The Dual Implication of Dual Affordance

Stimulus-Task Binding and Attentional Focus Changing During Task Preparation

Nachshon Meiran

Ben-Gurion University of the Negev, Beer-Sheva, Israel

Abstract. In task switching experiments, comparing performance with bivalent stimuli (affording both tasks) to univalent stimuli (affording one task) confounds the need to change focus between dimensions and stimulus-task binding, because bivalent stimuli require focusing (and refocusing) but also appeared in the competing task before. To separate these influences, participants switched between vertical and horizontal judgments performed on bivalent (e.g., *up-left*) or univalent (e.g., *left*) actual locations or location words. In a critical condition involving bivalence without stimulus-task binding, actual locations and location words were each linked to a different task. Bivalence increased switch costs and preparation reduced switch costs only with bivalent stimuli. Stimulus-task binding affected performance in task repetitions, especially when little preparation time was afforded.

Keywords: task switching, cognitive control, reaction time, attention, bivalent stimuli, task decision, stimulus-task binding

Introduction

Objects often afford multiple actions. A dining knife used for cutting food may also be used to shortcut an electric circuit. When asked whether a particular knife may be used as an electrical conductor, one is faced with two challenges. First, a knife involuntarily reminds one of the irrelevant goal of cutting food. Because an irrelevant goal is involuntarily retrieved, the correct goal takes longer to retrieve, thus prolonging the time needed to make a *task-decision*, which is the decision on the task goal: to judge whether the knife is an electrical conductor. Second, one needs to change the focus of attention from one of the object's dimensions (e.g., "Is it sharp enough?") to another ("Is it made of metal [and conducts electricity], or plastic?").

The situation just described involves a task switch, a phenomenon widely studied with the task-switching paradigm (see Logan, 2003; Monsell, 2003, for reviews) in which participants are asked to switch between simple cognitive tasks. Many task switching studies focused on the behavioral costs associated with task switching, or *switch costs.* These costs are defined as the decrement in performance in *switch* trials, in which the task has changed, relative to a baseline which is typically a *repeat* trial, in which the task has repeated. Another baseline that is sometimes used is a *single-task* baseline, which involves blocks without task switching.

Some theories of task switching make a distinction between task decision (or goal setting) and task rule implementation (Rubinstein, Meyer, & Evans, 2001; see also Sohn & Anderson, 2001), which is akin to the distinction I made between task decision and focus change, respectively. There are two important notes to make regarding these theories. First, they have a somewhat counter-intuitive implication that a task decision can be made even without task implementation. To appreciate this distinction, consider the everyday examples in which a principled decision to perform a task is made without taking the necessary steps to carry it out, such as a decision to go on a trip without actual preparation, or the decision to start a diet while keeping the chocolate within reach. Second, focus change is just a particular instance of task rule implementation, which has been described by some task switching theorists as a change in the task control parameters (Logan & Gordon, 2001; Meiran, 2000a). These parameters include response priority, decision rule, a change in the meaning assigned to each response (Brass et al., 2003; Meiran, 2000a; Schuch & Koch, 2003, 2004), and in cases where the task involves multiple steps, the serial position of the steps (Luria & Meiran, 2003, 2006; Schneider & Logan, 2006).

Preparation has featured a prominent role in the task switching literature (e.g., Allport, Styles, & Hsieh, 1994; Altmann, 2004, Logan & Bundesen, 2003; Meiran, 1996; Meiran, Chorev, & Sapir, 2000; Rogers & Monsell, 1995). My present question refers to the influence of preparation on task decision and attentional refocusing.

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Stimulus-Task Binding

Allport and Wylie (2000) and Waszak, Hommel, and Allport (2003, 2004) showed that a single encounter with an object is sufficient to associate this object with the task which was performed on it through a process of *stimulus-task binding.* As a result of this binding, later encounters with the same stimulus result in an involuntary retrieval of the previous task which was performed on it. If the required task is different than the task with which the stimulus was bound, the retrieval of the correct task is slowed and larger switch costs are observed. Koch and Allport (2006) concluded (see also Waszak & Hommel, in press) that what gets involuntarily retrieved by the stimulus is not a particular response associated with the wrong task, but an abstract task representation. Accordingly, in the present paper I refer to stimulus-task binding as a factor which mainly affects the hypothesized process of task decision.

