BRIEF REPORTS

Semantic generalization of stimulus-task bindings

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People find it difficult to switch between two tasks, even if they have time to prepare—the so-called residual task shift cost. We studied a switch of tasks from picture naming to word reading, using picture–word Stroop stimuli. Consistent with previous findings, we demonstrate that a large part of the observed task shift cost was due to priming from prior stimulus–response episodes, in which the current task stimulus was encountered in a competing task. We further show that this task-priming effect generalizes to semantically related stimuli, which opens the possibility that most or all of these residual shift costs reflect some sort of generalized proactive interference from previous stimulus–task episodes.

Switching from one task to another is something humans find difficult to accomplish (Allport, Styles, & Hsieh, 1994). Even if subjects are given information about an upcoming task switch and considerable time to prepare, they still show longer reaction times (RTs) than if they were to repeat the same task—the so-called residual task shift cost (TSC; Allport et al., 1994; Meiran, 1996; Rogers & Monsell, 1995).[1] Apart from possible "reconfiguration" costs reflecting efforts to disable the previous task (Mayr & Keele, 2000) and/or to enable the new task (Meiran, 1996; Rogers & Monsell, 1995; Rubinstein, Meyer, & Evans, 2001) and "restart" costs (see note 1), a substantial portion of the—conventionally defined—residual TSC may result from a kind of stimulus-specific, proactive interference: Having performed task A on an earlier occasion and in response to a given stimulus can interfere with switching to a different task, B, in the presence of that same stimulus (Allport & Wylie, 2000; Waszak, Hommel, & Allport, 2003, in press; Wylie & Allport, 2000). For example, Waszak et al. (2003) had subjects name either the word or the picture constituent of incongruent (Stroop-like) picture–word stimuli, shifting

task every second or third trial. Switching to word reading was much easier with stimuli that subjects had never picture-named before (unprimed items) than with stimuli that they had previously picture-named (primed items), even though more than a hundred trials intervened between the priming event (picture naming) and the probe event (word reading).[2] Importantly, this long-term priming effect on word reading was obtained only on task switch trials, not on task repetition trials. This result is consistent with the idea that task-related priming is manifest primarily when there is ongoing conflict between mutually competing tasks, as on a task switch trial (Waszak et al., 2003). It would also explain why long-term priming of this kind has not been detected hitherto.

The finding of long-term priming effects that are both stimulus- and task-specific suggests that executing a task in response to a given stimulus induces some sort of episodic binding between the codes of that stimulus and the other, task-related representations involved—in other words, that subjects encode the activated stimulus- and task-related codes into an integrated episodic trace (Allport, 1987; Hommel, 1998; Hommel, Pösse, & Waszak, 2000; Logan, 1988) that is automatically retrieved when the same stimulus is encountered at a later time. If the retrieved task is one that is needed or useful under the given circumstances, this automatism is likely to be of great benefit, as has been discussed in a variety of contexts, such as long-term action planning (Bargh, 1989; Gollwitzer,

1999), selection for action (Allport, 1987, 1989), automatization (Logan, 1988; Logan & Etherton, 1994), and memory (e.g., "transfer appropriate processing"; Crowder, 1993). However, the drawback of this automatism is that stimuli might retrieve their associated tasks even under unsuitable conditions—"transfer inappropriate processing" (Neill & Mathis, 1998; Wood & Milliken, 1998). The combination of an old stimulus with a new task in a task-switching experiment is an example that is particularly unfavorable for the system. Under these conditions, encountering a stimulus previously experienced in the context of a different task seems to reactivate that other task, and thus to interfere with implementing the new task.

However, all available studies about priming in task switching (Allport & Wylie, 1999, 2000; Waszak et al., 2003, in press; Wylie & Allport, 2000) have been restricted to what one may call identity priming, since primes and probes have always consisted of physically identical stimuli or stimulus elements. In the present study, we therefore asked whether episodic stimulus–task bindings can also generalize to semantically related stimuli.

