Abstract

Task-switching paradigms are well-researched paradigms and the effects of switching are well established. Baddeley et al. (2001) required participants to complete lists of forty simple addition and subtraction problems in either switch or blocked conditions while also occasionally being subject to a concurrent verbal secondary task. Participants in that study exhibited a significant mixing cost during controlled trials, and furthermore exhibited a significant increase in mixing cost when the secondary task was introduced. The authors concluded the phonological loop to be an important mechanism in the maintenance of a switch plan, supporting models of verbal control of action. The present study seeks to investigate whether these effects of switching and verbal self-instruction apply in equal strength to every participant. Individual difference measures are a useful tool in investigating well-established effects of this kind. To what extent can measures of individual difference reveal subtleties about the mechanisms individuals use to switch effectively? In the present study, participants were subject to the same addition and subtraction problems and secondary task as Baddeley et al. (2001). In addition, participants completed 5 post-experiment questionnaires and tests designed to measure and group participants according to cognitive style, strategy selection, and working memory capacity. Three of these measures were subsequently used as covariates of analysis. Individual differences in strategy selection revealed differential performance on the primary addition and subtraction task for participants who reported using non-verbal strategies. Implications for models of verbal control of action and further research are discussed.

Introduction

Individual differences form an important aspect of cognitive research. For instance, individual differences in working memory capacity have been shown to impact strategy selection and implementation, while differences in cognitive style impact the medium of material best suited for the individual (Beilock & Decaro, 2007; Mayer and Massa, 2003). In fact, measures of individual difference have been applied to wide range of cognitive research domains and tasks with established effects in attempts to explain individual variance (Richardson, 1977; Daneman & Carpenter, 1980; Davis, 1983; Stanovich, 1986; Kirby, 1988).

Task-switching paradigms are an example of one such domain, and are known to produce replicable and reliable effects. One such effect of switching is mixing cost and refers to the difference in task performance in switching and non-switching (blocked) conditions. It is the cost associated with having to remember to switch and appears under conditions of endogenous control. In lieu of external signs or cues, the burden is on the individual to internally set-up, maintain, and operate a task-specific program to appropriately switch (Baddeley et al, 2001). This burden, absent in blocked conditions of task-switching paradigms, is manifest in the mixing cost as the difference in performance between blocked and switching conditions.

Mixing cost has been investigated in a number of different modalities and conditions (Baddeley et al., 2001; Miyake et al., 2004; Emerson and Miyake, 2003; Kray et al., 2004). These studies aimed to investigate the question: in the absence of external cues, how do people effectively switch between tasks? Specifically, in Baddeley et al. (2001), participants were required, without external cues, to add or subtract “1” from single digit numbers appearing in a two-column list. Half of these lists were completed in a blocked condition in which the all operations within each column were the same (i.e. all addition in the left column, all subtraction in the right column). Half of these lists were completed in an alternating condition in which participants switched operations on every problem (i.e. add, subtract, add, subtract…). Using this set-up, participants exhibited the expected mixing cost. That is, it took participants longer to complete the alternating lists, indicative of the cost associated with maintaining an action plan to guide switching behavior. The authors sought to investigate the mechanism by which this action plan was maintained and, following previous studies implicating his own working memory model, Baddeley et al. (2001) included several secondary tasks to be performed concurrently with the primary arithmetic task (Baddeley et al., 2001; Allport, Styles, & Hsieh, 1994). Using the Baddeley and Hitch (1974) working memory framework, the authors created dual-task conditions designed to selectively interfere with the different components of working memory: the central executive, the visuospatial sketchpad, and the phonological loop. Of these, the secondary task designed to interfere with the phonological loop interacted with the requirement to switch. Participants experienced a significant increase in completion time for alternating lists under conditions of phonological interference compared to control conditions. Participants experienced no such increase for blocked lists and this interaction was regarded as indicative of a common mechanism, whereby the secondary task occupies the resource utilized in the maintenance of the plan to switch (Baddeley et al., 2001). As a result of a significant interaction between alternating lists and phonological loop suppression, the authors concluded the phonological loop to be a mechanism by which action plans can be maintained and controlled. One interpretation of this result was the utilization of verbal self-instruction as an internal cue-mechanism to maintain the switching program in the absence of exogenous cues (i.e. subvocalizing "plus"-"minus"-"plus" using the phonological loop).

