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Running Head: PERSEVERATION IN THE GO/NO-GO TASK

# Examining Perseveration in Three-Year-Olds Using the Go/No-Go Task

Lauren Burakowski

Carnegie Mellon University

Abstract

Perseveration, or responding in a previously relevant way that is no longer appropriate, has been traditionally studied in the context of the Dimensional Change Card Sort task (Zelazo, 2006). This study uses a modified version of the Go/No-Go task, which controls for spatial location of the test cards and perceptual conflict of the display, to examine perseveration. Three-year-old children were found to perseverate in the dimensional switch condition; they could not flexibly modify responding behavior and continued to respond to stimuli when no longer appropriate. Children did not perseverate in the non-dimensional switch condition. These findings suggest that perceptual conflict and spatial location associations are not necessary for perseveration errors.

# Examining Perseveration in Three-Year-Olds Using the Go/No-Go Task

Perseveration is observed in both children and adults. Children are prone to the phenomenon, often repeating behaviors at inappropriate times. A young infant will watch an adult hide a toy under a blanket and successfully reach for it several times, and then reach for the same location when the toy is subsequently hidden under a different blanket (Piaget, 1954; Munakata, 1998). Adults perseverate in more subtle ways, such as continuing to search for one's morning coffee cup in the cabinet where it was previously kept before a reorganization of the kitchen.

Young children have difficulty behaving flexibly at times, such as when switching rules in the middle of a game. A child can tell you that a rule has been changed, but she may fail to apply the new rule and continue playing the game by the old rule. Understanding this behavior is important in describing the development of executive function, which includes a set of processes responsible for action control (planning, inhibition, co-ordination and control of action sequences), and the maintenance and focus on mental goals (Perner & Lang, 2002; Verbruggen & Logan, 2008). The prefrontal cortex, which many researchers believe is responsible for executive function, develops through childhood and adolescence, finally maturing in young adulthood (Durston, Thomas, Yang, Ulug, Zimmerman & Casey, 2003). The development of the prefrontal cortex may be examined through tasks that measure executive function, including tasks that target perseveration.

The standard version of the Dimensional Change Card Sorting (DCCS) task (Zelazo, 2006) has traditionally been used to measure perseveration and executive function in children from three to five years of age. The task involves sorting cards that

vary on two dimensions (e.g., color and shape). The child is shown two target cards (e.g. a blue rabbit and a red boat) and is instructed to sort bivalent test cards (that match both test cards on one dimension, such as a blue boat and a red rabbit) along a specified dimension (e.g. shape). In this case the child has to sort a blue rabbit with a red rabbit, because they are both rabbits. The target dimension is then switched and the children are asked to sort the same test cards by this new dimension (e.g., color). In this case, the child needs to sort a blue rabbit with a blue boat, because they are both blue (see Appendix A for a schematic description of the task).

Typically developing three-year-olds have no difficulty in sorting by the pre-switch dimension but are unable to switch to sorting cards by the newly relevant dimension; they perseverate on sorting by the previously relevant dimension, whereas five-year-olds succeed at this task and are able to flexibly switch sorting dimensions (Zelazo, 2006). Children do not sort to by one dimension more successfully than another; their performance on the task does not change depending on which dimension they are asked to sort by initially (Zelazo, 2006; Fisher, 2008). Conflict between the currently and previously relevant dimensions is believed to play a role in three-year-olds' difficulties with flexible switching in the post-switch phase of the task.