This issue is important, theoretically, because resolving it would help to pit a strictly perceptual or sensory-motor account of event learning against a more abstract feature-based or semantically based account. It is important, practically, because it would open a whole range of opportunities to transfer prior task learning to new routines—such as in implementing everyday routines in Alzheimer patients (Camp, Foss, Stevens, & O'Hanlon, 1996). Indeed, many sorts of priming effects have been demonstrated to generalize to semantically related events, be it between words (Meyer & Schvaneveldt, 1971; Neely, 1991) or pictures (Durso & Johnson, 1979; Irwin & Lupker, 1983). Negative priming effects have also been found to generalize semantically (Fuentes & Tudela, 1992; Tipper & Baylis, 1987; Tipper & Driver, 1988; but see also Enright & Beech, 1993; Yee, 1991). Recently, Hutchison (2002) showed how episodic retrieval theories could account for semantic negative priming by assuming that items associated with the prime distractor are tagged as "to be ignored" during prime selection, a proposition that is very similar to our account for negative priming effects in task switching (Waszak et al., 2003, in press). However, the specific mechanism of semantic priming is not the focus of the present paper. The important point here is that there are reasons to expect that stimulus–task bindings (and their impact on task-switching performance) also generalize to stimuli that share the same semantic category.

We tested this hypothesis by having subjects alternate between a word-reading and a picture-naming task, both being carried out in response to picture–word Stroop stimuli. The task we focused on was word reading, which was probed in three different conditions, as follows. (see Figure 1): In one condition, subjects responded to picture–word stimuli that had been presented previously in the competing picture-naming task (set PW, *picture and word*). In a second condition, they responded to picture–word stimuli that they had never encountered in the picture-naming task (set WOun, *word only, semantically unrelated*). These two conditions were conceptual replications of Waszak et al. (2003), so we expected TSCs to be more pronounced with set PW than with set WOun. Most important, a third word-reading condition required subjects to respond to stimuli that (like set WOun) they had never encountered in the picture-naming task, but that (in contrast to set WOun) were semantically related to items already presented in the picture-naming task (set WOsem, *word only, semantically related*). If stimulus-to-task priming depends on recurrence of the identical stimulus items, then only set PW should show larger TSC than set WOun. In contrast, if stimulus–task bindings generalize to semantically related stimulus items, TSCs in WOsem should also be larger than in WOun.

METHOD

Twelve subjects participated (mean age: 23 years). Seventy-two picture–word conjunction stimuli were presented in black on a white background (mean extension: $1.9° \times 1.9°$). No picture was also presented as a word, and vice versa. Individual conjunctions of picture and word elements were always drawn from the same semantic category.

The 72 conjunction stimuli were subdivided into three sets of 24 items each, such that the semantic overlap between sets was minimal, as follows. Set A items were all drawn from the category *animals* ($n = 24$); set B items consisted of *body parts* ($n = 10$) and *clothing* ($n = 14$); and set C items consisted of *vehicles* ($n = 8$), *buildings/dwellings* ($n = 6$), and *furniture* ($n = 10$). Counterbalanced across subjects, one of these sets was chosen for the WOun condition; items in this set appeared in word reading only, hence they were neither identity primed nor semantically primed (see Figure 1). The remaining two sets were first split into two halves, such that each half contained the same number of items from each category. For example, if set A was assigned to condition WOun, then set B was split into B1 and B2, each containing 5 body-part items and 7 clothing items, and set C was split into C1 and C2, each containing 4 vehicle items, 3 buildings/dwellings items, and 5 furniture items. Half of sets B and C (e.g., B1 + C2) were then taken to form the material for condition PW, and the other two halves (e.g., B2 + C1) formed condition WOsem.

PW items were presented for both picture-naming and word-reading; they were thus identity primed (by virtue of the identical item having appeared in picture naming) and also semantically primed (by virtue of different exemplars from the same semantic category having appeared in picture naming). WOsem items were presented for word reading only, so they were not identity primed, but they were semantically primed, because other items from the same category had appeared in picture naming (see Figure 1).