The concept of verbal control of action through sub-vocalization or so-called “inner speech” is not a recent one and appeared most prominently in the work of Luria (1959) and Vygotsky (1962). Baddeley et al. (2001) provided a reliable framework with which to examine this control. The aim of the present study is to investigate the role individual differences play in the verbal control of action and the extent to which they can reveal subtleties in how participants’ effectively switch between tasks. Towards this end, this research utilized a straightforward task-switching paradigm modeled after Experiment 2 of Baddeley et al. (2001). Participants completed simple addition and subtraction problems in both blocked and alternating lists, while concurrently performing a verbal secondary task. Based on the results of Baddeley et al. (2001) we expected an increase in mixing cost when participants had to concurrently perform the secondary task, which is assumed to reflect verbal working memory interference. We also collected measures of individual differences in cognitive style, strategy selection, and verbal working memory capacity in order to group and compare different subsets of participants.

Method

Participants

36 University of California, San Diego (UCSD) undergraduates participated for course credit.

Materials

8 lists consisting of 40 numbers were created using random single digit numbers ranging from 1 to 8. Each list was divided into two columns, with 20 numbers in each column. The primary task was to add or subtract "1" from each digit, beginning at the top of the left-hand column and proceeding down the column before transitioning to the right-hand column. In the blocked condition, the participant was instructed to exclusively perform addition on the numbers

appearing in the left-hand column, while exclusively performing subtraction on the numbers appearing in the right-hand column. In the switching condition, participants were instructed to alternate between addition and subtraction on every problem in an ABAB fashion. The lists were coded using MATLAB (32bit R2010b - version 7.11.0.584) and Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997; Kleiner et al, 2007). Lists were presented visually on a computer screen. Participants entered their responses manually using the keyboard and every input was recorded and time-stamped using MATLAB. A metronome app for IPhone (Metronome Pro by EUMLab) was used to aid participants in the secondary task. Pre-prepared lists were used to record errors on the secondary task and to prompt the experimenter as to the order of conditions. This set-up was an adaptation of Experiment 2 in Baddeley et al. (2001), using a paradigm first utilized by Jersild (1927).

Five post-experiment tests were also gathered and administered. A verbal working memory task, cognitive style questionnaires, and individual strategy report questionnaires were used to separate participants based on three dimensions of difference: verbal working memory capacity, cognitive style, and strategy selection. The Automated Reading Span Task (RSPAN) was adapted from Daneman & Carpenter (1980) and presented using Inquisit software distributed by Millisecond Software. The Visual-Verbal Questionnaire (VVQ) and the Santa Barbara Learning Styles Questionnaire (SBQ) were used to measure the verbal and visual preferences of subjects (Mayer and Massa, 2003). The VVQ is adapted from Kirby et al. (1988) and contains twenty questions, while the SBQ is first used by Mayer and Massa (2003) and contains 6 questions [see Appendix:1,2]. Subjects rated agreements with statements about visual and verbal modes of thinking and learning on a 7-point scale, ranging from “Strongly Disagree” to “Strongly Agree”. Raw scores were collected from participant responses and used to group subjects into those with either a visual or verbal cognitive style. Subjects also completed free response and forced choice strategy response questionnaires. They were informed that there was no right or wrong method or procedure and they could take as long as needed in order to faithfully recount the steps in any strategy they used during the primary task. These instructions were to encourage participants not to modify their self-reported strategies. Participants were instructed to write down the processes they used to solve the previous problem, both in control conditions and conditions involving the secondary suppression task. Subjects were asked primarily to give a free-response version of their strategy, followed by a forced-choice version [see Appendix:3,4]. Strategy questionnaires were filled out in this specific order so as to not affect the free-response answers. Responses to the free-response strategy questionnaire were grouped into one of three classes of response and assigned a point value correlated with class. Scores were then used to separate subjects based on self-reported strategy. With the exception of the Automated RSPAN task, all questionnaires were administered using GoogleForms.

Procedure

First, participants were greeted, signed a consent form, and listened to instructions detailing both the primary and the secondary task. Participants first practiced the secondary task, articulatory suppression, in isolation. The articulatory suppression task was adapted directly from Experiment 2 of Baddeley et al. (2001) and required participants to continuously repeat, in order, either the months of the year (i.e. June, July, August) or days of the week (i.e. Monday, Tuesday, Wednesday) at a rate of one item per second in time with a metronome. No participant required more than one practice trial to successfully perform the secondary task in isolation. One half of trials required recitation of months and half the trials required recitation of days and each trial began at a random point in the sequence to prevent overlearning.