Bivalence Effects

The evidence that task switching is associated with focus changing is nearly exclusively based on bivalence effects. I will explain these effects in reference to a task switching experiment involving two tasks, shape (*square* vs. *circle*) and color (*red* vs. *blue*). A *univalent* stimulus is one which affords only one of the tasks among which the participants switch. It may be a *square* in *yellow* color which is irrelevant for the color task. A *bivalent* stimulus is one which afford both tasks. It may be a *square* in *red* color, for example, because both *red* and *square* are among the alternatives in the tasks.

Classic papers by Jersild (1927) and Spector and Biederman (1976) showed poorer performance with bivalent stimuli as compared to univalent stimuli in switch trials relative to single-task conditions. More recent studies additionally show that bivalence impairs performance also in repeat trials (trials involving a task repetition taken from blocks involving task switching) relative to a single-task baseline (Koch, Prinz, & Allport, 2005; Mayr, 2001; Rubin & Meiran, 2005; see also Woodward, Meier, Tipper, & Graf, 2003). Crone**[Krone in refs]**, Wendelken, Donohue, and Bunge (2006), Koch et al. (2003), Mayr (2001), Meiran (2000b), and Rogers and Monsell (1995) further show that bivalence increases switch cost, meaning that bivalence has a stronger effect on switch trials than on repeat trials.

Bivalence effects are taken to indicate focus changing. Specifically, univalent stimuli presumably do not require focusing on the relevant stimulus dimension during response selection or require it less than bivalent stimuli because the irrelevant information (e.g., color when making a shape decision) cannot activate the irrelevant task's responses. Because there is no (or less) focusing in univalent stimuli, there is also no need for a focus change during task switching. In contrast, bivalent stimuli require focusing because the currently irrelevant stimulus dimension can activate a competing response. Therefore, these stimuli require a focus change during task switching. Mayr's (2001) results support these hypotheses. This author showed that bivalence effects were larger when the response keys of the tasks overlapped. This result supports the idea that focusing is required to overcome response competition. The reasoning is that when the responses of the two tasks are separated, participants can avoid involuntary response activation by simply lifting the hand or fingers which corresponds with the irrelevant task's responses. This simple strategy is prevented when the responses of the two tasks overlap. In these cases, the means to avoid involuntary response activation is through focusing on the relevant stimulus dimension, a process which filters out the irrelevant task's information that could activate wrong responses (see Meiran, 2000a).

The problem with studying bivalence in this context is that this manipulation, which presumably involves focus changing, confounds this factor with stimulus-task binding. The reason is that univalent stimuli can only be used in one task while bivalent stimuli may appear in the context of either task. In the shape-color paradigm described above a (univalent) *yellow square* stimulus cannot be used in the color task because the color *yellow* is not involved in that task (requiring *red-green* decisions). Therefore, this stimulus cannot get bound with the color task. As a result, the color task goal would not be involuntarily retrieved by that stimulus when the shape task is required. In contrast, a bivalent *red square* stimulus may be used in either task because both *red* and *square* are alternatives in the tasks. Therefore, bivalent stimuli can get bound with the color task and this task goal may be involuntarily retrieved when the shape task is required. In the present experiment, I studied the influence of bivalence when the confound with stimulus-task binding was removed.

The Present Study

Stimulus-Task Binding and Refocusing

In the present study, participants switched between two randomly ordered spatial tasks, vertical (*up* vs. *down*) and horizontal (*right* vs. *left*). Teasing apart bivalence and stimulus-task binding was accomplished by comparing performance with bivalent stimuli and univalent stimuli, and by creating a condition in which the stimuli were bivalent yet did not involve stimulus-task binding (Group 3; Figures 1 and 2). This condition involved two classes of stimuli that were visually clearly distinguishable. This aspect was important because Waszak et al. (2004) found increased switch costs in stimuli (e.g., a line drawing of a nose) that were semantically related to stimuli (e.g., a foot) presented beforehand. The effect was not as large as that observed with repetition proper (nose after nose), though. Given literature showing that pictures of semantically related objects tend to share visual features, the authors cautiously concluded (p. 1031) that the task binds with all the object features, visual and semantic alike.