One cycle of the experiment included first a small block of picture naming only (PP-PP-PP- . . .) in which all items of set PW were presented twice in a random order followed by an alternating block in which subjects switched between picture naming and word reading in runs of two trials (PP-WW-PP-WW- . . .). Only the alternating blocks were of interest to us. In the course of one alternating block (of 144 trials), all items (PW, WOun, and WOsem) were presented once each for word reading, in a random order. Set PW items were also presented for picture naming (three times per alternating block, in order to equalize the number of picture-naming and word-reading trials, also in a random order). At the end of the cycle, the procedure was repeated for the next cycle. Four cycles were conducted.

Picture Naming
Set PW

Word Reading
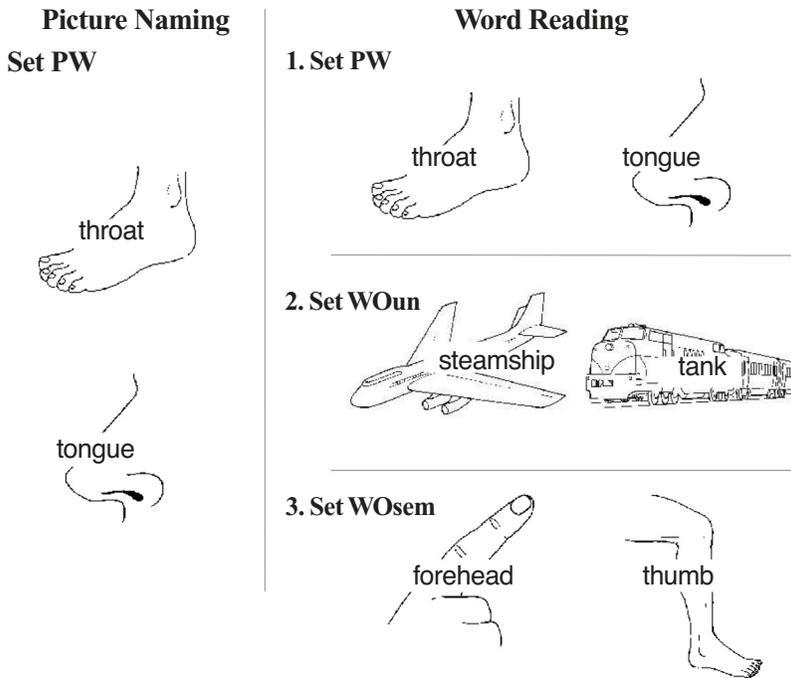### 1. Set PW

2. Set WOun

3. Set WOsem

Figure 1. The three priming conditions of Experiment 1. The figure shows examples of two stimulus items from each of the three sets (which contain 24 stimulus items each). Left: picture naming (prime events), for which only items of set PW were presented. Right: word reading (probe events), for which items from set PW, set WOun, and set WOsem were presented. (1) Items in set PW were both identity primed and semantically primed. (2) Items in set WOun were neither identity primed nor semantically primed. (3) Items in set WOsem were semantically primed but not identity primed.

Each 144-trial alternating block was presented in the form of 36 successive, 4-trial "miniblocks": 2 picture-naming trials followed by 2 word-reading trials (PP-WW; see Figure 2). After the subjects initiated the miniblock by a keypress, the screen remained blank for 500 msec. Then the task cue for the PP run of the miniblock, a non-alphanumeric symbol, appeared for 2,000 msec on the screen. After another blank interval of 500 msec the first stimulus was presented. The stimulus remained on the screen until the subject's response, which triggered a blank interval of 500 msec followed by the presentation of the second stimulus of the PP run. The procedure then repeated, commencing with the presentation of the task cue for word reading, the letter W, indicating the start of the WW run. Thus, the RSI between PP and WW task runs was 3,000 msec and any resulting RT costs of the task switch can be considered to be residual. The procedure for one miniblock was repeated, with different items, through the 144-trial cycle.