Second, participants practiced the primary task in isolation by completing one blocked and one alternating list. Following these practice trials, participants began experimental trials. Before each trial, a fixation cross was displayed on the screen. At this point, the experimenter prompted subjects as to whether the immediately subsequent list would be blocked or alternating and whether the secondary suppression task was to be concurrently performed. One half of the participants began with a blocked list and one half began with an alternating list before they proceeded in either an ABBA or BAAB fashion, respectively. Subjects used the keyboard numpad to input a response at which point the response appeared next to the digit in the list. Participants then used “ENTER” to confirm their response, or changed their response by pressing another key to select a different number. On every other trial, subjects were prompted to perform the primary and secondary task simultaneously. Before such trials, the experimenter articulated the first two items in the sequence to be recited. Participants repeated these same two items before continuing on in the sequence. After four such utterances, the participant was prompted to “BEGIN” at which point the participant pressed the spacebar and the trial began. After participants confirmed their final response in each list, a fixation cross was displayed again and subjects waited for instructions before the next list. Subjects completed 8 experimental lists: 2 lists in each combination of task and condition. During suppression trials, the experimenter manually recorded any errors in the secondary task on pre-prepared sheets. The dependent measure in this experiment was total time taken to complete each list, and was recorded automatically using MATLAB. After each subject had completed all 8 experimental lists sets they provided responses to 4 post-experiment questionnaires. Following completion of the questionnaires, participants received instructions about and completed the Automated RSPAN test. Data from the primary task, secondary task, and post-experiment questionnaires and tests was used to determine the effect of individual differences on verbal control of action in task-switching paradigms.

Results and Discussion

Preliminary Results

Figure 1 shows average time of completion across the two conditions for both blocked and alternating lists. This completion time data was analyzed using a two-way analysis of variance (ANOVA) in which Task (blocked vs. alternating) and Condition (control vs. articulatory suppression) were within-subject factors. Analysis showed main effects of Condition $F(1,35) = [69.84]$, $p < .0001$, and Task, $F(1,35) = [97.20]$, $p < .0001$, and an interaction between the factors, $F(1,35) = [20.95]$ $p < .0001$. In addition, error data was collected on both the primary and secondary task. All subjects included maintained greater than 90% mean accuracy on the primary task and made fewer than 15 total errors on the secondary task.

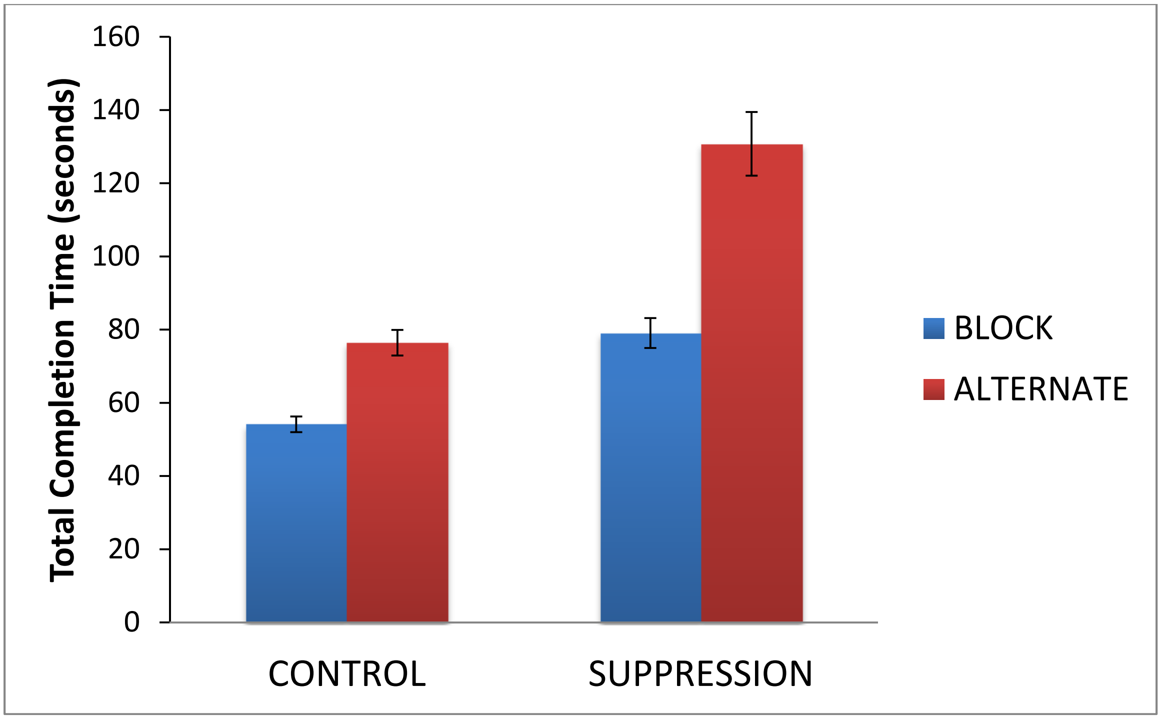

Figure 1. Time taken to complete blocked and alternating lists as influenced by a concurrent articulatory suppression task.