Accordingly, one class of stimuli used in Group 3 involved bivalent locations while another class of stimuli involved bivalent location word pairs such as *up-left* (or *left-up*). Critically, in Group 3, each of the two tasks was systematically paired with one class of stimuli, so, for example, horizontal judgments were always made on actual locations whereas vertical judgments were always made on the bivalent location words. To ensure that participants would use this information, the pairing of stimuli to tasks was explicitly announced. The mixing of two target types is justified by theories arguing that response selection in speeded classification tasks of the sort being used in task switching paradigms involve abstract categorical representations mediating between stimuli and responses (e.g., Hommel, 1998; Pashler & Baylis, 1991; Proctor & Cho, 2006). Note, however, that while response selection presumably involves abstract representations, the task could bind with superficial visual features. In stable environments where there is little task switching, such stimulus-task binding would help retrieving the relevant task identity. Retrieving task identity would then lead to the extraction of the relevant abstract representations that are required to select a response according to the relevant task rule.

The experiment involved 4 control groups. Groups 1 and 2 received bivalent actual locations and location word pairs, respectively. I reasoned that stimulus-task binding and focus changing would operate in both of these groups. Groups 4 and 5 received univalent locations and location words, respectively. I reasoned that task decision would be fast in these groups because the stimuli never appeared in the alternative task, so that stimulus-task binding interfered less with task decision. I also reasoned that the degree of feature overlap between the stimuli used in the two tasks would be large in Groups 1 and 2 and similarly lower in Groups 3 through 5. That is, while in Groups 4 and 5, the stimuli used in the two tasks were visually similar (they were all words or all locations) but semantically less similar (one referred to the vertical task and the other to the horizontal task, such as *up* and *left*), in Group 3 they were visually dissimilar (one was a location and the other was made of location words) but semantically similar (both involved semantics that were relevant to the two tasks). As a result, stimulus-task binding was predicted to influence performance more strongly in Groups 1 and 2 than in the remaining groups. I also reasoned that there would not be focus changing in Groups 4 and 5 because there was no need for focusing to begin with. The responses used in the two tasks overlapped (Figures 1 and 2); so that switch costs were predicted even with ample preparation time as I have shown before (Meiran, 2000b).

Preparation Effects

Because preparation effects were of foremost interest, the *task-cue to target interval* (CTI) was varied. Based on previous studies, I hypothesized that because the tasks were ordered randomly, a task decision needed to be made both in switch trials and in repeat trials (e.g., Koch, 2005). That is, participants need to process the task cue in order to know which task is required in the given trial. For this reason, I checked for preparation effects in repeat trials by comparing performance with short and long CTIs. The reasoning for excluding switch trials in this comparison is that they may involve additional preparatory processes.

I also focused on preparation effects on switch costs (switch vs. repeat), because, according to my theory (Meiran, 2000a, 2000b), focus changing takes place in switch trials and does not take place in repeat trials. The reasoning is that task rule implementation amounts to a parameter change in the task execution system or systems (see also Logan & Gordon, 2001). Because these systems cannot be *parameter-less,* they retain their state until the next task goal is known. One parameter in my theory is the stimulus-task set, which dictates the direction of attention to stimulus dimensions. Logan and Gordon's (2001) ECTVA theory has similar parameters which dictate which input will enter response selection. With respect to the focus of attention, it needs to be directed somewhere (namely, directed to a particular dimension). Changing its direction to another dimension would make little sense until it is known which dimension is relevant in the next trial. Therefore, refocusing presumably does not take place in repeat trials (because attention is already focused on the relevant dimension) and is needed in switch trials (because the required dimension has changed). In other words, refocusing is predicted to reflect in switch costs. I would like to note that there are two possible reasons why focusing affects responses in task switches. This may be due to the additional time associated with refocusing which adds to RT**[pls define here]**. Alternatively, switch responses may be slowed because the focus is inappropriately set. No attempt is made here to distinguish between these possibilities.