RESULTS AND DISCUSSION

Figure 3 shows RTs and errors for alternating picture naming and word reading. The error pattern did not counteract the RT pattern. Thus, a speed–accuracy tradeoff can be excluded. An analysis of variance (ANOVA) was run on the word-reading RT data, including the factors cycle (1–4), stimulus set (PW vs. WOun vs. WOsem), and trial position (1 vs. 2). Two significant main effects, stimulus set [$F(2,22) = 6.14$, $MS_e = 7,264.285$, $p < .01$], and trial position [$F(1,11) = 18.20$, $MS_e = 85,167.263$, $p < .01$],

were accompanied by a significant interaction of set and trial position [$F(2,22) = 7.72$, $MS_e = 5,610.666$, $p < .01$]. The latter indicates that stimulus-set effects were restricted to the first trials-that is, trials where a task switch was also required. Figure 3 shows that, although task switches took longer than repetitions under all three conditions, the TSC was most pronounced with identity primed items (PW), intermediate with semantically primed items (WOsem, see black circle), and smallest with unprimed items (WOun). From a comparison of conditions WOun and PW, we see that identity priming roughly doubles the TSC obtained for WOun, which replicates the findings of our previous study (Waszak et al., 2003).

More importantly for present purposes, TSCs were also larger for the semantically primed WOsem items than for unprimed items. Indeed, task-switching performance on WOsem items overall fell midway between WOun and PW and differed significantly from both [WOsem vs. PW, $t(11) = 2.13$, $p < .03$; WOsem vs. WOun, $t(11) = 2.65$, $p < .02$].

Before we interpret this pattern, however, it is important to note that identity priming and semantic priming were not matched in terms of the recency distribution of their respective priming events. With regard to identity priming (in PW), the primes preceded their respective probes by a lag of 5–45 trials. In contrast, semantic
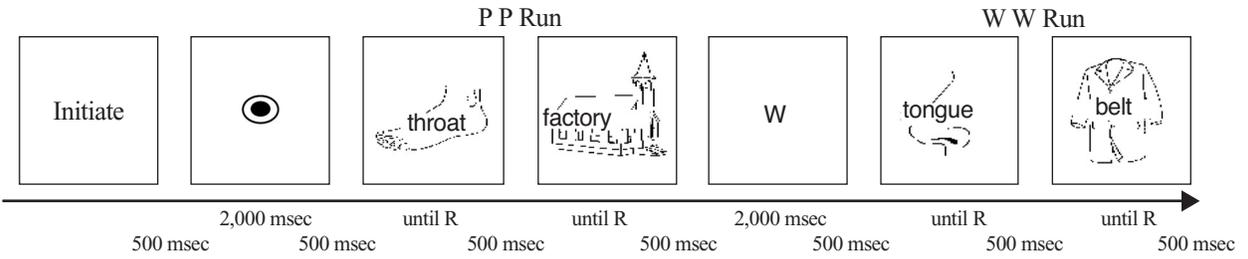
Figure 2. One miniblock of the alternating phase in Experiment 1.

priming (in both PW and WOsem) could have been induced by primes with lags as short as 1 trial, such as when a switch to word reading was made in response to an item that was semantically related to the stimulus of the preceding picture-naming trial. Accordingly, identity priming was always relatively long-term, whereas semantic priming could have included both long- and short-term effects.

Hence, we were interested to see whether immediate, trial-to-trial priming would behave differently from longer-term priming. For this purpose, we split the WOsem data into those (few) trials with a lag of zero (i.e., probe trial immediately follows prime trial) and those with greater lags. As Figure 3 shows (see small circles), immediate

(lag 0) semantic priming strongly increased TSC, up to the PW level, whereas longer lags showed a weaker effect. The lag effect was reliable, as confirmed by a two-tailed t test [$t(11) = 2.49, p < .05$]. Importantly, even performance with longer-lag semantic priming still differed reliably from WOun, even when only lags of more than 4 trials were considered [WOsem lag 0 vs. WOun, $t(11) = 2.98, p < .01$; WOsem lag >4 vs. WOun, $t(11) = 2.29, p < .05$].[3]

