SITUATIONAL AND INDIVIDUAL FACTORS OF REACTIVE COGNITIVE CONTROL:

EXAMINING FEEDBACK AND MOTIVATION

By

Robert J. Robbins

Amanda Clark, Ph.D.
Associate Dean, College of Arts and Sciences
Associate Professor of Psychology
(Chair)

Kristen Black, Ph.D.
Assistant Professor of Psychology
(Committee Member)

Jill Shelton, Ph.D.
UC Foundation Associate Professor
Psychological Science Graduate Program Director
(Committee Member)

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Robert Jacob Robbins

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ABSTRACT

This study examined the influences of individuals' cognitive intrinsic motivation and the presence or absence of feedback on a cognitive task that encouraged reactive cognitive control. I hypothesized that the presence of feedback would facilitate faster responses. I also hypothesized that cognitive intrinsic motivation, one's disposition towards exerting cognitive effort, would be related to reactive cognitive control in reward situations. Sixty-six individuals completed the Need for Cognition questionnaire (Cacioppo & Petty, 1984) to measure cognitive intrinsic motivation and were randomly assigned to either a rewarded feedback or informative feedback Stroop task. My findings support my first hypothesis indicating a role of feedback in reactive cognitive control. There was partial support for my second hypothesis, that cognitive intrinsic motivation is related to rewarded reactive control performance.

Keywords: Feedback, reward, intrinsic motivation, reactive cognitive control, Stroop task

DEDICATION

This thesis is dedicated to my dad who has dedicated himself to my family and our goals in life. I will never forget what you told me before I began my first year of college, “Do what you want to do, not what others want you to do, and do it well.” Your unconditional kindness and devout sacrifice are the reasons why I am where I am today.

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Activities of daily life require the use of cognitive control, utilizing internal goals to guide information processing and action selection, rather than relying on routine behavior (Bejanni et al., 2020). Quite often we find ourselves needing to inhibit routine responses to achieve a particular goal. For example, imagine driving through town and seeing several marathoners running along the street. As you approach a busy intersection, you see that the traffic light is out and that there is a police officer directing vehicles. Rather than being able to attend to the traffic light to achieve your goal of getting safely through the intersection, you must inhibit this routine response in favor of attending to the police officer. Situations that pit such routine behavior against pre-established goals are referred to as instances of conflict and require cognitive control to resolve and execute the goal-directed behavior. Put another way, conflict emerges when automatic responses to stimuli are challenged by goal-directed behavior. Such situations are emulated in lab settings as conflict paradigms (discussed below), and they are used to examine cognitive control. Although several prominent theories of cognitive control have emerged, they share the key principle of attention modulation. That is, in the face of conflict, attention is ostensibly directed away from task-irrelevant information in favor of the task-relevant information (Abrahamse et al., 2013). Proactive control, a preparatory form of attention modulation, has been shown to be enhanced by situations that involve reward as well as by individual differences like fluid intelligence (Braver, 2012). However, the in-the-moment form of control, called reactive cognitive control, has received less empirical study regarding situational and individual differences. To address this, my study examined situational differences and individual differences in how attention is modulated using reactive cognitive control. Specifically, I examined how rewarded and informative feedback altered reactive cognitive control in a Stimulus-Reward Association (SRA) Stroop task (Krebs, Hopf, & Boehler, 2010). Regarding individual differences in reactive cognitive control, I also examined Need for Cognition, or the extent to which a person is intrinsically motivated towards exerting cognitive effort. Specifically, I investigated how one's Need for Cognition level impacted performance in reward situations of the SRA Stroop task.

Proactive and Reactive Cognitive Control

There are two ways that cognitive control is used to resolve conflict and execute one's goal. The first way is called proactive control and it prepares the individual to reduce conflict in an ahead-of-time fashion. Proactive control is a form of early selection in which goal-relevant information is actively maintained and sustained, prior to encountering cognitively demanding events (i.e., conflict), to modulate attention in a goal-driven fashion (Braver, 2012). Proactive control is thus useful when a person knows that there will be conflict occurring in the future (Braver, 2012). Contrary to proactive control, reactive cognitive control directs attention in a stimulus-driven, trial-by-trial manner (Abrahamse et al., 2013). Reactive control is deployed as a 'late correction' and is elicited on an as needed, just-in-time fashion, such as after conflict is detected (Braver, 2012). Reactive cognitive control is thus used when conflict is not as predictable (Braver, 2012).

