-solving, on skills related to writing (Graham, 2018, 2021; Jacob & Parkinson, 2015). To enrich these approaches, I propose a different perspective aiming at a more direct comparison of components of cognitive control and abilities relevant for the (academic) writing process.

By pointing out similarities between tasks (SWC(S)T) measuring components of cognitive control (interference inhibition and task switching) and activities of the (academic) writing process (scanning a text for keywords and proofreading for orthographic errors), I offer a perspective focusing on the degree of transferability between the two. This is important, because, more generally, the transferability of results obtained in a specific context to another context should be theoretically and empirically justified. The SWC(S)T task resembles proofreading for orthographic errors and scanning a text for keywords because of two critical reasons: 1. The stimuli are all words and 2. a shift in focus from word meaning towards visual properties of the text is relevant for task fulfilment.

Besides the similarities mentioned, there are dissimilarities hampering a direct comparison of the SWC(S)T and scanning or proofreading a text. The goal of the SWC(S)T task to focus on visual properties instead of word meaning is imposed on a participant by an experimenter, while it seems to be an intuitive choice to do so when scanning a text for keywords or proofreading for orthographic errors (Bean & Bouffler, 1987; Dampuré & Vibert, 2014; Larigauderie et al., 2020; Porte, 2001; Vibert et al., 2019, 2023). It should be considered that this difference could restrain the comparability of these tasks, because for the execution of "intuitive" behaviour it might not be necessary to suppress irrelevant stimuli during its execution in a manner comparable to a rather new, unusual behaviour as required by the SWC(S)T. Furthermore, it remains debatable whether specific reactions displayed in the different tasks are comparable, e.g. if naming the colour symbolized by the word in the SWCST is comparable to the reaction of reading when having found the keyword looked for in a text. Such differences should be considered, because different response types in the SWC(S)T are associated with different intensities of interference (Penner & Calabrese, 2012; Kinoshita et al., 2017).

However, tasks measuring components of cognitive control using verbal stimuli (such as the SWC(S)T) seem to better predict reading-related abilities compared to tasks using non-verbal stimuli (such as numbers or pictures). This supports the view that tasks that are more similar to real-life (academic) writing situations (such as the SWC(S)T for the activities discussed) are more accurate in assessing components of cognitive control in such (academic) writing abilities. Albeit evidence supporting this view still needs to be gathered. To further clarify the relationship between cognitive control and abilities relevant for the (academic) writing process, I argue for considering the ecological validity of tasks measuring components of cognitive control, when transferring knowledge about such components to abilities relevant for the (academic) writing process.

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