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TOP-DOWN AND BOTTOM-UP INFLUENCES ON ACTION AND INHIBITION

BY

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THESIS

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ABSTRACT

A series of studies with complex Go/No-Go tasks systematically examined the influence of tasks that require different combinations of Go and No-Go responses. Specifically, this thesis investigated how commission and omission errors are influenced by the actual distribution of the responses required during the trials (bottom-up factor) and a response mapping rule provided in the beginning (top-down factor). Results indicated that the Go-trial proportion and the Go-mapping rule moderate action (Go responses) and action inhibition (No-Go response) in different ways. Experiment 1 found that a high-Go-trial proportion that coincided with a high-Go-mapping rule produced significantly higher commission-error rates, lower omission-error rates, and shorter hit RTs than a low Go-trial proportion that coincided with a low Go-mapping rule. Experiments 2 and 3 differentiated the effect of the Go-trial proportion from the effect of the Go-mapping rule. These two experiments revealed that a higher Go-trial proportion increased commission-error rates but decreased omission-error rates, whereas a higher Go-mapping rule increased both commission-error rates and omission-error rates. Implications for designing effective behavioral programs are discussed.

Keywords: action, inhibition, Go/No-Go, behavioral facilitation, action and inaction goals

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CHAPTER 1

INTRODUCTION

Through thousands of years of human evolution, we have learned that achieving a goal often requires both engaging in and inhibiting various responses as opposed to just one (Simmonds, Pekar, & Mostofsky, 2008). Success in such multi-tasking situations is likely to depend on how frequently each response is practiced in daily life and how many behaviors require active engagement vs. suppression in an *a priori* way. Consider performance in a Go/No-Go task in which participants are required to press a button in response to some targets and not to others. Imagine also that the task has more than two targets such that the proportion of Go-requiring targets encountered during task performance can be separated from the proportion of targets mapped to a Go response based on the learned rule. For example, participants may be instructed to go to A, B, and C out of A, B, C, and D; but A, B, and C might appear 50% of the total times during the actual practice of the task. Will the effect of the practice (i.e., the bottom-up effect) be different from the effect of the rule (i.e., the top-down effect)?

On the one hand, the frequent execution of actions (hereafter termed *Go-trial proportion*) might be assumed to facilitate other actions, whereas frequent suppression would facilitate further suppression (Van der Molen et al., 1989). If one responds by going to 75% of the task trials and not going to the other 25% of the task trials, then commission errors may be more likely for the other 25% of the task trials. Correspondingly, if one responds by going to 25% of the task trials and not going to the other 75% of the task trials, then omission errors may be more likely for the other 75% of the task trials. In other words, a high-Go-trial proportion (i.e., the proportion of Go-trials in the total Go-trials and No-Go trials is relatively high) may trigger more commission errors but fewer omission errors than a low-Go-trial proportion.

On the other hand, the proportion of Go-requiring targets out of the total number of targets (hereafter termed *Go-mapping rule*) may be hypothesized to have the same effect as the proportion of Go-requiring targets in the trials. The *Go-mapping rule* may hinder both Go and No-Go responses by exerting a potentially distracting effect as in research with the feature positive effect (Jenkins & Sainsbur, 1970; Ross, 1977). If Go targets attract more attention than No-Go targets in a learned mapping rule, a high number of Go targets (i.e., a high-Go-mapping rule) may become more distracting and produce more commission and omission errors than a low number of Go targets (i.e., a low-Go-mapping rule).

The present thesis, by employing a series of complex Go/No-Go tasks, examined the possibility that performance on a cluster of behaviors would be influenced by the Go-trial proportion and the Go-mapping rule. Three experiments were conducted to examine this possibility. Briefly, the first experiment preliminarily tested the bottom-up effect in a way that confounded the mapping rule with the trial proportion. The second experiment separately examined the effects of the mapping rule and the trial proportion without fully crossing the two factors. The third experiment fully crossed the Go-trial proportions with the Go-mapping rules.

The Go/No-Go Task

In the laboratory, the Go/No-Go task has been commonly used to investigate performance on action execution and action inhibition (Donders, 1969; Gomez, Ratcliff & Perea, 2007; Liddle, Kiehl & Smith, 2001; Simmonds et al., 2008). In this task, two kinds of target stimuli are randomly presented, and participants are instructed to respond to one of the stimuli (Go stimuli) and withhold responding to the other (No-Go stimuli). The Go/No-Go task usually produces four useful dependent variables: commission error rate, omission-error rate, commission-error reaction time, and hit reaction time. According to signal detection theory (SDT; Swets, 1989; Tanner & Swets, 1954), correctly going to a Go stimulus represents a "hit" whereas not responding to a Go stimulus represents an "omission error." Conversely, responding to a No-Go stimulus represents a "commission error," whereas not responding to a No-Go stimulus entails a "correct rejection." Error rates are calculated based on the numbers of Go stimuli and No-Go stimuli (see Results section in Experiment 1 for details); response times are calculated from both correct responses (i.e., "hits") and incorrect Go responses (i.e., "commission errors").