Perseveration has generated a great deal of interest and research in the field. Several theories have been proposed to explain the phenomenon. Cognitive Complexity and Control (CCC) theory contends that children's inability to integrate multiple higher order rules is at the root of perseveration (Zelazo et. al., 2003; Zelazo, Frye & Rapus, 1996). Attentional Inertia focuses on inhibition, suggesting that children perseverate because they have difficulty inhibiting attention to a previously relevant object

dimension, and thus cannot switch their attention to sorting by the currently relevant dimension (Kirkham, Cruess, & Diamond, 2003). Dynamic Field theory is a neural model in which representations of shapes and colors build up to form peaks of activation which are spatially bound, leading to the selection of the correct sorting response (Buss & Spencer, 2008); spatial location-dimension associations are important to the explanation of this model. The Competing Memory Systems theory argues that inflexible behaviors arise due to competition between active and latent memory systems (Yerys & Munakata, 2006; Munakata, Morton & Yerys, 2003; Morton & Munakata, 2002). According to this theory, working memory maintains active representations of the currently relevant information for interacting with one's environment, and is represented by activation between units; latent memory contains representations of habits or learned behaviors, which corresponds to changes in connections between units in the model. Perseveration occurs when latent representations are stronger than active representations maintained in working memory.

Perseveration in card sort tasks may be affected by many different factors. This study focuses on two such factors which have been implicated in causing perseveration errors: perceptual conflict and spatial location. It was recently suggested that spatial representation of objects is an important component in forming memory traces when performing a sorting task and the inability to overcome this latent representation and adjust to a new sorting location leads to perseveration after a rule switch (Buss & Spencer, 2008; Buss & Spencer, in press). However, the contribution of spatial associations to inflexible behavior in card sorting tasks remains unclear.

In the absence of conflict between the previously and currently relevant dimensions, three-year-olds succeed in card sorting tasks (e.g. Perner and Lang, 2002; Zelazo et al, 2003). Conflict seems to be the root of the apparent knowledge-action dissociation in which children correctly answer a question about the currently relevant rule, but immediately afterwards sort the card incorrectly (Kirkham, Cruess & Diamond, 2003; Munakata & Yerys, 2001; Zelazo, Frye & Rapus, 1996). In particular, when a child is asked to state the rule that they are using to play the card sort game in the post-switch phase, she may correctly respond that she is sorting the blue cards in the box with the blue rabbit and the red cards in the box with the red boat. When she actually sorts the cards, however, she places the blue boat with the red boat target card (sorting by shape, the pre-switch rule, rather than color). This apparent dissociation between knowledge and action draws the role of perceptual conflict in sorting to the foreground, as the knowledge question does not involve a conflict with the previously relevant dimension like sorting does. Munakata and Yerys (2001) found no evidence of the knowledge-action dissociation when the question included the same level of conflict as the sorting task, suggesting that the same systems control both the sorting and retention of the knowledge to answer the question.

Furthermore, Cepeda and Munakata (2007) found that five- and six-year-old children who successfully performed in the post-switch phase responded faster to non-conflict knowledge questions after the task. This finding is consistent with the competing memory systems approach; switchers have a stronger working memory representation of the current task than perseverators and thus have advantages in overcoming conflict when applying the post-switch rule.

The role of perceptual conflict in perseveration errors was examined by Kirkham, Cruess & Diamond (2003). To manipulate the level of perceptual conflict, these researchers asked children to sort cards into piles face up, which increases perceptual conflict in the task compared to standard face down sorting. Leaving sorted cards face up resulted in perseveration errors even in four-year-old children, who typically perform successfully on the standard version of the task. This finding supports the idea that perceptual conflict may play an important role in perseveration errors, however the extent to which perceptual conflict is responsible for perseveration is unclear.

All of the theories mentioned above are based primarily on the study of perseveration in the context of sorting tasks with 3- to 5-year old children. The present study examines perseveration using a different task - a modified version of the Go/No-Go task. Traditionally, the Go/No-Go task has been used to examine the development of sustained attention and response inhibition in older children and adolescents (Verbruggen & Logan, 2008), and selective attention and active engagement in young children (Akshoomoff, 2002). However, this task can be adapted to closely examine the role of perceptual conflict and spatial location in perseveration errors.

