Back in control : the episodic retrieval of executive control

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CHAPTER 2: THE CONTROL OF EVENT-FILE RETRIEVAL

Single co-occurrences of stimulus events and actions are integrated and encoded into episodic "event files". If later presented with one or more of the constituent features of such a file, the other previously bound features are retrieved, which creates conflict if these do not match the current episode (partial-repetition costs). Partial-repetition costs depend on the task relevance of the repeated features: task-relevant features create higher costs, suggesting that the handling of event files is under contextual control. To disentangle whether control affects the creation or the retrieval of event files, we employed a task that prevented the control of creating stimulus-response bindings. Participants were precued to carry out a manual response to the onset of two irrelevant words, before categorizing one of two words (the target) by means of a manual binary choice response while ignoring the other word (the foil). Repeating the target word interacted with response repetition, showing the standard partial-repetition cost, while repeating the foil had no effect. This does not necessarily rule out that event-file creation is under contextual control, but it demonstrates that event-file retrieval is.

Introduction

Just like that of other primates, the human brain is highly modular and processes the different features of an event, and of the action it possibly requires, in various cortical areas. Though this division of labour lends many useful qualities to the brain, it also raises the question how all the processes devoted to coding a given event are coordinated. Impressed by the considerable number of visual areas, researchers assume that visual features belonging to a given event are somehow bound into what Kahneman, Treisman, and Gibbs (1992) have called an object file. Research on feature integration has indeed provided evidence that the features of an object are spontaneously bound, so that repeating one of these features is particularly beneficial for performance if the other features also repeated (for an overview, see Hommel, 2004).

Modularity and parallel processing is not restricted to the visual system, suggesting that binding processes cross borders between sensory modalities and perception and action. Indeed, if participants carry out two actions in a row (R1 and R2) in response to two stimuli (S1 and S2), stimulus repetition effects and response repetition effects interact: performance is better if either both stimulus and response are repeated or if they both change than if the stimulus is repeated and the response alternates or vice versa (Hommel, 1998). In other words, there are *partial-repetition costs* (as compared to complete repetitions or alternations), suggesting that a single co-occurrence of a stimulus and a response is sufficient to integrate the two into a kind of event file (Hommel, 1998, 2004). This file is retrieved automatically if it matches at least one feature of the present stimulus or response, which creates conflict if this entails the retrieval of a stimulus or response feature code that is actually not present or necessary. For instance, having carried out a left-hand response to the letter X leaves behind a trace connecting that letter with that response; processing the same letter and/or the same response a second later retrieves this trace, which creates conflict if either another response is required more the present letter is different from X.

Further research has revealed that stimulus-response binding is not comprehensive, in the sense that a whole object is bound to an action, but feature based. For instance, if people attend to shape information, they show strong evidence of shape-response binding but not of color-response binding; if they attend to color information, this pattern reverses to show strong color-response binding (e.g., Hommel, 1998). This means that feature binding is spontaneous, in the sense that it takes place even in tasks that do not require the integration of features, but controlled through the current attentional set to particular feature dimensions. The main question of the present study was which aspect of the handling of event files is being controlled. On the one hand, it may be that the creation of bindings is under attentional control. Features from dimensions that are task relevant may be primed or selected for integration, and thus be more likely to enter the object or event files being created. On the other hand, it may be that the retrieval of bindings is under attentional control. The creation of bindings may (or may not) be entirely nonselective, but bindings that include task-relevance features may be more likely to be retrieved when a stimulus and/or a response related to the given binding is encountered (cf., Logan, Taylor & Etherton, 1996). The standard paradigms to investigate repetition effects and their interactions are not suitable for distinguishing between these two possibilities: A binding effect can only be present if a given binding was both created and retrieved, and its absence does not tell us anything about which of the two preconditions failed to operate.

The present study was designed to overcome this limitation and to modify the standard paradigms accordingly (see Fig. 1). S1, the prime display, consisted of two words, both being nominally irrelevant to the task but taken from the same pool as the relevant words presented on S2. As in the standard paradigm (e.g., Hommel, 1998), participants were cued to prepare a left or right keypressing response (R1) that was to be carried out as soon as S1 was presented. That is, the content of S1 was entirely uninformative but its presence had to be noticed to trigger the prepared R1. A second later, S2 appeared, again two different words. One word was underlined, indicating that this word was to be categorized as referring to an animate or a non-animate object (requiring a left vs. right keypressing response). This set up required the selection of a target word from the S2 display, which appeared at a position that was not known when S1 was presented. Accordingly, control processes could affect S2 processing but not S1 processing. The main question was whether the repetition of the (later) target (the word that was underlined and to be responded to upon S2 presentation) would interact with response repetition to show the standard partial-repetition costs (i.e., worse performance if the target is repeated but the response alternates, or vice versa), and whether this pattern would also be obtained for the (later) nontarget or foil (i.e., for the word that was not underlined and to be ignored).