The Go/No-Go task appears perfect for investigating top-down and bottom-up influences on performance. First, the bottom-up effect can be easily manipulated by varying the number of Go trials in the Go/No-Go task. For example, a task of total 45 trials may present 30 trials that require a Go response and 15 trials that require a No-Go response; it can also present only 15 trials that require a Go response and 30 trials that require a No-Go response. Second, we can also manipulate the top-down effect by varying the Go mapping rules (changing the numbers of stimuli of the total set of targets that require Go and No-Go responses). Specifically, we can set different numbers of Go stimuli and thus the proportion of Go stimuli across all stimuli. For example, a Go/No-Go task may include four stimuli: "A," "B," "C" and "D." Setting one of the four stimuli (e.g., "A") as a Go stimulus and the other three stimuli (i.e., "B," "C" and "D") as No-Go stimuli produces a 25%-Go-mapping rule. Similarly, setting three of the four stimuli (e.g., “B,” “C” and “D”) as Go stimuli and the other stimulus (i.e., “A”) as No-Go stimulus produces a 75%-Go-mapping rule.

Bottom-up and Top-down Influences on Actions

Bottom-up and top-down processes have been defined and studied for virtually every process of interest in cognitive psychology (Roepstorff & Frith, 2004). According to these models, the “bottom” refers to all that comes to the organism “from the outside,” whereas the “top” refers to the understanding and knowledge that an organism has (Frith & Dolan, 1997). In performance contexts, bottom-up processes usually stem from practicing, whereas top-down processes usually stem from an organism’s theory and philosophy (Law, 2007). Bottom-up influences on subsequent behaviors can be illustrated by practicing particular behaviors. For example, if behavioral practice induces 30 Go responses and 10 No-Go responses, one may be better prepared for further Go than No-Go responses. Consistent with this possibility, previous research did in fact find that the average reaction time per trial was lower when individuals execute 60 trials than 20 Go trials (Van der Molen et al., 1989). Similar results have also been obtained by Milan et al. (2006), Simpson and Riggs (2006), and Wager et al. (2005). However, little is known about how the bottom-up influences of practice interact with the top-down influences of an *a priori* rule. In any case, we hypothesized that a high Go trial proportion (e.g., 75%) would produce a higher commission-error rate, a lower omission-error rate and faster reaction times than a low Go trial proportion (e.g., 25%).

Top-down influences on subsequent behaviors can be illustrated by general action goals. According to Albarracin and her colleagues (Albarracin et al., 2008), general action goals are “goals with end states at the extremes of the continuum of activity level” (p. 511). Once a general action goal is activated, people may search for and engage in a variety of behaviors that can ensure an active end state. A general action goal can be activated by exposure to general action words, such as “do,” “act,” and “go” as well as by exposure to advertisement slogans such as “Just Do It,” “It’s Time to Fly” and “Victory Won’t Wait for the Nation That’s Late” (Albarracin et al., 2008; Laran, 2010). In one prior study (Albarracin et al., 2008: Experiment 3), participants primed with general action words learned and moved more than those primed with neutral words (e.g., “pear”). In another study (Albarracin, Wang, & Leeper, 2009), action goals presumably activated by viewing pictures with action phrases (e.g., “Walk three times a week,” etc.) produced more consumption of raisins than control goals (e.g., “Be in a group,” etc.).

Besides general action goals instilled in this manner, top-down processes are also likely to involve expectations about what to do and the desire to comply with these expectations. Different expectations may influence action responses in a top-down manner. For example, if most of the behaviors in a behavioral cluster require Go responses, one may expect actions more frequently and become more ready to execute the actions. In contrast, if most of the behaviors in a behavioral cluster require No-Go responses, one may have a stronger expectation of suppressing behavior. Thus, the number of Go and No-Go responses in a mapping rule may have the same influence as the number of Go and No-Go responses in the practice trials. Specifically, a high Go mapping rule (e.g., 75%) may produce a higher commission-error rate, a lower omission-error rate and faster reaction times than a low Go mapping rule (e.g., 25%).

Although the *Go-mapping rule* may have the same effect as the proportion of Go-requiring targets in the trials, it could also have distracting effects. This assumption is based on the long established *feature-positive effect* (Jenkins & Sainsbury, 1970; Ross, 1977). In pigeons, there is faster learning when reinforcement is associated with the presence of a stimulus (the *feature-positive* condition) than the absence of a stimulus (the *feature-negative* condition) (Jenkins & Sainsbury, 1970). In humans, the response of doing something (active response) is more cognitively demanding than the response of doing nothing (passive response) (Allison & Messick, 1988). Correspondingly, if individuals pay more attention to the Go targets than the No-Go targets in a learned mapping rule, a high-Go-mapping rule may take up more cognitive capacity and become more distracting when multiple targets and responses are being tracked. For example, people may make more commission and omission errors when they are asked to press a key in response to three targets while omitting responses to a fourth target than when they are asked to press a key in response to one target while omitting responses to the other three targets.

Hypotheses

The analysis of bottom-up and top-down influences on actions derived the following three hypotheses:

1) A high-Go-trial proportion (e.g., 75%) may produce a higher commission-error rate, a lower omission-error rate and faster reaction times than a low-Go-trial proportion (e.g., 25%).