CONCLUSION

First, we address the question of why these priming effects were observed here on switch trials only. Our ten-
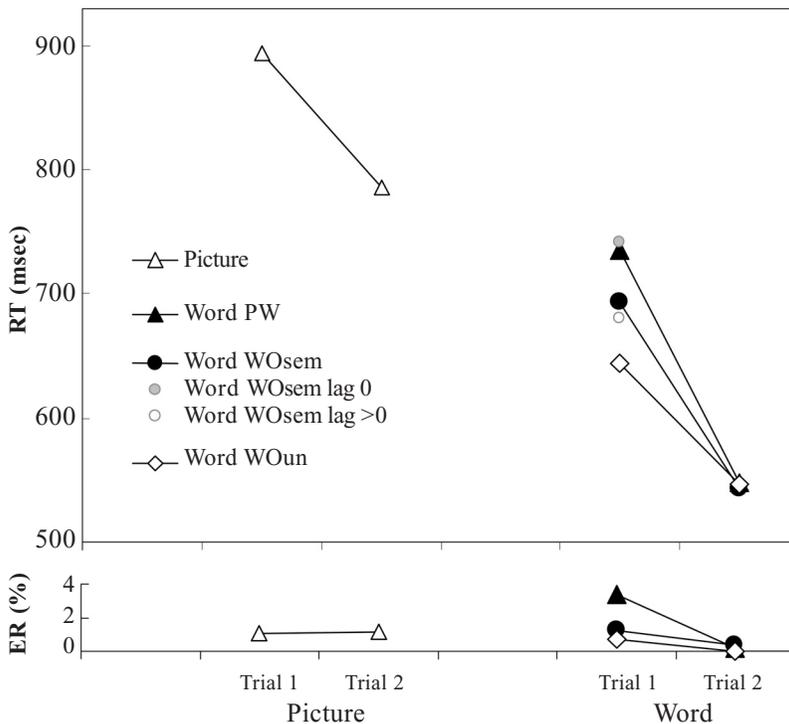

Figure 3. Mean reaction times (RTs), in milliseconds, and error rates (ERs) for picture naming and word reading in the alternating blocks, as a function of trial position (1st, 2nd) and stimulus set (PW, WOun, WOsem) (large symbols). The two small circles denote set WOsem word-reading RTs separately for priming lags of 0 and >0, respectively.

tative answer to this question is that people are especially susceptible to bottom-up priming on word-reading *switch* trials because, on these trials, activation of the word-reading task remains weak. In terms of the "task set inertia" (TSI) model (Allport et al., 1994), this is because on a switch from picture naming to word reading, the persisting trial-to-trial TSI keeps the picture-naming task set activated and the word-reading task set inhibited. Thus, aftereffects of recently executed competitive tasks (trial-to-trial TSI; Allport et al., 1994; Allport & Wylie, 1999) may be a precondition for the retrieval interference effects as observed in the present experiment. On task repetition trials, by contrast, TSI from the preceding trial serves only to strengthen the relevant task set, so that task set activation is strong; hence, word reading is not interfered with by competing stimulus–task associations. This issue has been discussed at length elsewhere (Waszak et al., 2003, in press). Note that we do not rule out that the increased interference in turn increases the need for some "control" process, which could contribute to the observed slowing. If so, however, this type of control process would be common to many other interference paradigms and by no means specific to switching or reconfiguring tasks.

The main goal of this study was to see whether stimulus-to-task bindings generalize to semantically related stimuli. As expected, switching to word reading was more difficult when responding to a stimulus that had been presented previously for the competing task of picture naming. What is more, task switching was also impaired for stimuli that were only semantically related to previously picture-named stimuli. Hence, stimulus–task bindings do generalize semantically.

Interestingly, TSCs associated with WOsem overall fell midway between WOun and PW, a pattern that might result from visual feature overlap. A number of authors have pointed out that pictures from the same semantic category typically share a variety of perceptual features (Snodgrass & McCullough, 1986; Sperber, McCauley, Ragain, & Weil, 1979), and the same argument can be made for the referent objects of semantically related words (Schreuder, Flores D'Arcais, & Glazenborg, 1984). Accordingly, the difference in priming between WOsem and PW may be more quantitative than qualitative. If so, this result would point to a general rule: TSC increases with the degree of feature overlap between the current stimulus and the stimuli that has already appeared in a competing task.