Preliminary Discussion

The results of this initial analysis bear resemblance to the results of Baddeley et al. (2001) in terms of the main effects of Task, Condition, and the interaction effect between the factors. One difference of note is the difference in the overall length of completion time between the present study and Baddeley et al. (2001). This difference may be reflective of the main difference in methodology of the two studies. In Baddeley et al. (2001), participants performed all computations by hand on a paper list whereas in the present study an external keyboard mediates participant responses. Despite this, the preliminary results of this experiment give little reason to doubt the conclusions made in Baddeley (2001) that, generally, participants recruit verbal control of action while performing the switch task. Further analysis was conducted in order to investigate the extent to which individual difference measures predict performance under conditions of switching with concurrent articulatory suppression. Participants were measured along three dimensions of difference, using five different tests and questionnaires.

Measures of Individual Differences and Secondary Results

Visual-Verbal Questionnaire

The Visual-Verbal Questionnaire used here was adapted from Kirby et al (1988). It consisted in twenty statements regarding preference and comfort using verbal and visual material. There were ten questions pertaining to each dimension of style (visual vs. verbal), and each dimension was separated into five questions in the positive valence and five questions in the negative valence [see Appendix:1]. Participants were instructed to rate their agreement with each of the twenty statements using a 7-point scale which ranged from “Strongly Disagree” to “Strongly Agree”.

We quantified cognitive style by assigning a point value (1-7) to each response and then separating out four raw scores based upon the four combinations of style and valence (positive-verbal, positive-visual, negative-verbal, negative-visual). Style scores averaged across the five statements ranged from 2 to 5 for positive-visual scores (M=3.57, SE=.111), 4 to 6.2 for negative-visual scores (M=5.09, SE=.090), 1.8 to 5 for positive-verbal scores (M=3.68, SE=.104), 2.4 to 5 for negative-verbal scores (M=3.91, SE=.092). Upon initial analysis, this measure was determined not to be internally valid. Within participants, responses to statements of one combination of valence and style (i.e. positive-visual) had no correlation to statements in the same style but with opposite valence (i.e. negative-visual). If this test was internally consistent, it was expected that a participant who agrees with a positive-visual statement should trend towards disagreement with a negative-visual statement. Since neither statements of visual nor verbal style exhibited such a correlation between valences, the Visual-Verbal Questionnaire was not included as a factor of variance in secondary analysis.

Santa Barbara Learning Styles Questionnaire

The Santa Barbara Learning Styles Questionnaire was adapted from Mayer and Massa (2003). It consisted in six statements regarding preference and comfort using visual and verbal material. Three questions each were devoted to each dimension of style (visual vs. verbal). Compared to the Visual-Verbal Questionnaire, the Santa Barbara Learning Styles Questionnaire statements were more explicit in asking about cognitive style [see Appendix:2]. Participants were instructed to rate their agreement with all six statements using a 7-point scale which ranged from "Strongly Disagree" to "Strongly Agree". We quantified cognitive style by assigning a point value (1-7) to each response before separating scores into two raw scores based on the two dimensions of style (visual vs. verbal). Style scores averaged across the three statements ranged from 3.33 to 7 for visual scores (M=6.24, SE=.130) and from 1.33 to 6.33 for verbal scores (M=4.21, SE=.243). We included these raw scores as between-subject factors of covariance in subsequent analysis. Neither verbal scores [$F(1,11)=0.583$, $p=0.461$] nor visual scores [$F(1,11)=1.900$, $p=0.195$] were significant factors of covariance.