The Go/No-Go task is useful in examining the development of executive function because the task requires response inhibition and working memory. Performance on the task has been associated with development of the prefrontal cortex (Durston et al., 2002). In the Go/No-Go task, participants are presented with a stream of visual stimuli and asked to respond with a button press to one stimulus (e.g. mouse) and intermittently inhibit the response to the other stimulus (e.g. cheese). Traditionally, the task is used to measure vigilance in adults and older children, so the duration ranges from 5-10 minutes.

Several versions have been adapted for use with children, such as a picture selection task (Akshoomoff, 2002) and the box search task (Simpson & Riggs, 2007).

This task was chosen to examine perseveration errors for two main reasons: since only one stimulus is present on the screen at any point in time, the task allows a direct examination of whether (1) perceptual conflict and (2) spatial location-dimension associations are critical for perseveration errors to occur. Specifically, if these factors amplify but do not cause perseveration errors, we might observe that perseveration errors persist in a task that eliminates perceptual conflict and spatial location information.

In order to examine perseveration errors, the Go/No-Go task was modified in two important ways. The task has been shortened, and now incorporates a rule switch. Card sorting stimuli are used to allow for this switch between sorting dimensions. The task controls for spatial location of the test card by presenting each card in the same location on the screen. To control for perceptual conflict, the test stimulus is the only picture the child sees on the screen, thus eliminating perceptual conflict while preserving representational conflict (between the relevant and previously relevant rules).

The study involves two conditions: a non-dimensional switch and a dimensional switch condition. In the non-dimensional switch condition, the rule switch occurs between responses to two objects and does not involve switching between dimensions. In the dimensional switch condition, children must adapt responses to consider values of the newly relevant dimension because of the switch between relevant dimensions that occurs when the rule changes (e.g. color to shape).

Overall, the current study aims to explore the mechanism(s) behind perseveration errors in the context of a task different from the traditional DCCS task, a Go/No-Go task.

We expected children to switch flexibly in the non-dimensional condition, as three-year-olds have been found to flexibly switch sorting behavior when rules are reversed (reversal shift condition, Perner & Lang, 2002). We expected to observe perseveration in the dimensional switch condition. Finding evidence of perseveration in the Go/No-Go task would pose challenges to several existing theories of perseveration.

## Methods

### *Participants*

The participants were 37 typically developing three-year-olds (18 females, 19 males, $M$=3.40, $SD$=0.27, range 2.97-3.98). Ten males and eight females were tested in the dimensional switch condition, and nine males and ten females were tested in the non-dimensional condition. The children were recruited through a database of parents in the Pittsburgh, PA area, local Pittsburgh preschools, and the Children's School at Carnegie Mellon University. Informed consent was obtained from the parent of each child. Data from two additional children were excluded from analysis due to unwillingness to attend to or inability to understand the rules of the task.

### *Design*

Participants were tested in one of two conditions of the modified Go/No-Go task: dimensional switch condition or non-dimensional switch condition. Each condition involved a practice, pre-switch, and post-switch phase. The practice phase had four go trials and two no-go trials to provide the children with an opportunity to practice the button push associated with go trials. The pre-switch phase consisted of 12 trials, six of which were go trials and the other six were no-go trials. The post-switch phase consisted of the same stimuli as the pre-switch phase. Presentation of trials was randomized within

each phase. The initial sorting dimension as well as designation of stimuli as "go" versus "no-go" stimuli was counterbalanced among participants.

*Materials*

The stimuli were displayed in the middle of a laptop computer screen using SuperlabPro software. The stimuli consisted of a realistic red umbrella and blue car for the practice phase, and green and yellow birds and butterflies for the pre- and post-switch phases (see Appendix B for the list of stimuli). In the non-dimensional switch condition, only two of the stimuli were used in each version (e.g. yellow bird and green butterfly). This condition involved no conflict between dimensions after the rule switch, as the switch was inter-dimensional, or between objects. For example, if the yellow bird was designated as the "go" stimulus and the green butterfly was designated as the "no-go" stimulus in the pre-switch phase, in the post-switch phase the yellow bird became the "no-go" stimulus whereas the green butterfly became the "go" stimulus.