This issue bears on the possible mechanism of the interference effect. Two different factors are at work in episodic priming: the facilitation of current distractor stimuli (competitor priming) and impaired processing of previously suppressed responses (negative priming) (Waszak et al., in press). The present experiment could not resolve whether semantically mediated negative priming, competitor priming, or both, account for the observed priming effects. However, two results reported repeatedly in the semantic priming literature suggest that the competitor priming component may be more influential. First,

semantic negative priming effects appear to be rather fragile, since several studies have failed to find such effects (e.g., Fuentes & Tudela, 1992; Tipper & Baylis, 1987). Second, pictures (compared with words) are particularly effective as primes and also very susceptible to priming as probes (e.g., Durso & Johnson, 1979; Sperber et al., 1979). It has been suggested that such results occur because pictures are "functionally closer" to the common semantic representation than words are, and that pictures therefore activate semantic representations more rapidly. Furthermore, Experiment 1 by Waszak et al. (in press) revealed that, in experiments using a large stimulus set (as in the present experiment), long-term negative identity priming does not contribute to first-trial word-reading switch costs. However, this issue requires further examination.

If supported by further investigation, the general rule mentioned above would have considerable implications. It is clear that even the items in the WOun condition shared certain features with the to-be-named items: Both types of item were picture–word compounds of a particular size and drawing style, both appeared at the same location on the screen, both required a vocal response, and so forth. If we can assume that perceptual, semantic, and contextual features of a given stimulus–response episode are encoded into a coherent event representation (Hommel, 1998; Hommel et al., 2000), then even our WOun items must have been primed to at least some degree—in the sense that some of their features were already associated with the competing naming task. It would then follow that even when the same specific stimulus items are not shared by two competing tasks, at least some of the TSC measure can be attributed to stimulus-driven interference from previously established stimulus-task bindings, mediated by stimulus generalization. Stimulus-to-task priming can thus be added to the variety of other "nonexecutive" processes, all of which have been demonstrated to contribute to TSCs. These processes include the first-trial cost (see note 1), the aftereffects of task set inhibition (Mayr & Keele, 2000), task set inertia (Allport et al., 1994; Altmann & Gray, 2002), and task cue recoding processes (Logan & Bundesen, 2003; but see Mayr & Kliegl, 2003). When all these nonexecutive processes have been excluded, there may not be much of a residual TSC left for any executive control process to explain.

REFERENCES

ALLPORT, A. (1987). Selection for action: Some behavioral and neurophysiological considerations of attention and action. In H. Heuer & A. F. Sanders (Eds.), *Perspectives on perception and action* (pp. 395-419). Hillsdale, NJ: Erlbaum.

ALLPORT, A. (1989). Visual attention. In M. I. Posner (Ed.), *Foundations of cognitive science* (pp. 631-682). Cambridge, MA: MIT Press.

ALLPORT, A., STYLES, E. A., & HSIEH, S. (1994). Shifting intentional set: Exploring the dynamic control of tasks. In C. Umiltà & M. Moscovitch (Eds.), *Attention and performance XV: Conscious and nonconscious information processing* (pp. 421-452). Cambridge, MA: MIT Press.

ALLPORT, A., & WYLIE, G. (1999). Task-switching: Positive and negative priming of task-set. In G. W. Humphreys, J. Duncan, & A. M.

Treisman (Eds.), *Attention, space and action: Studies in cognitive neuroscience* (pp. 273-296). Oxford: Oxford University Press.

ALLPORT, A., & WYLIE, G. (2000). "Task-switching," stimulus–response bindings and negative priming. In S. Monsell & J. Driver (Eds.), *Attention and performance XVIII* (pp. 35-70). Cambridge, MA: MIT Press.

ALTMANN, E. M., & GRAY, W. D. (2002). Forgetting to remember: The functional relationship of decay and interference. *Psychological Science*, **13**, 27-33.