To summarize, the critical comparisons in this study involved stimulus-task binding and refocusing. Stimulus-task binding was assumed to take place in Groups 1 and 2 (switch and repeat trials alike) because the target stimuli were associated with the competing task beforehand, which was not true for the remaining groups. Attentional refocusing was assumed to take place only in switch trials when the stimuli were bivalent and required focusing to begin with. Therefore, stimulus-task binding effects (and preparation effects on them) were evaluated by examining the repeat condition and by comparing performance in Groups 1 and 2 (binding present) to that in Group 3 (binding absent). Refocusing effects were evaluated by examining switch costs and by comparing performance in Group 3 (refocusing required) to that in Groups 4 and 5 (refocusing not required). In addition, the influence of preparation (CTI) on these component processes was also examined.

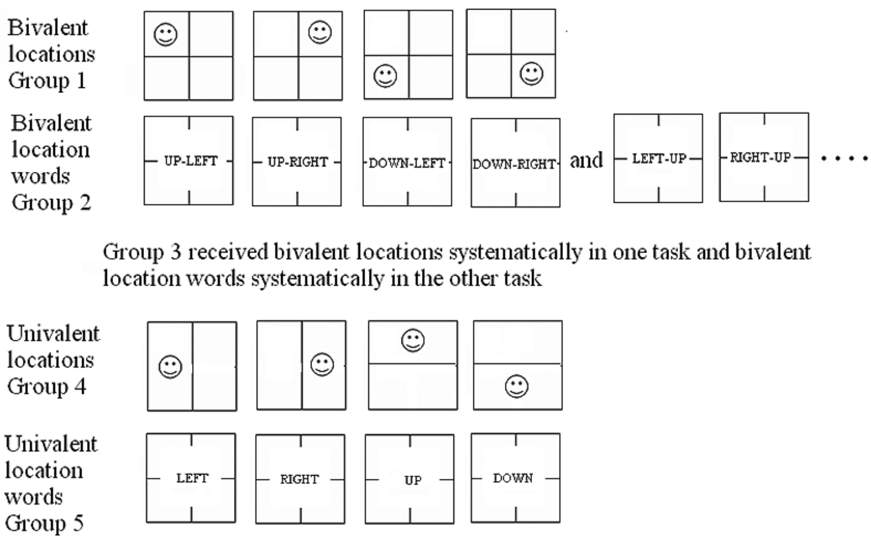

Figure 2. The target stimuli (the task cues were the same for all the groups).

Method

Participants

A total of 40 students from Ben-Gurion University of the Negev or one of its affiliated colleges, Sapir and Ahva, took part in the experiment in return for a partial course credit. All of them were native Hebrew speakers and reported having normal or corrected-to-normal vision and not suffering from reading disabilities.

Eight participants were assigned to each group according to the order of entry into the experiment. The response setup (*up-left* and *down-right* vs. *up-right* and *down-left*, see Figure 1 and Figure 2) was counterbalanced across participants. In Group 3, the stimulus-to-task assignment was also counterbalanced across participants.

Apparatus and Stimuli

The experiment was run on a desktop computer equipped with Pentium III processor and 14-inch (35.56 cm) monitor and controlled by software written using the MEL 2.1 platform. The stimuli were drawn in white on black and included a 2 × 2 grid in the middle of the screen and subtended a visual angle of approximately 3.4° (width) × 2.9° (height). The target for actual positions was the smiley-face character, subtending approximately .3° (width) × .5° (height). The univalent location word stimuli were placed in the center of the grid and subtended approximately .9–1.2° (width) by .5° (height). The bivalent location word stimuli subtended a visual angle of approximately 2.4° (width) by .5° (height). Within the word pair, the position of the vertical information (*up*/*down*) and the horizontal information (*right*/*left*) was randomly determined in each trial. For example, the pair *up-left* was as likely to appear as the pair *left-up*. The task cues were two arrow heads pointing either up and down to indicate the vertical task, or right and left to indicate the horizontal task, subtending approximately .3° × .3° and positioned .7° from the end of the grid.