In the dimensional switch condition, the switch was intra-dimensional, or within dimensions of the stimulus. For example, if yellow pictures were designated as the "go" stimuli and green pictures were designated as the "no-go" stimuli during the pre-switch phase, in the post-switch phase birds could be designated as the "go" stimuli and butterflies as the "no-go" stimuli. Due to the nature of the task in the dimensional switch condition, children did not have to adjust their responses after the rule switch for half of the stimuli (hereafter referred to as the no conflict trials) but had to adjust their responses for the other half of the stimuli (hereafter referred to as the no conflict trials). For example, if yellow objects were designated as the "go" stimuli in the pre-switch phase and birds were designated as "go" stimuli in the post-switch phase, children would not

have to change their responses for yellow birds (the no conflict trials) but would have to change their responses for yellow butterflies and green birds (the conflict trials) (see Appendix B for examples of conflict and no conflict trials).

*Procedure*

Each child was tested individually in a quiet room at either the Cognitive Development Laboratory at Carnegie Mellon University, the Children's School at Carnegie Mellon University, or the child's preschool. The session lasted approximately 10 minutes. The child was seated at a child-sized table level with the laptop computer screen. The space bar of the laptop keyboard was covered in a pink piece of paper to provide a salient target for the child to press. The child was directed how to complete the practice phase ("*press the pink button when you see the red umbrella, don't press the button when you see the blue car"*) and given feedback on each trial. Then, in the pre-switch phase of the dimensional switch condition, the experimenter introduced the child to the stimuli and the rules of the game (shape game in the example below) by saying: "*In the shape game, every time you see a butterfly, you press the pink button; but be careful, because when you see a bird you don't press any buttons*!" At the conclusion of the pre-switch phase participants were told: "*We are not playing the shape game anymore; now we're going to play a different game with different rules. The new game is called the color game. In the color game, every time you see a yellow picture, you press the pink button. But be careful, because when you see a green picture you don't press any buttons.*"

In the non-dimensional switch condition, the child was given the same practice task as in the dimensional switch condition. After the child completed the practice trials,

the experimenter explained the rules of the pre-switch phase: "*Now we're going to play the green butterfly game. In the green butterfly game, every time you see a green butterfly, you press the pink button. But be careful, because when you see a yellow bird you don't press any buttons.*" At the conclusion of the pre-switch phase the experimenter explained the post-switch rules: "*We're not playing the green butterfly game anymore; now we're going to play a different game. The new game is called the yellow bird game. In the yellow bird game, every time you see a yellow bird, you press the pink button. But be careful, because when you see a green butterfly you don't press any buttons.*" After the child completed both phases of the game, he was praised and offered a prize for participation.

## Results

Children's responses were entered into two separate ANOVAs for the dimensional and non-dimensional switch conditions. The mean proportions of correct responses are presented in Table 1.

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Insert Table 1 about here

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Children were not expected to make perseveration errors in the non-dimensional switch condition because children have been found to switch successfully in tasks requiring a rule reversal that do not involve dimensional shifts (Perner & Lang, 2002). Accuracy scores were submitted to a two-way ANOVA with trial type (go vs. no-go) and phase (pre- vs. post-switch) as within-subject factors. The analysis indicated that there was no effect of phase ($F(1, 18) = 0.83$, $p = 0.37$) and no effect of trial type ($F(1, 18) =$

2.61, $p$= 0.12). However, there was a significant interaction between phase and trial type ($F$(1, 18) = 6.20, $p$= 0.02). A series of follow-up t-tests were conducted to explore this interaction. A paired-sample t-test conducted on accuracy scores on the no-go trials indicated that there was no change in performance on the no-go trials in the post-switch phase (74% correct) as compared to the pre-switch phase (83% correct) ($t$(18)= 1.19, $p$= 0.250). However, as shown in Figure 1, there was a significant improvement in participants performance on the go trials: not only was there no perseveration, children's performance on the go trials improved from 67% of correct responses in the pre-switch to 80% correct responses in the post-switch phase, ($t$(18)= 2.12, $p$= 0.048). Overall, results in the non-dimensional switch condition indicate that children were able to switch their responses appropriately by the new rule when no dimensional switching was required. Furthermore, children's performance on the go trials suggests a facilitation effect – improved accuracy as a result of increased experience with the task, despite the rule switch.