2) A high-Go-mapping rule (e.g., 75%) may produce a higher commission-error rate, a higher omission-error rate and faster reaction times than a low-Go-mapping rule (e.g., 25%).

3) The Go-trial proportion and Go-mapping rule may exert different effects on the two types of errors—commission error and omission error. Thus, there might be a significant interaction effect of Go-trial proportion and Go-mapping rule on commission-error rate and omission-error rate.

The Present Research

Three studies using Go/No-Go tasks were conducted to explore the aforementioned three hypotheses. Departing from previous research, the Go/No-Go tasks in this research included four stimulus words that allowed both the practice and mapping rules to vary in a flexible way. Experiment 1 manipulated three levels of Go responses (25%, 50% and 75%) with the same distribution appearing in the practice trial and the mapping rule distribution. That is, the block with 25%-Go-trial proportion also had a 25%-Go-mapping rule, and so forth. Based on the expectation for the trial proportion, the block with high Go was expected to produce a higher commission-error rate, a lower omission-error rate and a shorter reaction time than the block with the low Go.

Experiment 2 differentiated from the effect of the Go-trial proportion from the effect of the Go-mapping rule. To explore the effect of Go-mapping rules, the Go-trial proportions were kept at 50%. Similarly, to explore the effect of the Go-trial proportion, the Go-mapping rule was kept at 50%. Overall, the design had either a 75% or a 25% Go-mapping rule, and the Go-trial proportion could be either the same or different, with the different condition having a Go trial-proportion distribution of 50%. Experiment 3 was similar to Experiment 2 but fully crossed the Go trial proportions with the Go-mapping rules. Specifically, two levels (25% and 75%) of Go-trial proportions were crossed with two levels (25% and 75%) of Go-mapping rules.

CHAPTER 2

EXPERIMENT 1

In Experiment 1, a within-subject design was used to test Hypothesis 1: a high Go trial proportion (e.g., 75%) would produce higher commission error rates, faster reaction times and fewer omission errors than a low Go-trial proportion (e.g., 25%). Participants were asked to respond to four different words with Go distributions of 25%, 50% and 75%, and these same proportions were maintained across the trials.

Method

Participants and Design

One hundred and nine introductory psychology students (55% females; *M* age = 18.76, *SD* = 0.92) participated in this study. All participants had normal or corrected-to-normal vision. In the context of a within-subjects design, we manipulated three proportions of Go responses at 25%, 50% and 75%. This study consisted of 12 experimental blocks, and each participant completed all the blocks.

Procedures and Experimental Settings

Participants were told that they would be taking a visual-behavioral test requiring them to press a key as quickly and as correctly as possible to respond to words on the screen. They were also told that this test consisted of two sections: one practice section and one experimental section. The task was explained before participants started the practice section. The practice section had 20 trials in which two words (“earth” and “nature”) were randomly presented on the screen. As part of this practice, for the first ten words, participants were required to respond to “earth” by pressing the space bar and to withhold pressing a key in respond to “nature.” The Go and No-Go requiring words were switched for the remaining ten trials. Participants were instructed to use the index finger of their dominant hand to press the space bar when Go stimulus words are presented.

A complex Go/No-Go task manipulating the proportion of Go responses across twelve blocks (Go proportions: 25%, 50%, and 75%) followed the practice session. Four words were used in this task: "condom," "bed," "sex" and "disease." For the 25%-Go block, one of the four words was set as Go stimulus, for which participants had to press the space bar to respond; for the 50%-Go block, two of the four words were set as Go stimuli; for the 75%-Go block, three of the four words were set as Go stimuli. For each Go-proportion condition, the word order rotated so that the Go stimuli or No-Go stimuli were counterbalanced over four blocks. For example, for the four blocks of the 25%-Go condition, "condom" was set as the Go stimulus for the first block, "bed" for the second block, "sex" for the third block and "disease" for the fourth block. For the four blocks of 50%-Go condition, the two Go stimulus words were "disease" and "sex" for the first block, "bed" and "sex" for the second block, "condom" and "disease" for the third block, and "condom" and "bed" for the fourth block. For the four blocks of 75%-Go condition, the three Go stimulus words were "bed," "sex" and "disease" for the first block; "condom," "bed" and "sex" for the second block; "sex," "disease" and "condom" for the third block; and "disease," "condom" and "bed" for the fourth block. Thus, this experiment included 12 blocks: three Go-conditions with four word order blocks for each Go condition. The arrangement of the Go/No-Go stimulus words for the 12 blocks appears in Table 1.