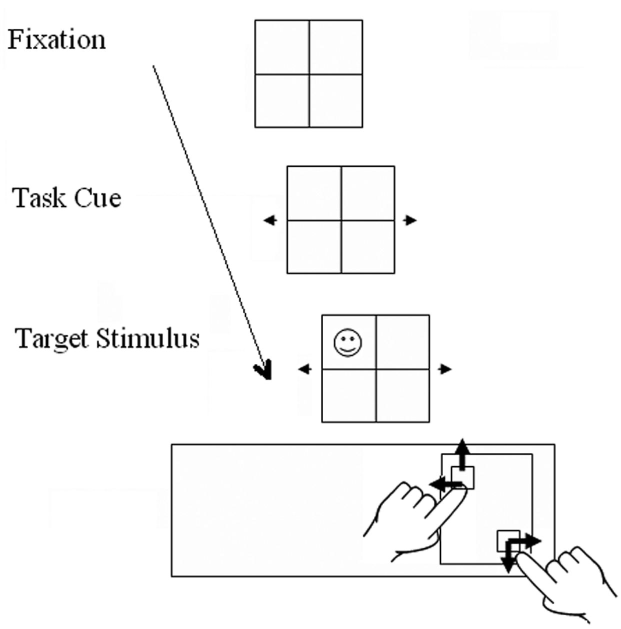

Figure 1. Schematic depiction of the trial sequence with bivalent actual locations.

Procedure

There were 30 practice trials, followed by 8 identical blocks of 64 trials, each. Each trial consisted of the task cue, presented for a randomly chosen CTI of 166 or 1016 ms, followed by a display containing both the cue and the target, which was presented until the response was given. The cue indicated which one of the two tasks to execute vertical or horizontal. The response meaning depended on

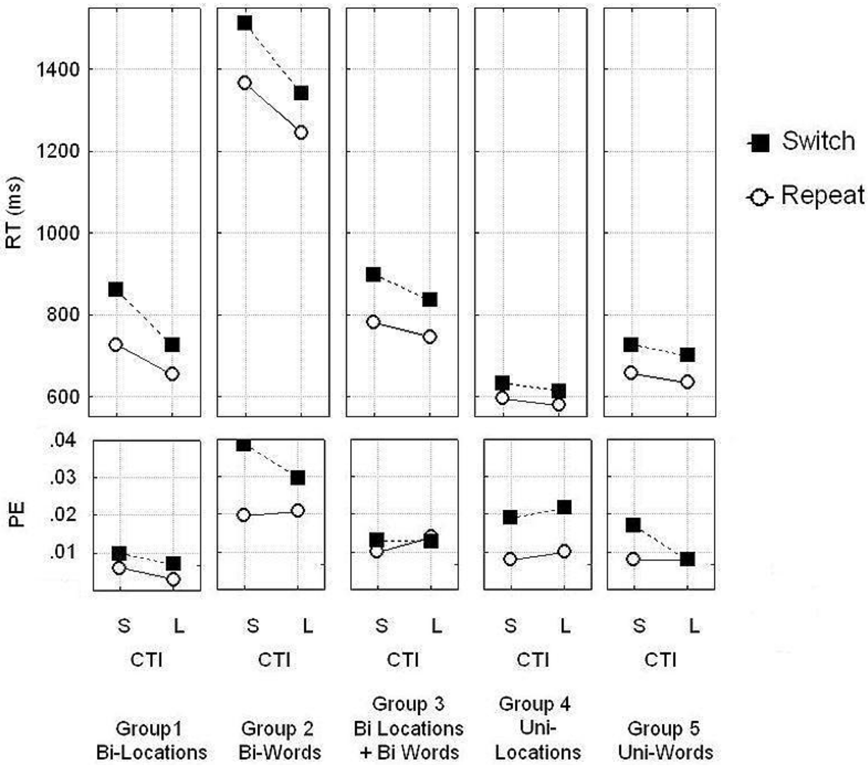

Figure 3. Mean RT and proportion of errors (PE) as a function of cue-target interval, switch, and group. CTI = cue-target interval, S = short CTI, L = long CTI, Bi = bivalent, Uni = univalent. In Group 3, each stimulus type was uniquely linked to one task.

the task, so for example (see Figure 1 and Figure 2) the upper-left key indicated *up* in one task and *left* in another task. The interval from the n-1st response and the nth cue was fixed at 1500 ms. Errors were signaled by a 400 Hz beep lasting for 200 ms. The experimental session lasted a little less than 1 h.