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Insert Figure 1 about here

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Unlike the non-dimensional switch condition, children were expected to perseverate in the dimensional switch condition because the rule switch changed the relevant sorting dimension. Accuracy scores were submitted to a three-way ANOVA with phase (pre- vs. post-switch), trial type (go vs. no-go), and conflict level (conflict vs. no conflict trials) as within-subject factors. The analyses indicated a significant effect of phase ($F$(1, 17) = 5.31, $p$= 0.03), no significant effect of trial type ($F$(1, 17) = 0.69, $p$= 0.42), and no

significant effect of conflict level ($F(1, 17) = 1.31$, $p= 0.27$). There was also a significant interaction between conflict level and trial type ($F(1, 17) = 5.66$, $p= 0.03$), and a marginally significant interaction between conflict level and phase ($F(1, 17)= 4.23$, $p= 0.06$). A series of t-tests were conducted to explore these effects.

As shown in Figure 2, children were significantly less accurate in the post-switch phase on the no-go conflict trials (54% correct) compared to the pre-switch no-go conflict trials (83% correct), indicating that they responded when inappropriate much of the time, paired-samples $t(17)= 3.06$, $p=0.007$. There were no significant differences between phases for both the go and no-go no conflict trials, as shown in Figure 3, all paired-samples $t$s < 1.4, $p$s > .2. This finding reflects that fact that children did not have to adjust their responses on the no conflict trials and were able to respond appropriately in both pre- and post-switch phases. Performance on the pre-switch go conflict trials (59% correct) was not significantly different from performance on post-switch go conflict trials (52% correct), paired-samples $t(17) =0.656$, $p=0.521$. Note, that performance on the go trials in the dimensional switch condition did not show the facilitation effect observed in the non-dimensional switch condition (as shown in Figure 3).

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Insert Figures 2 and 3 about here

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Children's performance on go trials was not different from chance for both the pre-switch phase (59% and 48% correct for conflict and no conflict trials, respectively) and the post-switch phase (61% and 52% correct for conflict and no conflict trials, respectively), all $t$s < 1.4, $p$s > .18. It is likely that perseveration did not occur on the go

trials because children never established a prepotent response on these trials. It is possible that children's performance on the go trials can be improved if these trials are presented more frequently than the no-go trials; such improvement in performance on the go trials would indicate acquisition of the prepotent response, and could lead children to exhibit perseveration errors on the go trials as well as the no-go trials.

## Discussion

Three-year-old children perseverated in the dimensional switch version of the modified Go/No-Go task: They failed to adjust their responses to the no-go conflict trials after the rule switch. Specifically, children correctly withheld responses to the stimuli in the pre-switch no-go trials, but they failed to withhold response to the no-go conflict stimuli in the post-switch phase. The decrease in accuracy in the post-switch no-go conflict trials cannot be attributed to loss of interest or fatigue because performance did not diminish on the post-switch no-go no conflict trials.

In contrast to the dimensional switch condition, children did not perseverate in the non-dimensional switch condition. This condition does not involve a switch between dimensions, and the task does not require the object to be decomposed into dimensions. Children were able to make the switch from responding to a green butterfly and withholding response to a yellow bird, to withholding response to the green butterfly and responding to the yellow bird. This finding supports results of prior research indicating that children can flexibly switch between responses when no dimensional switching is required (Perner and Lang, 2002).

Perceptual conflict and spatial location-dimension associations are two factors that have been implicated in perseveration errors in children. Perceptual conflict has

been shown to increase perseveration errors (Kirkham, Cruess & Diamond, 2003). The present study controls for perceptual conflict by presenting one stimulus on the screen at a time. If perceptual conflict were necessary to elicit perseveration, we would have found no evidence of perseveration. However, children perseverated in the dimensional switch condition even in the absence of perceptual conflict, suggesting that perceptual conflict is not necessary for inflexible behavior.