Reading Span Task

The Automated Reading Span Task was adapted from Daneman and Carpenter's (1980) RSPAN and administered using Inquisit 3.0.6.0 computer software distributed by Millisecond Software LLC (2012). It is known to be a reliable measure of working memory capacity and was used to measure the verbal working memory capacity of participants (Conway et al., 2005). Participants were required to read sentence-letter strings (i.e. I like to run in the park; Q). After reading each sentence, participants made judgments about whether the sentence made sense. After making such judgments, the letter portion of the string was flashed and participants were required to hold the letter in working memory. At the end of the series participants recalled as many letters as possible in the order in which they were seen from twelve possible letters presented visually on the screen. Both Absolute scores (consisting of the total number of letters recalled from perfectly recalled sets) and Total scores (consisting of total numbers of letters recalled correctly) were collected and had a possible range of 0-75. Absolute scores ranged from 19 to 75 (M=44.22, SE=2.435), while Total scores ranged from 39 to 75 (M=61.92, SD=1.472). Both measures were included as between-subject factors of covariance in subsequent analysis. Neither Absolute scores [$F(1,11)=0.206$, $p=0.659$] nor Total scores [$F(1,11)=1.888$, $p=0.139$) were significant factors of covariance.

Strategy Selection Questionnaire – Free Response

The Free Response version of the Strategy Selection Questionnaire was created in order to garner self-reports regarding strategy selection from participants. Participants were asked to report any conscious strategies they put forth to aid in completion of the primary task. The questionnaire consisted of two questions. The first prompted participants to note and contrast any strategies they put forth as they related to Alternating and Block tasks during control conditions. The second prompted participants to note and contrast any strategies they put forth as they related to Alternating and Block tasks during Articulatory Suppression conditions [see Appendix:3]. The strategies were coded without any reference to subject number, performance on the primary task, or results of other individual difference measures. Each written strategy was classified into one of the following three categories:

1. A verbal strategy. Examples include the following: “In the switch trials, I had to say in my head "add" "minus" over again;” “when doing "switch" trials, I tried to keep in mind whether I had to add or subtract by saying to myself "add" and then "minus" repeatedly;” and “in my head I named out whether the problem was addition or subtraction, and followed the pattern.”

2. A visual strategy. Examples include the following: “I ended up having to look at the previously answered questions to see if I was supposed to be adding or subtracting;” “I referred to the previous answer for guidance- something I did not need when I did not have to recite;” and “When asked to switch, I often looked at the number above it to reference whether or not I was supposed to add or subtract.”

3. An intuitive strategy. Examples include the following: “Just winging it, trying to move on to the next problem somewhat quickly so I still remembered what I had just done;” “no conscious effort, just trying to stay focused;” and “I feel I used less or no strategy when doing while reciting.”

Responses to both questions were combined into one strategy-pair (strategy type in response to question one – strategy type in response to question two) and coded into one of three categories. Three types of code pairs successfully described every participant, with fairly equal distribution and are as follows:

1. A verbal, verbal strategy pairing. This includes participant who reported using a verbal strategy during control conditions and maintained a verbal strategy during articulatory suppression conditions. Twelve participants reported this pair of strategies.

2. A verbal, non-verbal strategy pairing. This includes participants who reported using a verbal strategy during control conditions and switched to a visual or intuitive strategy during articulatory suppression conditions. Fourteen participants reported this pair of strategies.

3. A non-verbal, non-verbal strategy pairing. This includes participants who reported using a visual or intuitive strategy during control conditions and maintained a visual or intuitive strategy during articulatory suppression conditions. Ten participants reported this pair of strategies.

In addition, no participants reported a non-verbal, verbal strategy pairing. Strategy selection, based upon pairing factors of covariance in secondary analysis. A significant three-way interaction effect was found between the factors of Task, Condition, and Strategy [$F(1,34)=5.238$, $p=.0284$]. Figure 2 displays average time of completion in each Task and Condition for each of the three strategy pairing groups.