Results

RT

RTs that fell outside the 100–3000 ms range (5.4%) were removed from the analysis. An Analysis of Variance according to CTI, switch and group indicated that all the effects as well as the interactions were statistically significant, most notably, the triple interaction was also significant, $F(4, 35) = 2.67$ (Figure 3). Because all the predictions were directional, they were tested by a series of one sided contrast *t*-tests with an α of .05. As recommended by Kirk (1968, p. 267), I used the pooled MSes across the five groups in all of the focused tests, which is why the df in these contrasts equals 35.

Effects on Repeat RT

First, I examined the effects of stimulus-task binding on repeat RT. The first contrast compared Group 3 to Groups 1 and 2 and it yielded a significant result, $t(35) = 2.48$. This result shows that stimulus-task binding slowed responses. The second contrast compared Group 3 to Groups 4 and 5. This contrast yielded a nonsignificant result, $t(35) = 1.54$. Admittedly, these results are somewhat inconclusive. First, Group 2 responses were exceptionally slow and the focused contrast of Group 1 versus Group 3 was nonsignificant. Second, the comparison with Groups 4 and 5 yielded a marginal result. I will turn now to the main question concerning preparation.

The CTI-related reduction in repeat RT was 73, 120, 34, 16, and 22 ms in Groups 1–5, respectively. It was significant in Groups 1 and 2 and nonsignificant in Groups 3 to 5, $t(35) = 2.45$, 3.99, 0.55, 0.73, and 1.15, respectively. A focused comparison of Group 3 to Groups 1 and 2 (pooled) yielded a significant result, $t(35) = 1.69$. A similar contrast comparing Group 3 to Groups 4 and 5 (pooled) yielded a nonsignificant result, $t(35) = .41$, *ns*. Admittedly, the nonsignificant preparation effects in Groups 3–5 may reflect insufficient statistical power, so that one cannot claim that they are totally absent. Still, it is obvious that the effects are numerically at least twice as large in Groups 1 and 2 (where stimulus-task binding was operative) as in the remaining groups (where stimulus-task binding was inoperative). Furthermore, the claim here is that stimulus-task binding slows task decision time but that such decision takes place even when such binding plays lesser role. Therefore, the present results do not undermine this claim. In any event, the much larger preparation effects seen in conditions in which stimulus-task binding played a major role is in line with Koch and Allport's (2006) conclusions who, based on a different approach, concluded that preparation helps overcoming the adverse effects of stimulus-task binding.

Effects on Switch Costs

Before examining preparation effects, it was essential to show that bivalence alone increased switch costs. Indeed, switch costs in Group 3 did not differ significantly from those in Groups 1 and 2 (pooled), $t(35) = .36$, *ns*. Group 3 differed significantly from Groups 4 and 5 (pooled) in which the stimuli were univalent, $t(35) = 2.57$. This result shows that bivalence *per se* increased switch costs even when the influence of stimulus-task binding was removed (Group 3). With respect to preparation, the CTI-related reduction in switch cost was 70, 51, 28, 3, and 4 ms in Groups 1 through 5, respectively. It was significant in Groups 1 through 3 but not in Groups 4 and 5, $t(35) = 3.73$, 3.15, 1.71, .12, and .28, respectively. Here, the preparation effect was clearly totally absent in Groups 4 and 5 as predicted. The focused comparisons between Group 3 and Groups 1–2 or Groups 4–5 were nonsignificant, however.