Spatial location-dimension associations have been suggested to be a critical factor in perseverative behavior (Buss & Spencer, 2008). However, in the present study children perseverated in the dimensional switch condition in the absence of location-dimension associations. This finding is problematic for the Dynamic Field theory (Buss & Spencer, 2008), which emphasizes the importance of spatial location in perseveration errors.

Furthermore, findings presented above are problematic for the Attentional Inhibition account (Kirkham, Cruess, & Diamond, 2003) because it cannot explain why children can flexibly switch their responding in the non-dimensional switch condition but not in the dimensional switch condition. The CCC theory (Zelazo, Frye & Rapus, 1996) is faced with potential problems in accounting for these findings, as both conditions may involve representing higher-order rules (Perner & Lang, 2002).

An alternative explanation that may be able to account for the pattern of results obtained in this research is attentional blocking. In the non-dimensional switch condition, children do not have to break down the stimulus into dimensions and can attend to the objects holistically; one dimensional cue is not more relevant than the other, and thus children do not learn to ignore (or block) irrelevant cues. In the dimensional

switch condition, children are required to attend to one dimension and therefore may block the irrelevant dimension cue. When the previously ignored dimension becomes relevant, children may have difficulty attending to the cue to which attention has been previously blocked. Further research is required to examine whether attentional blocking can provide a comprehensive account of perseveration errors.

One limitation of the present study is different number of stimuli in the dimensional and non-dimensional switch conditions. Specifically, greater number of stimuli can lead to increased perceptual load and, potentially, perseveration errors. Further research is required to separate effects of dimensional switching from the possible effect of increased perceptual load.

*Conclusions*

The present research examined the effects of perceptual conflict and spatial location-dimension associations on flexible responding. Three-year-old children perseverated on the old rule when faced with a dimensional rule switch in the absence of perceptual conflict and location-dimension associations. Therefore, neither perceptual conflict nor spatial location-dimension associations are necessary to elicit perseveration.

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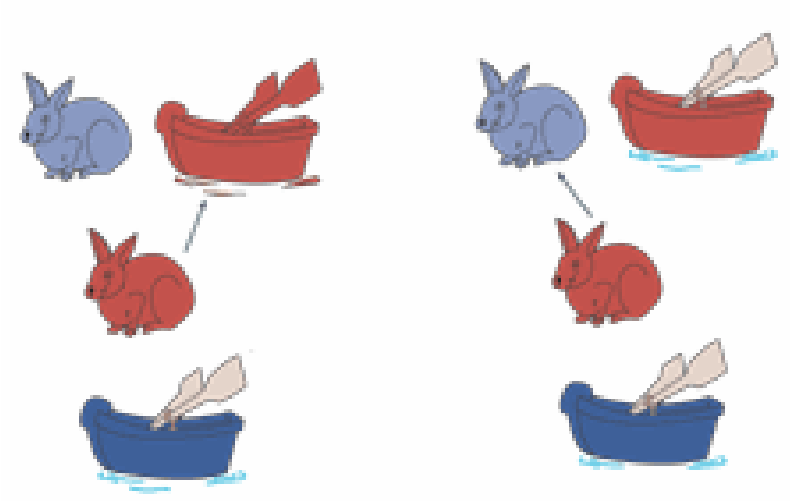
Appendix A

Example DCCS stimuli from Zelazo, 2006.

| | Pre-Switch Phase | Post-Switch Phase |
|---|---|---|
| Target |  | |
| Test | | |

Appendix B

Example stimuli from the dimensional switch condition.


Example stimuli from the non-dimensional switch condition.