BARGH, J. A. (1989). Conditional automaticity: Varieties of automatic influence in social perception and cognition. In J. A. Bargh & J. S. Ulman (Eds.), *Unintended thought* (pp. 3-51). New York: Guilford Press.

CAMP, C. J., FOSS, J. W., STEVENS, A. B., & O'HANLON, A. M. (1996). Improving prospective memory task performance in persons with Alzheimer's disease. In M. Brandimonte (Ed.), *Prospective memory: Theory and applications* (pp. 351-367). Mahwah, NJ: Erlbaum.

CROWDER, R. G. (1993). Systems and principles in memory theory: Another critique of pure memory. In A. F. Collins & S. E. Gathercole (Eds.), *Theories of memory* (pp. 139-161). Hove, U.K.: Erlbaum.

DURSO, F. T., & JOHNSON, M. K. (1979). Facilitation in naming and categorizing repeated pictures and words. *Journal of Experimental Psychology: Human Learning & Memory*, **5**, 449-459.

ENRIGHT, S. J., & BEECH, A. R. (1993). Further evidence of reduced cognitive inhibition in obsessive-compulsive disorder. *Personality & Individual Differences*, **14**, 387-395.

FUENTES, L. J., & TUDELA, P. (1992). Semantic processing of foveally and parafoveally presented words in a lexical decision task. *Quarterly Journal of Experimental Psychology*, **45A**, 299-322.

GOLLWITZER, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, **54**, 493-503.

GOPHER, D., ARMONY, L., & GREENSHPAN, Y. (2000). Switching tasks and attention policies. *Journal of Experimental Psychology: General*, **129**, 308-339.

HOMMEL, B. (1998). Event files: Evidence for automatic integration of stimulus–response episodes. *Visual Cognition*, **5**, 183-216.

HOMMEL, B., PÖSSE, B., & WASZAK, F. (2000). Contextualization in perception and action. *Psychologica Belgica*, **40**, 227-245.

HUTCHISON, K. A. (2002) The effect of asymmetrical association on positive and negative semantic priming. *Memory & Cognition*, **30**, 1263-1276.

IRWIN, D. I., & LUPKER, S. J. (1983). Semantic priming of pictures and words: A levels of processing approach. *Journal of Verbal Learning & Verbal Behavior*, **22**, 45-60.

LOGAN, G. D. (1988). Toward an instance theory of automatization. *Psychological Review*, **95**, 492-527.

LOGAN, G. D., & BUNDESEN, C. (2003). Clever homunculus: Is there an endogenous act of control in the explicit task cuing procedure? *Journal of Experimental Psychology: Human Perception & Performance*, **29**, 575-599.

LOGAN, G. D., & ETHERTON, J. L. (1994). What is learned during automatization? The role of attention in constructing an instance. *Journal of Experimental Psychology: Learning, Memory & Cognition*, **20**, 1022-1050.

MAYR, U., & KEELE, S. W. (2000). Changing internal constraints on action: The role of backward inhibition. *Journal of Experimental Psychology: General*, **129**, 4-26.

MAYR, U., & KLIEGL, R. (2003). Differential effects of cue changes and task changes on task-set selection costs. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **29**, 362-372.

MEIRAN, N. (1996). Reconfiguration of processing mode prior to task performance. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **22**, 1423-1442.

MEYER, D. E., & SCHVANEVELDT, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, **90**, 227-234.

NEELY, J. H. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner & G. W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264-336). Hillsdale, NJ: Erlbaum.

NEILL, W. T., & MATHIS, K. M. (1998). Transfer-inappropriate processing: Negative priming and related phenomena. In D. Medin (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 38, pp. 1-44). San Diego: Academic Press.

ROGERS, R. D., & MONSELL, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General*, **124**, 207-231.

RUBINSTEIN, J., MEYER, D. E., & EVANS, J. E. (2001). Executive control of cognitive processes in task switching. *Journal of Experimental Psychology: Human Perception & Performance*, **27**, 763-797.

SCHREUDER, R., FLORES D'ARCAIS, G. B., & GLAZENBORG, G. (1984). Effects of perceptual and conceptual similarity in semantic priming. *Psychological Research*, **45**, 339-354.