Table 1

Go/No-Go Target Words in 75%, 50% and 25%-Go Conditions in Experiment 1

Word orders	Blocks	75%-Go	Blocks	50%-Go	Blocks	25%-Go
1	1	C = Ø B = sb S = sb D = sb	2	C = Ø B = Ø S = sb D = sb	3	C = sb B = Ø S = Ø D = Ø
2	4	D = Ø C = sb B = sb S = sb	5	D = Ø C = Ø B = sb S = sb	6	D = sb C = Ø B = Ø S = Ø
3	7	B = Ø S = sb D = sb C = sb	8	B = Ø S = Ø D = sb C = sb	9	B = sb S = Ø D = Ø C = Ø
4	10	S = Ø D = sb C = sb B = sb	11	S = Ø D = Ø C = sb B = sb	12	S = sb D = Ø C = Ø B = Ø

Note. C = "condom"; B = "bed"; S = "sex"; D = "disease";
Ø = No-Go stimulus;
sb = the stimuli word required responses of pressing the space bar.

As shown in Table 1, each Go condition included four blocks of different word orders, for a total of 12 counterbalanced blocks. Across order conditions, the order of the blocks was 1, 2, 3, 4, 5, 6, …, 10, 11, 12; 1, 3, 2, 4, 6, 5, …, 10, 12, 11; and 2, 1, 3, 5, 4, 6, …, 11, 10, 12; and so on. Within a block, each of the four words appeared ten times, and these forty words were randomly presented on the center of the screen. Before each trial, a series of "X"s was displayed for 400 ms to fix participants' attention. Following this signal was a stimulus word was presented for 400 ms. Participants were instructed to respond as quickly as correctly as possible for each trial. Based on participants' responses, the computer recorded the reaction time for each response-eliciting trial and the numbers of omission and commission errors. At the end of the study, participants provided demographic data (age, gender and ethnicity), were thanked and were debriefed.

Results

Reaction time data were cleaned based on the most common method (Gomez, Ratcliff & Perea, 2007; Justine & Yoshio, 1987; Ratcliff, 1993; Robert, 2008; Verbruggen & Logan, 2008). This method assumes that, for the reaction time data, the difference between experimental conditions is contained in the middle of 85%–95% of the reaction time distribution. It also suggests that cutoff of extreme outliers is more powerful than other methods such as transforming data. To be conservative, for the data analysis of this thesis, only RTs that lay outside ± 3 standard deviations were excluded. Then, for each block, we calculated four dependent variables: commission-error rates, omission-error rates, commission-error reaction times, and hit reaction times. For each condition, commission and omission error rates were obtained using the following formula:

$$\text{Commission error rate} = \frac{\text{number of trials eliciting false alarms}}{\text{total number of No} - \text{Go} - \text{stimuli trials}}$$

$$\text{Omission error rate} = \frac{\text{number of missed trials}}{\text{total number of Go} - \text{stimuli trials}}$$

Hit reaction time was calculated based on the correct hit trials and commission error reaction time was calculated based on the false alarm trials. To calculate the four dependent variables, the four word order blocks for each Go-proportion condition were averaged. Finally, the four dependent variables were analyzed using repeated measures ANOVA. The results from this analysis are summarized in Table 2. This analysis revealed significant main effects of the Go-proportion manipulation on all dependent measures (for Commission-error rates, $F_{(1, 108)} = 364.92$, $p < .001$; for Omission-error rates, $F_{(1, 108)} = 25.51$, $p < .001$; for Commission-error RTs, $F_{(1, 83)} = 21.77$, $p < .001$; for Hit RTs, $F_{(1, 108)} = 204.95$, $p < .001$). Consistent with expectations for the proportion of Go trials in practice (Hypothesis 1), these effects indicated that higher Go-proportions triggered more false alarms, fewer omission errors, and faster RTs than lower Go-proportions. Contrasts are indicated with superscripts in Table 2 and show that each condition was different from the others for commission-error rates and hit RTs. For omission-error rates and commission-error RTs, the 75%-Go condition differed from both the 50%-Go and 25%-Go conditions, but these two conditions did not differ from each other.

Table 2

Descriptive Statistics of 75%, 50% and 25%-Go-Proportion Conditions

Dependent variables	Go-proportion conditions		
	75% M (SD)	50% M (SD)	25% M (SD)
Commission-error rates	0.30^{a} (0.15)	0.08^{b} (0.06)	0.03^{c} (0.04)
Omission-error rates	0.28^{a} (0.12)	0.36^{b} (0.13)	0.36^{b} (0.20)
Commission-error RTs	293.39^{a} (27.89)	319.05^{b} (37.75)	315.20^{b} (37.24)
Hit RTs	319.58^{a} (19.01)	337.66^{b} (13.72)	347.07^{c} (14.74)

Note. Different superscripts within rows indicate a significant difference between the two means, whereas the same superscripts within rows indicate no significant difference between the two means.

Given the opposite pattern of findings for commission- and omission-error rates, it was important to confirm that these patterns were significantly different from each other. Thus, error type was introduced as an additional repeated-measure factor in the previous analysis. This analysis revealed that the interaction effect was significant, $F_{(2,216)} = 75.20$, $p < .001$, indicating that Go-proportion conditions had different effects on commission- and omission-error rates.

Discussion

The results from this experiment revealed, for the three Go-proportion conditions, as the proportion of Go stimuli increased, commission-error rates increased, ,but omission-error rates decreased, , hit reaction times and commission-error reaction times also decreased. Thus, this experiment supported the hypothesis that action responses were facilitated when the Go condition included a higher proportion of Go targets. However, this experiment confounded the Go-trial proportion with an identical mapping rule. This ambiguity was eliminated in Experiment 2, which separated the Go-trial proportion for the Go-mapping rule.