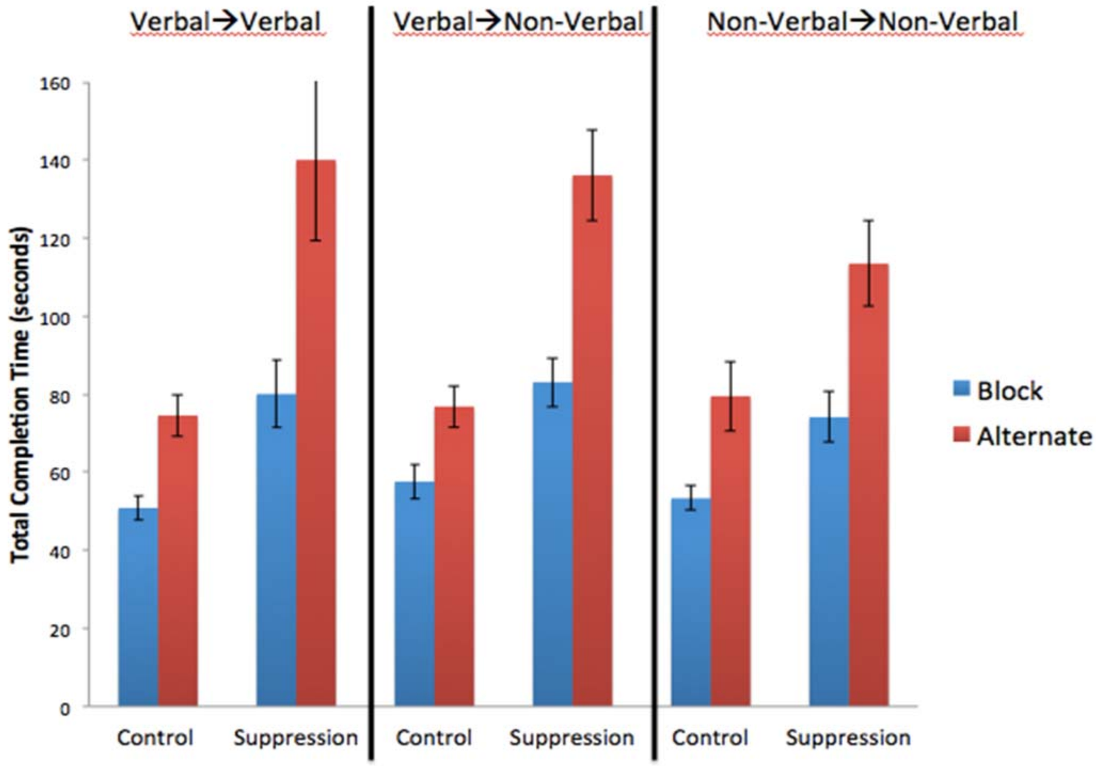

Figure 2. Time taken to complete blocked and alternating lists as influenced by a concurrent articulatory suppression task. The left group represents participants who self-reported using a verbal strategy in both control and suppression conditions. The middle group represents participants who self-reported a verbal strategy in the control condition and a non-verbal strategy in the suppression condition. The right group represents participants who self-reported using a non-verbal strategy in both control and suppression conditions.

In order to further investigate the three-way interaction, separate two-way analyses of variance (ANOVAs) were run for each subgroup of strategy pairing participants in which Task and Condition were within-subject factors. Strategy Pair 1 (verbal-verbal) participants showed main effects of Task [$F(1,11)=29.64$, $p=.0002$] and Condition [$F(1,11)=22.79$, $p=.0005$] and an interaction between the factors [$F(1,11)=10.43$, $p=.008$]. Strategy Pair 2 (verbal-nonverbal) participants showed main effects of Task [$F(1,13)=70.22$, $p<.0001$] and Condition [$F(1,13)=47.46$, $p<.0001$] and an interaction between the factors [$F(1,13)=19.76$, $p=.0006$]. Strategy Pair 3 (nonverbal-nonverbal) participants showed main effects of Task [$F(1,9)=17.94$, $p=.002$] and Condition [$F(1,9)=46.45$, $p<.0001$], however no interaction between the factors was found [$F(1,9)=1.093$, $p=.323$].

Strategy Selection Questionnaire – Forced Choice

The Forced Choice version of the Strategy Selection Questionnaire was created in order to support the self-reports regarding strategy selection giving by participants. Participants responded to two Yes/No questions regarding strategy selection. When originally developed, only two questions were included; one question regarding verbal strategy selection and one question regarding visual strategy selection [see Appendix:4]. However, the Free Response version of the Strategy Selection Questionnaire provided much richer information than simple reports of visual or verbal strategies. Examples of intuitive strategies and changing of strategies between Conditions were self-reported by subjects which the Forced Choice version failed to take into account. Due to the discrepancy between the information gathered from participant responses in the Free Response and the Forced Choice, scores on the Forced Choice Questionnaire were not included as a factor covariance in secondary analysis.