Because Group 3 results could be driven by just one target type, I repeated the analysis above, this time limiting it to actual locations data (meaning that Groups 2 and 4 were excluded from the analysis and Group 3 was represented by only half of the data). The restriction to actual locations is justified by the fact that the paradigm employed, until this study, just this target type (see Table 1 for the descriptive statistics). As before, the triple interaction between Group, CTI and Switch was significant, $F(2, 21) = 3.74$. CTI effects on repeat RT were significantly larger in Group 1 (72 ms) than in Group 3 (40 ms), $F(1, 21) = 4.81$. Group 3 did not differ significantly from Group 4 (16 ms) however, $F = 1.84$. As predicted, switch costs did not differ significantly between Group 1 (104 ms) and Group 3 (80 ms), $F = 1.45$, but differed significantly between Group 3 and Group 4 (35 ms), $F(1, 21) = 5.01$. With respect to preparation effects on switch costs, the numerical trend roughly accorded with the predictions but this tend failed reaching significance. Specifically, in Group 3, the reduction in switch cost with increasing CTI was 22 ms ($t(21) = 1.35$, $p = .09$, one-sided test), less than in Group 1 (70 ms) and more than in Group 4 (3 ms). The contrast comparing Group 1 to Group 3, which was not predicted was almost significant, $F(1, 21) = 3.18$, $p = .09$, while the predicted difference between Group 3 and Group 4 was far from significance, $F < 1$. Moreover, the reduction in switch cost in Group 3, failed reaching significance. In summary, the present results support the predictions with respect to preparation effects on repeat RT and group effects on switch costs. The predicted differences regarding preparation effects on switch costs were not significant but there was a numerical trend of preparation in Group 3 which was practically absent in Group 4.

Table 1. Mean RT (ms) in Group 3 according to target type*

	Switch	Repeat	Cost
		Actual locations	
Short CTI	718	627	91
Long CTI	656	587	69
		Location words	
Short CTI	1086	942	144
Long CTI	1008	920	88

* CTI = cue-target interval. The means in the table do not sum up to the totals presented in Figure 3 and the text because of the higher trial exclusion rate (6%) and error rate (2.5%) for location words than for actual locations (2.5% and .5%, respective), which led there to underrepresentation of location word data.

A peculiar finding was that Group 2 generated exceptionally slow responses. This, however, did not result from the presence of exceptionally slow participants in this group. In fact, the fastest participant in this group had a mean RT of 927 ms, which was slower than all the participants in Groups 4 and 5 (individual mean RT ranges 469–841 and 503–890 ms, respectively) and slower than all but one participant in each of Groups 1 and 3 (510–998 and 632–1132 ms, respectively, with the next slowest means being 898 and 922 ms, respectively). Clearly, the tasks in this group were exceptionally demanding.

There are two possible reasons for this effect. First, the stimulus-response compatibility was higher for actual locations. Second, there was greater cue-task compatibility for actual locations. Specifically, the task cues which were used seem to efficiently direct attention to actual locations and seem much less efficient in directing attention to meanings as required for position words. Accordingly, there was a much larger difference in performance between Groups 1 and 2 (bivalent) than between Groups 4 and 5 (univalent). This discrepancy may result from the fact that focusing (and refocusing) was more needed for bivalent stimuli than for univalent stimuli, which is why cue-task compatibility was more crucial for the bivalent condition.

Proportion of Errors (PE)

A parallel ANOVA on PE revealed two significant main effects, Switch, $F(1, 35) = 12.63$, representing a difference between PE = .02 in switch trials and PE = .01 in task repetition trials, and Group, $F(4, 35) = 2.85$. The PE was .01 in all the groups except for Group 2, in which it was .03. Critically, the triple interaction was far from significant, $F < .4$. These results indicate that the critical RT effect is not compromised by speed-accuracy trade-off.

Discussion

The present results show, for the first time, that bivalence alone increases switch costs (Groups 3 vs. Groups 4,5). This effect supports the idea that task switching involves changing the attentional focus from one dimension to another. Stimulus-task binding (Groups 1, 2 vs. Group 3) on the other hand, affected repeat RT and did not significantly affect switch costs.