CHAPTER 3

EXPERIMENT 2

A higher proportion of Go responses in either or both the trial sequence or the mapping rule increased and accelerated Go responses while decreasing No-Go responses, as demonstrated in Experiment 1. Experiment 2 aimed to clarify the source of this effect by independently manipulating the proportion of Go responses in the actual trials and the mapping rule.

Method

Participants and Design

Thirty-three undergraduates (58% females; *M* age = 19.12, *SD* = 0.96) participated in this study in exchange for credit in an introductory psychology class. The design was a 2 (Go-trial proportions: consistent with the 75%/25% Go mapping rule vs. 50% Go) × 2 (Go-mapping rule: 75% Go vs. 25% Go) × 2 (word sets) factorial, with the first two factors manipulated within subjects and the word set manipulated between subjects.

Experimental Procedures

The procedure and experimental settings for Experiment 2 were similar to those for Experiment 1 except that the experimental conditions and words varied. The experiment included four conditions to examine the effects of differences in the Go proportion of the actual trials and the mapping rules. The mapping rule was manipulated by means of instructions that stated the expected responses. The Go mapping rule was 75% when three of the four words were set as Go stimuli and 25% when one of the four words was set as the Go stimulus. The proportion of Go responses in the trials was manipulated by varying how many of the actual trials corresponded to stimuli that, based on the rule, required a Go response. The Go-trial proportion was either consistent with the mapping rule of 75% Go or 25% Go or was inconsistent with the mapping rule (50% Go regardless of the proportion of Go targets in the mapping rule). Each Go mapping rule was tested over two blocks varying in Go trial proportions: one block adopted the Go trial proportion of the Go mapping rule proportion, whereas the other had a 50%-Go-trial proportion. For example, for the two blocks with a Go mapping rule of 75%, one block had a Go trial proportion of 75%, and the other block had a Go trial proportion of 50%. Similarly, for the two blocks with a Go mapping rule of 25%, one block had a Go trial proportion of 25%, and the other block had a Go trial proportion of 50%. This design permitted comparing the effect of each manipulation while controlling for the other. Overall, each of the four blocks in this experiment included 48 trials. The arrangement of Go and No-Go stimuli and the numbers of the trials for each stimulus word appear in Table 3.

The two sets of stimulus words were run between subjects for the purpose of ruling out the word effect. The words in set A were “health”, “doctor”, “energy” and “green”. The words in set B were “youth”, “drink”, “lives” and “fresh”. These words were selected from a word frequency list (http://www.edict.com.hk/lexiconindex/frequencylists/words2000.htm) to have highly comparable frequencies and numbers of letters. For each set of stimulus words, the four blocks varied within subjects. Both the order of the four blocks and the order of the 48 trials within each block were randomized.

Table 3

Four Blocks with Word Set A and B in Experiment 2

Four blocks with word set A

Go-mapping rules	Go-trial proportions			
	75%-Go-trial proportion		50%-Go-trial proportion	
	Go stimuli and # of trials	No-Go stimuli and # of trials	Go stimuli and # of trials	No-Go stimuli and # of trials
75%-Go	Block 1		Block 2	
	Health-12 Doctor-12 Energy-12	Green-12	Doctor-8 Energy-8 Green-8	Health-24
	25%-Go trial proportion		50%-Go trial proportion	
	Go stimuli and # of trials	No-Go stimuli and # of trials	Go stimuli and # of trials	No-Go stimuli and # of trials
25%-Go	Block 3		Block 4	
	Health-12	Doctor-12 Energy-12 Health-12	Green-24	Doctor-8 Energy-8 Health-8

Four blocks with word set B

Go-mapping rules	Go-trial proportions			
	75%-Go-trial proportion		50%-Go-trial proportion	
	Go stimuli and # of trials	No-Go stimuli and # of trials	Go stimuli and # of trials	No-Go stimuli and # of trials
75%-Go	Block 5		Block 6	
	Youth-12 Drink-12 Lives-12	Fresh-12	Drink-8 Lives-8 Fresh-8	Youth-24
	25%-Go-trial proportion		50%-Go-trial proportion	
	Go stimuli and # of trials	No-Go stimuli and # of trials	Go stimuli and # of trials	No-Go stimuli and # of trials
25%-Go	Block 7		Block 8	
	Youth-12	Drink-12 Lives-12 Fresh-12	Fresh-24	Youth-8 Drink-8 Lives-8

Results

The data were cleaned, and commission-error rates, commission-error RTs, omission-error rates, and hit RTs were calculated as in Experiment 1. First, participants' performance on the two sets of words was compared with a one-way between-subject ANOVA. As there were no significant differences between the two word sets for any of the four dependent measures (e.g., for Commission-error rates, $F_{(1, 61)} = 0.12$, $p < .05$; for Omission-error rates: $F_{(1, 61)} = 0.42$, $p < .05$; for Commission-error RTs: $F_{(1, 5)} = 0.92$, $p < .05$; for Hit RTs: $F_{(1, 61)} = 0.29$, $p < .05$), the two sets of words were combined for subsequent analyses. The means and standard deviations for each experimental cell are presented in Table 4.