Secondary Discussion

Based on the results of the preliminary analysis we concluded, like Baddeley et al. (2001), that the verbal control of action forms a general mode of behavioral control. Five individual difference tasks and questionnaires were administered to subjects in order to investigate the role of individual difference on this general mode of behavioral control. Two of the measures, the Visual-Verbal Questionnaire and the Strategy Selection Questionnaire (Forced Choice Version) were discarded before any secondary analysis took place and thus were not included as possible factors of covariance. The remaining three measures were all included as possible factors of covariance. Based on the results, we conclude there to be a subgroup of individuals who, in contrast to the general trend, recruit non-verbal strategies in order to maintain a switch plan in both control and articulatory suppression conditions. This subgroup differed from all other results in that no interaction between Task and Condition was found and participants of this subgroup was significantly more successful in terms of task performance. Consistent with these results is the conclusion that the secondary task of articulatory suppression was less effective at interfering with the ability of this subgroup to maintain a plan to switch. This is indicative of the subgroups recruitment of a different mechanism than the phonological loop, contrary to the general trend. If this subgroup did indeed recruit their phonological loop, one would expect similar performance in the suppression conditions as the verbal strategy users. However, based on self-reported strategies and performance in suppression conditions we conclude these participants to be recruiting a mechanism other than verbal working memory.

General Discussion and Directions for Future Research

This study sought to investigate the role individual difference plays in the verbal control of action during a task-switching paradigm. This study supports the original findings of Baddeley et al. (2001) in concluding that verbal self-instruction is in fact a general strategy employed during this task. Thus, verbal working memory is indeed an effective mechanism in maintaining and operating action plans. Furthermore, this study also sheds light on the subgroup of participants who employ non-verbal strategies. These participants, who self-reported using a nonverbal-nonverbal strategy pairing, did not exhibit significant impairment in alternating lists as a result of the secondary task. However, the mechanism by which participants realize this strategy remains unclear. The results of this study suggest that further research into this subgroup of participants with a focus on this question may prove fruitful.

The first step in future research would need to be an increase in the number of participants. The magnitudes of the main and interaction effects found in both this study and Baddeley (2001) are such that increasing the number of participants is unlikely to modulate them. However, more observations would allow for more precise combinations of individual difference measures; it may prove fruitful to target participants with, for instance, visual cognitive style, high visual working memory capacity, and who self-report using a visual strategy. Analogous attempts in the present study were made, but constrained by a lack of statistical power.

The mechanism recruited by this subgroup of participants may be is an interesting subject for future research. Following the logic used in this experiment, one would expect the visuospatial sketchpad to be involved in some capacity. In Experiment 5 of Baddeley (2001), he includes two non-verbal interference tasks with the intention of disrupting the visuospatial sketchpad. One issue with his approach, which he himself notes, is the separate components which comprise the visuospatial component of working memory. He includes a spatial and a motor to task which would serve to interfere with spatial or kinesthetic portions, but his findings do not support the conclusion that participants utilize these components of working memory. The present study, however, provides evidence of a non-verbal, in fact, a predominately visual, strategy. Possible future research may seek to explore this further by incorporating a secondary task designed to specifically impact the visual component of the visuospatial sketchpad.

In conclusion, we suggest that our study supports the general use of the phonological loop during task-switching paradigms. In addition, we believe to have revealed a small bit of information regarding alternative strategies employed in the maintenance of switching plans and the control of action.

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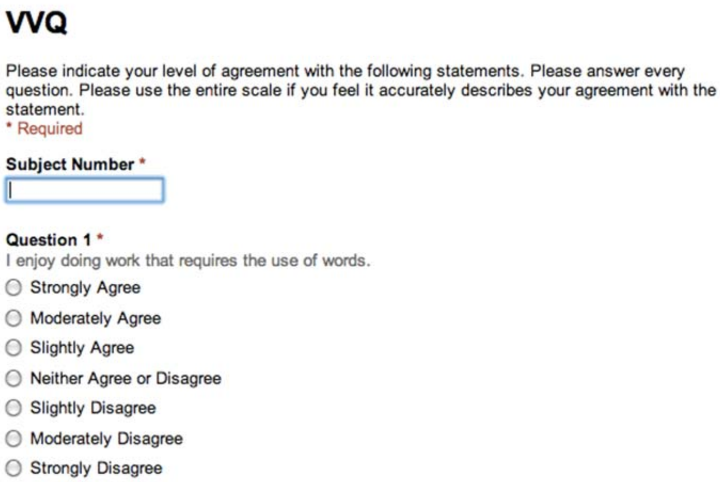
APPENDIX

1. VVQ format and list of all included questions, grouped by style and valence.



VVQ

Please indicate your level of agreement with the following statements. Please answer every question. Please use the entire scale if you feel it accurately describes your agreement with the statement.
* Required

Subject Number *

Question 1 *
I enjoy doing work that requires the use of words.
- Strongly Agree
- Moderately Agree
- Slightly Agree
- Neither Agree or Disagree
- Slightly Disagree
- Moderately Disagree
- Strongly Disagree

Positive-visual

Question 4: I find illustrations or diagrams help me when I'm reading

Question 10: I like newspaper articles that have graphs.