If it would be the retrieval of event files that is controlled, one would expect partial-repetition costs for the target word but not (or significantly less) for the foil. In contrast, if it would be the creation of event files that is controlled, one would expect equivalent partial-repetition costs for the target word and the foil. As neither the location nor the identity of the later target could be known upon S1 presentation, any S1 word should be equally bound to the respective R1. If retrieval would be purely automatic (i.e., unaffected by task relevance), word-response bindings should be retrieved irrespective of whether the target or the foil word is repeated. Hence, both target repetition and foil repetition should interact with response repetition. If, however, retrieval is controlled by task relevance, only the word-response binding matching the current target word would be retrieved. Hence, target repetition should matter while foil repetition should not.

Method

Participants

Thirty students from Leiden University voluntarily participated in this experiment for a small fee or course credits. Data from one participant did not enter analysis due to an error rate of more than 50%.

Apparatus and stimuli

Stimuli were presented on a 17” monitor in 800 x 600 pixels resolution and a refresh-rate of 100 Hz. A Pentium-III 450 MHz PC running E-Prime (1.1, SP3) on Windows 98 SE controlled stimulus-presentation and recorded reactions. The 120 words of animate and 120 words of inanimate referents consisted of 3-10 18-point-sized characters and varied in width accordingly. For presentation of S1 and S2 two horizontally centered words appeared, one 23 mm above the vertical screen center and the other 23 mm below the center. Letters were presented in black, bold-printed, “New Courier” font on a grey (RGB values 192, 192, 192) background.

Procedure

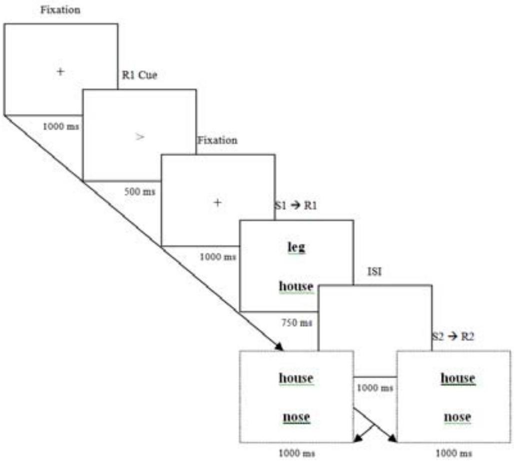

Figure 1: Sequence of events in a single trial. From top-left to bottom-left: foil repeated, target alternated; from top-left to bottom-right: foil alternated, target repeated.

As outlined in Fig. 2, a fixation cross was presented for 1000 ms, followed by a small arrow (the R1 cue). The arrow stayed for 750 ms and was replaced by the fixation cross for another 1000 ms, so that participants had ample time to prepare the cued R1. This response was to be executed on display of S1, two uninformative words. One word was animate and the other non-animate, with the locations (top or bottom) varying randomly. Participants were not required to attend the words or respond to them in any other way than pressing the pre-cued key: <Q> for the left –, <P> for the right-pointing arrow. After 750 ms, a blank screen was displayed for 1000 ms, creating a stimulus-onset asynchrony of 1750 ms. Then S2 was shown for 1000 ms, consisting of one word from the animate list and one from the inanimate list, one of them underlined. Half of the participants were to press <Q> if the underlined word was animate or <P> if it was not, and the other half had the opposite response mapping.

After each S1-S2 pair of trials, a 1500-ms blank inter-trial-interval (ITI) ensued if R1 and R2 were both correct, otherwise the ITI lasted 4500 ms, the extra

3000 ms showing a warning message. The ITI was also used every eighth trial to give participants feedback regarding their average number of correct responses and average reaction time. The experimented lasted about 30 minutes.