The current emphasis was on preparation effects. The results show that responses in task repetitions became quicker with increasing CTI and more so when there was stimulus-task binding (Groups 1 and 2). Similarly, switch costs decreased with increasing CTI and only so when the stimuli were bivalent (Groups 1–3). These results support the assumption that task preparation helps in task decision in general and in overcoming the adverse effects of stimulus-task binding in specific. They also support the notion that task preparation helps in directing attention to the relevant stimulus dimension. The fact that the number of target stimuli (8) in Group 3 was larger than in the remaining groups (4) cannot explain the results. Had this been critical, one would predict generally slower responses in this group, an effect that was not found.

The present results concerning task decision support and extend previous findings indicating that such decision is made in every trial, at least in paradigms involving randomly ordered tasks (Koch, 2005). Similar influences on switch and repeat trials were observed following explicit task expectations (Dreisbach, Haider, & Kluwe, 2002; Koch, 2005; Sohn & Carlson, 2000), implicit expectations (Gotler, Meiran, & Tzelgov, 2003; Koch, 2001; Heuer, Schmidtke, & Kleinsorge, 2001), and with an increasing number of task alternatives (Biederman, 1973; Meiran, Hommel, Bibi, & Lev, 2002).

The present conclusions regarding focus changing are in line with theories positing some form of focus change during task switching, including Gilbert and Shallice (2002), Kleinsorge and Heuer (1999), Logan and Gordon (2001), Mayr and Kliegl (2003), Meiran (2000a), Rogers and Monsell (1995), Rubinstein et al. (2001), and Sohn and Anderson (2001). In agreement with most of these theories, the attentional focusing required in task switching seems to involve abstract rather than concrete features. Specifically, CTI-related reduction in switch cost was found when task switching involved a shift from locations to location words or vice versa (Group 3).

The fact that switch costs were observed with univalent stimuli is explained by the change in response meaning associated with task switching. Specifically, a switch from, say, the vertical task to the horizontal task was associated with a change in meaning of the upper-left key press (see Figure 1) from *up* to *left*. Such a pattern of switch cost is exactly what is predicted based on my model (Meiran, 2000a) and has been replicated several times already (e.g., Meiran, 2000b, 2005). With respect to the lack of CTI effects on switch costs in these groups, one could argue that univalent stimuli made cue processing redundant. However, CTI effects on switch cost were observed in Group 3, in which cue processing was equally redundant because each target stimulus indicated its response uniquely without the need to use the cue.

The results of two recent papers may seem at odds with my conclusions because they found that stimulus-task binding affected switch costs and not only repeat RT. Rubin and Koch (2006) studied the same spatial paradigm that was used in the present Group 1. Their critical manipulation involved coloring the target stimulus so that each task was associated with one color in all or most of the trials (depending on the experiment). When the color-task assignment changed, switch costs increased, especially when the CTI was short. Koch and Allport (2006) studied switching between numerical judgment tasks and created a situation in which each subset of target digits was assigned to a different task. A reversal of the stimulus-task assignment resulted in slowing, which was more pronounced for switch trials than for repetition trials, again especially when the cue-target interval was short. The common denominator of these two studies is that the stimulus-task pairing was subtle and was not announced unlike the present manipulation which was clear and was announced. The reason why these more subtle forms of task cuing affect switch trials differentially should be explored in the future.

Finally, an interesting implication of the refocusing results is that switch cost may *not* be confined to conditions involving actual task switching. Switch costs are found whenever a switch entails a processing change such as a focus change. Specifically, Meiran and Marciano (2002) required participants to perform same-different judgments. In one of their groups, participants switched between judgments made on the basis of figure fill and judgments made on the basis of shape. In another conditions, there was a switch in the assignment of *yes* and *no* responses to response keys. These switches, despite not requiring task switching, produced substantial switch costs. Similar costs were found following shifts in the high-versus-low reference point in numerical judgments (Schneider & Logan, in press) and following changes in response modalities (Philipp & Koch, 2005).

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Nachshon Meiran

Department of Psychology
Ben-Gurion University of the Negev
Beer-Sheva
Israel, 84105
Fax + 972 8 6472932
E-mail nmeiran@bgumail.bgu.ac.il