Question 14: When I read books with maps in them, I refer to the maps a lot.

Question 16: The old saying "a picture is worth a thousand words" is certainly true for me.

Question 20: I find maps helpful in finding my way around a new city.

Negative-visual

Question 2: I don't believe that anyone can think in terms of mental pictures.

Question 6: I have a hard time making a "mental picture" of a place I've only been to a few times.

Question 8: I seldom use diagrams to explain things.

Question 12: I don't like maps or diagrams in books.

Question 18: I have always disliked jigsaw puzzles.

Positive-verbal

Question 1: I enjoy doing work that requires the use of words.

Question 3: I enjoy learning new words.

Question 5: I can easily think of synonyms for words.

Question 9: I prefer to read instructions about how to do something rather than have someone show me.

Question 11: I have better than average fluency in using words.

Negative-verbal

Question 7: I read rather slowly.

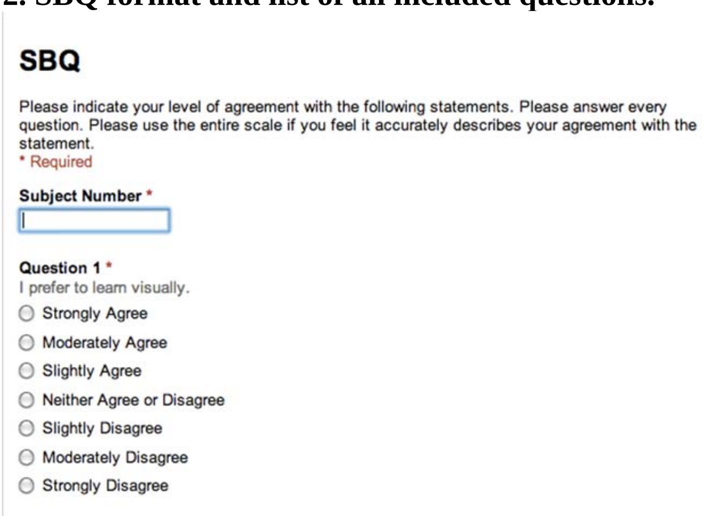
Question 13: I spend little time attempting to increase my vocabulary.

Question 15: I dislike word games like crossword puzzles.

Question 17: I dislike looking up words in dictionaries.

Question 19: I have a hard time remembering the words to songs.

2. SBQ format and list of all included questions.



SBQ

Please indicate your level of agreement with the following statements. Please answer every question. Please use the entire scale if you feel it accurately describes your agreement with the statement.
* Required

Subject Number *

Question 1 *
I prefer to learn visually.
- Strongly Agree
- Moderately Agree
- Slightly Agree
- Neither Agree or Disagree
- Slightly Disagree
- Moderately Disagree
- Strongly Disagree

Question 1: I prefer to learn visually.

Question 2: I prefer to learn verbally.

Question 3: I am a visual learner.

Question 4: I am a verbal learner.

Question 5: I am good at learning from labeled pictures, illustrations, graphs, maps, and animations.

Question 6: I am good at learning from printed text.

3. Strategy Selection Questionnaire (Free Response Version)

Strategy Questionnaire

The experimenters are interested in the steps you used to accomplish the problems you just completed. There is no right or wrong method or procedure and you may take as long as needed in order to faithfully recount the steps in any and all strategies you used. Please write down your memory of all the steps and processes you went through and any strategies you may have used in accomplishing the previous task.

If you have any questions, please ask your experimenter.

* Required

Subject Number *

How did you accomplish problems in the trials where you were asked to "switch"? *
How, if at all, did this differ from trials where you were asked to "stay"?

How did you accomplish problems in the trials where you had to continuously recite? *
How, if at all, did this differ from trials where you did not have to recite?

4. Strategy Selection Questionnaire (Forced Choice Version)

Strategy Questionnaire 2

The experimenters are interested in the steps you used to accomplish the problems you just completed. There is no right or wrong method or procedure and you may take as long as needed in order to faithfully recount the steps in any and all strategies you used. Please answer the following questions, as they pertain to you.

If you have any questions, please ask your experimenter.

* Required

Subject Number *

Did you recruit a verbal strategy? *

For example, did you say anything silently to yourself, or imagine hearing anything?

- [ ] Yes
- [ ] No

Did you recruit a visual strategy? *

For example, did you imagine anything in your mind's eye, or visualize anything on the screen?

- [ ] Yes
- [ ] No