It was predicted that higher Go proportions would facilitate actions but that higher Go mapping rules could either facilitate actions or exert distracting effects that would yield more commission and omission errors. A repeated-measures analysis of variance revealed a significant interaction between consistent vs. inconsistent Go-trial proportions and mapping rules and Go-mapping rules (75% vs. 25%) on the four dependent variables—Commission-error rates: $F_{(1, 62)} = 38.72$, $p < .001$; Omission-error rates: $F_{(1, 62)} = 67.03$, $p < .001$; Commission-error RTs: $F_{(1, 6)} = 6.75$, $p < .05$; Hit RTs: $F_{(1, 62)} = 59.03$, $p < .001$. This interaction indicated that the effect of each kind of Go proportion must be analyzed separately. The means and standard deviations corresponding to these analyses appear in Table 4.

The effect of the Go-trial proportion can also be analyzed by comparing the effects of the 25%-Go-trial proportion and the 50%-Go-trial proportion in the 25%-Go-mapping rule condition. This analysis revealed that the 25%-Go-trial proportion produced

Table 4

Descriptive Statistics of Each Experimental Cell in Experiment 2

Dependent variables	Consistency of Go-trial proportions	Go-mapping rules 75% M (SD)	Go-mapping rules 25% M (SD)
Commission-error rates	Consistent with Go-mapping rules	0.33 (0.21)	0.02 (0.08)
	Inconsistent (50%-Go-trial proportion)	0.18 (0.12)	0.04 (0.05)
Omission-error rates	Consistent with Go-mapping rules	0.30 (0.18)	0.41 (0.25)
	Inconsistent (50%-Go-trial proportion)	0.46 (0.19)	0.27 (0.17)
Commission-error RTs	Consistent with Go-mapping rules	296.25 (34.60)	335.31 (30.20)
	Inconsistent (50%-Go-trial proportion)	315.94 (30.71)	315.35 (41.55)
Hit RTs	Consistent with Go-mapping rules	321.63 (27.06)	358.30 (18.75)
	Inconsistent (50%-Go-trial proportion)	341.58 (21.45)	346.20 (20.56)

Note. Entries are means, with standard deviations in parentheses.

higher omission-error rates ($F_{(1, 63)} = 23.07$, $p < .001$) than the 50%-Go-trial proportion. There was no significance for commission-error rates ($F_{(1, 62)} = 2.29$, *ns*), commission-error RTs ($F_{(1, 6)} = 2.09$, *ns*), or hit RTs ($F_{(1, 63)} = 19.63$, $p < .001$). The interaction effect between error types (commission-error rates and omission-error rates) and Go-trial proportions (25% and 50%) was also significant ($F_{(1, 61)} = 31.71$, $p < .001$), confirming opposite effects of the Go-trial proportion on the two types of errors.

Consider now the effect of the Go-mapping rule. This analysis focused on the performance on the 50%-Go-trial proportion blocks of 75%- and 25%-Go-mapping rules. While keeping the Go-trial proportion constant at 50%, the commission-error rates and omission-error rates were significantly higher in blocks of the 75%-Go-mapping rule than in blocks of the 25%-Go-mapping rule (Commission-error rates: $F_{(1, 62)} = 145.77$, $p < .001$; Omission-error rates: $F_{(1, 64)} = 58.53$, $p < .001$). However, there were no significant differences for either commission-error RTs ($F_{(1, 29)} = 0.004$, *ns*) or hit RTs ($F_{(1, 64)} = 1.64$, *ns*). We also examined the interaction between error types (commission-error rates and omission-error rates) and the Go-mapping rules. This additional analysis revealed a significant interaction ($F_{(1, 62)} = 187.33$, $p < .001$), indicating that the Go-mapping rule had stronger effects on omission-error rates than on commission-error rates. However, unlike what was found in Experiment 1, the direction of the effect was the same, with more commission and omission errors in higher Go conditions.

The effect of the Go-trial proportion can be isolated by separately analyzing conditions with different Go-mapping rules. For example, for the 75%-Go-mapping rule, we can compare the effects of the 75%-Go-trial proportion and the 50%-Go-trial proportion. This analysis showed that the 75%-Go-trial proportion produced significantly higher commission-error rates ($F_{(1, 64)} = 48.80$, $p < .001$), lower omission-error rates ($F_{(1, 63)} = 39.70$, $p < .001$), smaller commission-error RTs ($F_{(1, 53)} = 21.84$, $p < .001$) and smaller hit RTs ($F_{(1, 63)} = 62.16$, $p < .001$) than the 50%-Go-trial proportion. The interaction effect between the two types of errors (commission-error rates and omission-error rates) and Go-trial proportions (75% and 50%) in the 75%-Go-mapping-rule condition was significant ($F_{(1, 63)} = 85.35$, $p < .001$). This interaction confirmed that the 75%-Go-trial proportion and the 25%-Go-trial proportion had opposite effects on commission-error rates and omission-error rates.