SNODGRASS, J. G., & MCCULLOUGH, B. (1986). The role of visual similarity in picture categorization. *Journal of Experimental Psychology: Learning, Memory, & Cognition,* **12**, 147-154.

SPERBER, R. D., MCCAULEY, C., RAGAIN, R. D., & WEIL, C. M. (1979). Semantic priming effects on picture and word processing. *Memory & Cognition*, **7**, 339-345.

TIPPER, S. P., & BAYLIS, G. C. (1987). Individual differences in selective attention: The relation of priming and interference to cognitive failure. *Personality & Individual Differences*, **8**, 667-675.

TIPPER, S. P., & DRIVER, J. (1988). Negative priming between pictures and words in a selective attention task: Evidence for semantic processing of ignored stimuli. *Memory & Cognition*, **16**, 64-70.

WASZAK, F., HOMMEL, B., & ALLPORT, A. (2003). Task-switching and long-term priming: Role of episodic stimulus-task bindings in task-shift costs. *Cognitive Psychology*, **46**, 361-413.

WASZAK, F., HOMMEL, B., & ALLPORT, A. (in press). Interaction of task readiness and automatic retrieval in task-switching: Negative priming and competitor priming. *Memory & Cognition*.

WOOD, T. J., & MILLIKEN, B. (1998). Negative priming without ignoring. *Psychonomic Bulletin & Review*, **5**, 470-475.

WYLIE, G., & ALLPORT, A. (2000). Task switching and the measurement of "switch costs." *Psychological Research*, **63**, 212-233.

YEE, P. L. (1991). Semantic inhibition of ignored words during a figure classification task. *Quarterly Journal of Experimental Psychology*, **43A**, 127-153.

NOTES

1. It is important to note that, even without any shift of task, the first trial of a run of speeded responses has a systematically longer RT than later trials (Allport & Wylie, 2000; Altmann & Gray, 2002; Gopher, Armony, & Greenshpan, 2000; Wylie & Allport, 2000). We may refer to this as the first-trial, or "restart," cost. In the so-called alternating runs paradigm (Rogers & Monsell, 1995), widely used to study task switching—as also in the present study—the conventional measure of TSC is the difference in performance between the first and second (or later) trials of a run. As is clear, this measure is thus liable to confound the "restart" cost with the cost of a switch of task. In this paper we continue, nonetheless, to use the term *TSC* in this conventional sense, as a shorthand.

2. Waszak et al. (in press) provide evidence that stimulus–task bindings may actually comprise two relations, one between the currently *relevant* stimulus features and the current task and one between the currently *irrelevant* stimulus features and the current task. For instance, naming the picture element in an incongruent picture–word combination may create (1) a facilitative association between the picture and the naming task and/or (2) an inhibitory association between the word and the naming task. Waszak (in press) demonstrated that these effects can be separated, and that both can contribute to TSC. The former type of association dominates with large stimulus sets (as used in the present experiment), while both types of association contribute with small stimulus sets. Given the different focus of the present study, we make no attempt to distinguish between these associations here, and thus we will use the generic term *priming effect*.

3. Notice that the mean lag between prime and probe events was not formally equated for PW and WOsem items, even for the item subset

with a lag >4. As stated in the text, identity primes preceded their respective probes (in PW) by a lag of 5–45 trials, i.e., by at least 5 trials and at most 45. With respect to semantic priming (in set WOsem lag >4), the minimum lag was, similarly, at least 5 trials. However, the maximum lag was much shorter for semantic priming and differed between the item groups. For example, lag was smaller for the large pool of animal items than for the few buildings/dwellings items. Evidently, this difference in mean lag has to be taken into account when comparing RTs from sets PW and WOsem, which is why we hesitate to draw strong conclusions from the size of this difference. Note, however, that it is not unwarranted to state that TSC for identity primed items (set PW) is larger than for semantically primed items (set WOsem). This is because the semantic priming is the same in both sets, but set PW in addition is identity primed—with a mean lag that is larger than the lag for semantic priming alone.