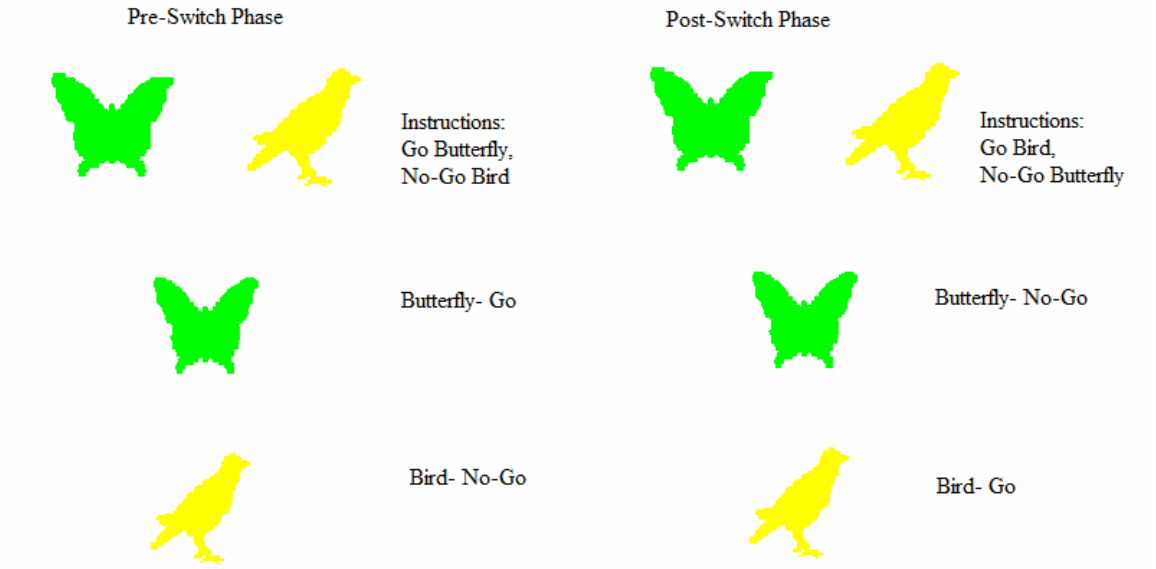


Table 1

*Table of Means of Proportion of Correct Responses*

| Dimensional switch condition | | | |
|---|---|---|---|
| Trial Type | Response Type | Pre-switch | Post-switch |
| Conflict | Go | 0.59 | 0.52 |
| | No-Go | 0.83 | 0.54 |
| No Conflict | Go | 0.48 | 0.61 |
| | No-Go | 0.80 | 0.76 |
| Non-dimensional switch condition | | | |
| | Go | 0.67 | 0.80 |
| | No-Go | 0.83 | 0.77 |

## Figure Captions

*Figure 1.* Proportion of correct responses on all trials in the non-dimensional switch condition.

*Figure 2.* Proportion of correct responses on no-go trials in the dimensional switch condition.

*Figure 3.* Proportion of correct responses on go trials in the dimensional switch condition.