Discussion

The results from this experiment indicated that both the Go-trial proportion and the Go-mapping rule influenced performance in the Go/No-Go task. However, the effects of each type of Go proportion were very different. Increasing the Go-trial proportions increased commission-error rates but decreased omission-error rates. In contrast, increasing the Go-mapping rule increased both commission- and omission-error rates. One limitation, however, is that the manipulation of the Go trial proportion was confounded by consistency with the mapping rule. Thus, it was desirable to confirm these results while fully crossing the design. This design was implemented in Experiment 3.

CHAPTER 4

EXPERIMENT 3

In Experiment 2, it was suggested that the proportion of Go responses in a mapping rule plays an important role in influencing performance. Of the two hypotheses, the mapping rule appeared to exert a distracting effect on performance, as judged by more commission and omission errors in the higher-Go conditions. However, this result was ambiguous because we examined the 75%- and 25%-Go-mapping rules when the Go proportion of the trials was 50%. Therefore, the distracting effect could have been due to the inconsistency between the mapping rule and the trials. Experiment 3 fully crossed these conditions so that the effects of consistency could be ruled out.

Method

Participants and Design

Seventy three undergraduate students from an introductory psychology subject pool participated in the study in exchange for credit. The design was a 2 (Go-mapping rules: 75% vs. 25%) $\times$ 2 (Go-trial proportion: 75% vs. 25%) factorial design with both factors manipulated between subjects. That is, participants were randomly assigned to complete one of the four blocks.

Experimental Procedures

The procedures in this study were similar to the earlier experiments with the exception of the selected conditions, the use of a single word set, and the inclusion of a single block of trials. The words used in this study were “youth,” “drink,” “lives” and “fresh,” which correspond to word set B in Experiment 2. The study included 54 trials, with conditions arranged as described in Table 5.

Table 5
Stimulus Arrangement in Experiment 3

Go-mapping rules	Go-trial proportions			
	75%-Go-trial proportion		25%-Go-trial proportion	
	Go stimuli and # of trials	No-Go stimuli and # of trials	Go stimuli and # of trials	No-Go stimuli and # of trials
	Block 1		Block 2	
75% Go	Youth-18 Drink-18 Lives-18	Fresh-18	Drink-6 Lives-6 Fresh-6	Youth-54
	Block 3		Block 4	
25% Go	Fresh-54	Youth-6 Drink-6 Lives-6	Youth-18	Drink-18 Lives-18 Fresh-18

Results

The data were cleaned and the four dependent variables (commission-error rates, omission-error rates, commission-error RTs and hit RTs) were calculated in the same way as in Experiments 1 and 2. Means and standard deviations of the four dependent variables for each experimental cell are presented in Table 6.

A between-subjects ANOVA was conducted to examine the effects of the Go-mapping rules and Go-trial proportions. With respect to the interaction, this analysis showed a marginal interaction on commission-error rates ($F_{(1, 59)} = 3.57$, $p = .064$), and no significant interaction on the other dependent measures (Omission-error rates: $F_{(1, 59)} = 1.12$, *ns*; Commission-error RTs: $F_{(1, 59)} = 1.05$, *ns*; Hit RTs: $F_{(1, 59)} = 0.96$, *ns*). The marginal interaction effect reflected the stronger effect of the mapping rule in the 75% than in the 25%-Go-trial proportion (see Table 6).

Table 6

Descriptive Statistics of Each Experimental Cell in Experiment 3

Dependent variables	Go-trial proportions	Go-mapping rules 75% M (SD)	Go-mapping rules 25% M (SD)
Commission-error rates	75%	0.53 (0.22)	0.26 (0.14)
	25%	0.11 (0.21)	0.03 (0.01)
Omission-error rates	75%	0.29 (0.12)	0.14 (0.10)
	25%	0.62 (0.14)	0.35 (0.26)
Commission-error RTs	75%	285.98 (45.66)	284.44 (23.05)
	25%	325.87 (30.70)	304.31 (45.27)
Hit RTs	75%	309.42 (45.33)	325.60 (17.06)
	25%	352.24 (26.38)	351.72 (24.26)

Note. Entries are means, with standard deviations in parentheses.

The analysis also revealed the main effects of the Go-trial proportion and the Go-mapping rule. Consistent with our earlier findings, the main effect of the Go-trial proportion was significant for all of the four dependent variables (Commission-error rates: $F_{(1, 59)} = 43.15$, $p < .001$; Omission-error rates: $F_{(1, 59)} = 42.14$, $p < .001$; Commission-error RTs: $F_{(1, 59)} = 9.35$, $p < .01$; Hit RTs: $F_{(1, 59)} = 16.42$, $p < 0.001$). With the increase of the Go trial proportions, commission-error rates increased, whereas omission-error rates, hit RTs and commission-error RTs decreased. The opposite pattern of effects for commission and omission errors was confirmed by a supplementary analysis including type of error as a repeated measure ($F_{(1, 69)} = 50.61$, $p < .001$).