Design

The experiment used a three-factor (response-repetition x target-repetition x foil-repetition) repeated measures design: The response to S2 was either repeating or not repeating the response to S1; the underlined word of S2 (i.e., the target) was either repeating or not repeating one of the two words making up S1; and the not-underlined word (i.e., the foil) was either repeating or not repeating one of the words making up S1 (see fig. 2). Each of the eight combinations of these factors was presented 40 times, and the word locations of animate and non-animate words, the location of the target words, and the two responses were distributed evenly across design cells.

Results

From the 29 participants, correct R2 responses from trials with both responses being correct were analyzed Few errors were made overall (M = 11.8%, SD = 8.6%), although their pattern was largely consistent with the pattern of reaction times.

In a repeated measures analysis of variance with target-repetition, foil-repetition, and response-repetition as factors, responses were found to be significantly faster if the target word was repeated, $F(1, 28) = 94.45$, MSe = 1088.72, $p < .001$, and if the foil word was repeated, $F(1, 28) = 31.76$, MSe = 449.73, $p < .001$. Responses were slower if the response was repeated, $F(1, 28) = 21.55$, MSe = 326.03, $p < .001$—indicating an alternation bias. More important for present purposes, response repetition interacted significantly with target-repetition, $F(1, 28) = 6.34$, MSe = 316.24, $p < .02$: as Figure 3 shows, the target-repetition benefit was more pronounced with response repetition than alternation. Interestingly, no such interaction was obtained between foil repetition and response repetition, $F(1, 28) = .04$, $MSe = 353.59$, $p > .8$.

Error-data showed no significant effect of target-repetition, $F(1, 28) = 1.77$, $MSe = 83.58$, $p > .19$ or foil-repetition, $F(1, 28) = 2.30$, $MSe = 66.54$, $p > .14$. Responses were less accurate when the response was repeated, $F(1, 28) = 15.53$, $MSe = 1071.27$, $p < .001$. Repeating the response showed a trend towards a significant interaction with repeating the target, $F(1, 28) = 2.95$, $MSe = 97.96$, $p < .1$, but not with repeating the foil, $F(1, 28) = 1.72$, $MSe = 38.29$, $p > .1$.

To allow for direct comparisons of the interactions between target and response repetition on the one hand and foil and response repetition on the other, we computed the two corresponding interaction terms, which can be taken to represent feature-overlap-costs (see Hommel, 1998). Target-related reaction time and error overlap costs (OC_{target}) were calculated as follows: OC_{target} = (target repeated | response alternated + target alternated | response repeated)/2 – (target repeated | response repeated + target alternated | response alternated)/2. Correspondingly, foil-related overlap costs (OC_{foil}) were calculated: OC_{foil} = (foil repeated | response alternated + foil alternated | response repeated)/2 – (foil repeated | response repeated + foil alternated | response alternated)/2. As predicted by the retrieval-control account, OC_{target} was significantly larger than OC_{foil}; both in reaction time, $t\ (28) = 1.78$, $p < .05$, and error rates, $t\ (28) = 1.84$, $p < .04$.

Table 1. *Effects of repeating target, foil and response on mean and SE (italicized) of RTs, demonstrating calculus of overlap-costs.*

Target			
Response	Alternated	Repeated	Priming effect
Alternated	677 (*13*)	641 (*13*)	36
Repeated	694 (*14*)	646 (*15*)	48
		Partial-repetition cost:	12
Foil			
Response	Alternated	Repeated	Priming effect
Alternated	667 (*14*)	652 (*14*)	15
Repeated	678 (*13*)	662 (*15*)	16
		Partial-repetition cost:	1

Discussion

Our findings provide direct evidence for the contextual control of event file retrieval. The way our experiment was set up did not allow for selective integration of one of the two words presented as S1—and yet, partial-repetition costs were only obtained for words that were marked as targets in S2. Apparently, then, focusing on the target word selectively retrieved the matching word-response binding created for the previous S1-R1 episode (in trials where the word was repeated), whereas bindings matching the unmarked word were not retrieved. This does not exclude the possibility that the creation of event files can be affected by the task context if the experimental set up allows for it, but given that the present design prevented such an impact our observations must reflect retrieval control. Another implication of our findings is that the two words forming S1 were apparently bound to the corresponding R1 independently from each other—otherwise repeating the target would have been sufficient to also retrieve the foil. This supports the idea that event files do not bind actions to un-interpreted visual snapshots but, rather, to feature-based descriptions of the respective visual event.