Figure 1

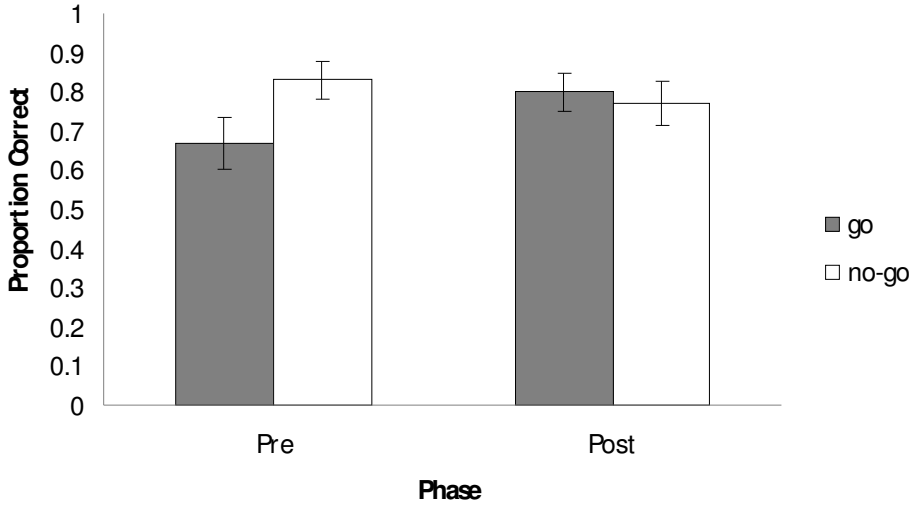

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion Correct
Pre
Post
Phase
go
no-go

Figure 2

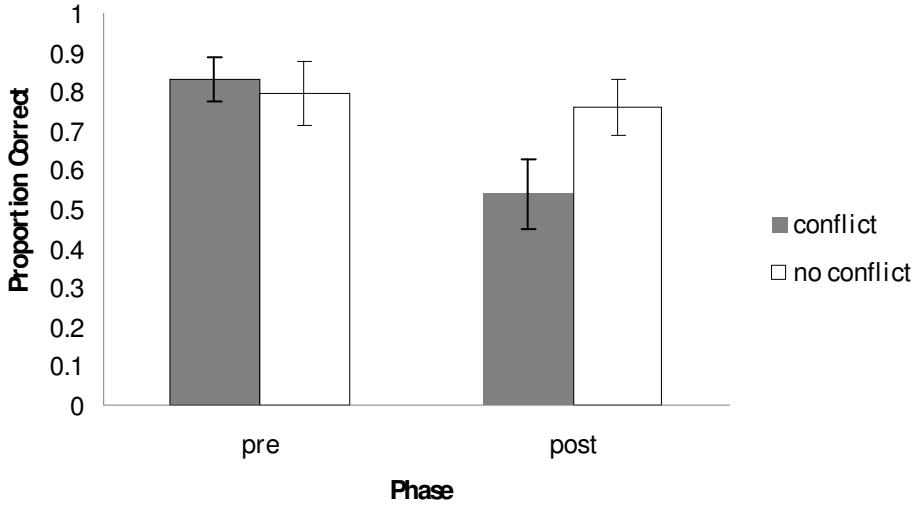
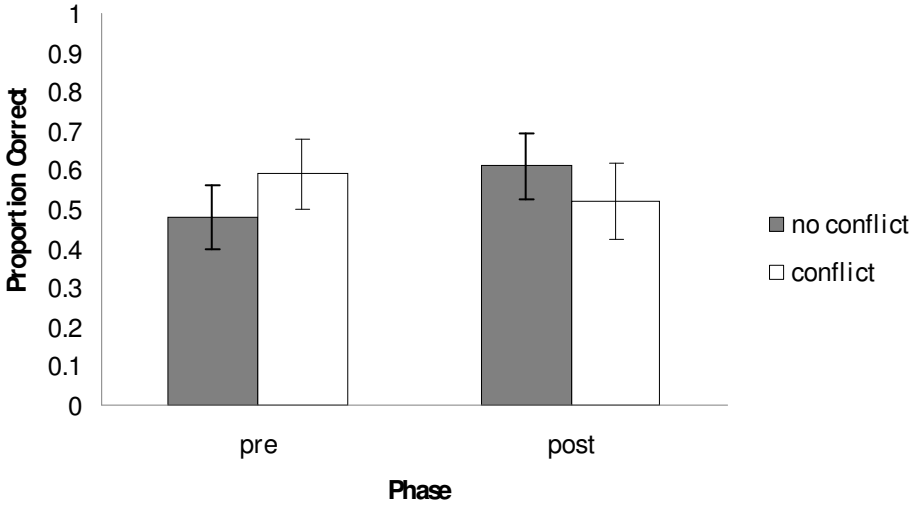

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion Correct
pre
post
Phase
conflict
no conflict

Figure 3


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Proportion Correct
pre
post
Phase
no conflict
conflict