The main effect of the Go-mapping rule was significant for commission-error rates and omission-error rates (Commission-error rates: $F_{(1, 59)} = 12.09$, $p < .01$; Omission-error rates: $F_{(1, 59)} = 21.58$, $p < .001$). However, the main effect of the Go-mapping rule was not significant for commission-error RTs and hit RTs (Commission-error RTs: $F_{(1, 59)} = 1.40$, *ns*; Hit RTs: $F_{(1, 59)} = 0.85$, *ns*). Similar to the results from Experiment 2, both commission- and omission-error rates were significantly higher in the 75%-Go-mapping rule than in the 25%-Go-mapping rule. Based on a supplementary analysis with type of error as a repeated measure, there was a significant interaction effect between error types and Go-mapping rule ($F_{(1, 69)} = 30.46$, $p < .001$). This reflected stronger increases in omission than commission errors as the Go mapping rule proportion increased.[1]

Discussion

This experiment confirmed the findings from Experiment 2. Increasing the proportion of Go targets in the mapping rule increases both commission-error rates and omission-error rates, whereas increasing the proportion of Go trials during the performance of the task increases commission-error rates but decreases omission-error rates.

[1]The three-way interaction effect involving error types, Go-mapping rules and Go-trial proportion was not significant ($F_{(1, 69)} = 2.51$, *ns*), again suggesting that the effects of the trial proportion and the mapping rule were independent.

CHAPTER 5

GENERAL DISCUSSION

This research has demonstrated that top-down and bottom-up sources of action have different effects on behavior performance. Specifically, we found that increasing the Go-mapping rules increases both commission and omission errors, but increasing the Go-trial proportions increases commission errors while decreasing omission errors. This finding also indicates that the two types of errors are different in nature.

Importantly, this research provides evidence for a feature-positive effect that was not previously uncovered. Simply put, asking people to do something and asking people to do nothing have different effects on their ability to respond correctly. The request to engage in multiple active behaviors appears to operate as a cognitive load manipulation, leading to errors of commission as well as omission. However, the role of attention to the Go targets must be investigated further. For example, generating conditions in which the No-Go instructions attract attention may mitigate the effect and provide support for our hypothesis and interpretation of this finding.

This research has important implications for designing behavioral programs in various domains, including health promotion. Previous research has suggested that human health is largely achieved through clusters of health behaviors. Active but appropriate behaviors are important to us not only for social success, but also for health goals (Albarracin et al., 2008; Munir et al., 2009). For example, keeping healthy usually necessitates engaging in a series of actions including exercising, eating vegetables and using condoms, but also inhibiting inappropriate behaviors such as using drugs. Thus, recommending a cluster of health behaviors usually entails different ratios of the number of actions to the number of inactions in the recommended cluster. By systematically manipulating the action proportion in several complex Go/No-Go tasks, the present research demonstrates that increasing the Go-mapping rules increases both commission and omission errors. Executing actions correctly may be facilitated by embedding a small proportion of actions in the context of several inactions. For example, if improving condom use is a target, combining using condoms (an action) with a large proportion of inactions (e.g., avoiding drugs, not smoking, not drinking coffee) might be an efficient way of improving health. Otherwise, combining a large proportion of actions (e.g., using condoms, exercising, eating vegetables) with a small proportion of inactions might be iatrogenic, because this strategy may increase tendencies to do what should not be done and not do what should be done.

In addition, behavior frequency is another important factor when designing a behavioral program. For example, eating vegetables may require daily decisions, whereas receiving vaccines requires much more infrequent decisions. According to the present research, then, people faced with frequent decisions in which the appropriate behavior is to do something are at higher risk for engaging in behaviors they should avoid. In contrast, people faced with frequent decisions in which the appropriate behavior is to avoid something are at higher risk for not engaging in behaviors they should perform. Thus, what behaviors to recommend or how to structure daily life may be guided by the need to increase action or action inhibition for particular individuals and situations. Such recommendations might emerge after research goes beyond the artificial, time-constrained responses we studied into more complex decisions in real settings.

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APPENDIX A: EXPERIMENT INSTRUCTIONS

In the beginning:

"In this study, you are to discriminate among the words CONDOM, BED, SEX and DISEASE. These words will be automatically presented every 1 second. Your job is to press the spacebar for some of the words. You should press the spacebar with your index finger of your dominant hand. You should be ready to respond to the word immediately and correctly!"

For the practice section:

"First, we would give you 20 practice trials in which you will be presented with two words: EARTH and NATURE. For the first 10 trials, when you see the word EARTH, please press the spacebar as quickly as possible; when you see the word NATURE, please do not press the spacebar. You should press the spacebar with your index finger on your dominant hand. And you must be fully attentive and press the spacebar quickly BEFORE the responding word (that is, EARTH) disappears on the screen.

Please press the space bar when you are ready to begin. Good luck!"

For the experiment section:

"Now please press the spacebar when CONDOM is presented, and do not press the spacebar when BED, SEX or DISEASE is presented. You should press the spacebar with your index finger on your dominant hand. And you must be fully attentive and press the spacebar quickly BEFORE the responding word (that is, CONDOM) disappears on the screen.

Please press the space bar when you are ready to begin."