One of the most popular experimental paradigms, the Stroop task, has shed light on the role of proactive and reactive cognitive control in conflict situations. The Stroop task requires naming the ink color of a color word (BLUE) while ignoring the task-irrelevant information (the word's meaning). Cognitive control modulates attention towards the relevant dimension (the color green) to complete the goal of naming the ink color. This decreases the conflict between the task-relevant (color: green) and task-irrelevant (meaning: "BLUE") information. Within a typical Stroop task, there are congruent words (the word BLUE in the color blue) and incongruent words (the word BLUE in the color green). Cognitive control is dormant for congruent words and becomes activated when encountering incongruent words. This activation results in a slowing of response time and is referred to as the response cost for resolving conflict. When experimenters increase the frequency of incongruent trials in a Stroop task, conflict becomes more expected and response costs decrease. This is referred to as conflict expectancy and is theorized to be driven by proactive control (Soutschek, Strobach & Shubert, 2013). When utilizing proactive control, the goal (e.g., "name the ink color") is internalized and continuously maintained to prepare responses to potential conflict (i.e., incongruent words; Abrahamse et al., 2013). Recalling our example of driving through town, imagine this time that you had heard about a marathon occurring prior to setting out about your drive. When approaching an intersection that you know is usually used by the runners, you can prepare for the conflict – inhibiting your attention towards the traffic signal in favor of the police officer.

Though seemingly less preferable to proactive control, reactive control can be advantageous. For instance, when the probability of a Stroop trial being congruent or incongruent is equal, adhering to a predetermined goal (e.g., "say the ink color") is less strategic. Rather, the instant the incongruent word is perceived, its conflict is better dealt with and resolved within the time frame of the trial. Thus, when utilizing reactive control, instead of leveraging a prepared attentional selection in favor of the ink color, the stimuli itself activates control to reduce conflict. When experimenters make the congruency of words in a Stroop task less expected, any conflict that is encountered is resolved using reactive, rather than proactive control. As the task goes on, people adjust to this unpredictability and their response costs decrease. This is known as conflict adaptation (Soutschek, Strobach & Shubert, 2013). Reactive control would thus be useful if you needed to drive through town and had not known about a marathon that would cause a variety of street closures. In this situation you are thus caught off guard by having to inhibit your attention toward the traffic light and instead adapt in the moment by attending to the police officer.

The dual mechanisms of control theory (DMC, Braver, 2012) provides two key insights in relation to my study. The first insight is that the DMC frames cognitive control as a flexible dynamic between proactive and reactive attentional modes. Proactive and reactive control are each associated with advantages and disadvantages to the extent that a mixture of both modes optimizes cognition for goal-directed behavior (Braver, 2012). The second key insight concerns the differences in how cognitive control is used. These differences come in two forms, situational and individual, and I argue, warrant further investigation. Therefore, because both situational and individual differences in cognitive control are relevant to my study, I will discuss each in more detail, beginning with situational.

Situational differences in cognitive control refer to environmental circumstances that result in the enhancement of a particular control mode (proactive or reactive) or a preference between the two. Burgess and Braver (2010), for example, observed that when participants experienced frequent cues that indicated interference in a working memory task, proactive control was favored. When the frequency of such cues was low, conflict was less expected, and reactive control was more heavily utilized. A major situational difference factor in how cognitive control is used is the presence of extrinsic reward. I will now discuss this situational factor in more depth before addressing how the relatively poor understanding of extrinsic reward warrants further investigation.

Situational Factors that Affect Cognitive Control: Reward and Feedback

For the purpose of this discussion, extrinsic reward can be defined as some monetary incentive embedded in a cognitive task that serves as feedback for performance. Braem et al. (2012) observed that when trials in a task-switching paradigm were associated with reward (via a "+1" symbol towards a 10 Euro coupon), participants' performance on subsequent conflict trials increased. That is, the situational presence of reward-based feedback improved goal-directed behavior. Hefer and Dreisbach (2017), used the AX-Continuous Performance Task, where letter pairs (one letter presented first as the cue, and the second letter later as the probe) are used to measure proactive and reactive control performance. According to the paradigm, responses to the letter pair AX, which occurs most frequently, should generate a bias toward using proactive control but when the probe letter is changed (participants see a Y rather than the expected X), responses require reactive control. Subjects could earn 10 cents if they responded correctly to the letter X only after it followed the cue A. This AX pair was present 70% of the time during the reward block and thus required the deployment of proactive control for successful performance. The authors found that reward blocks with a higher proportion of AX pairs increased performance and biased participants toward utilizing proactive control. Strikingly, this increase in use of proactive control impaired subsequent blocks that had equal proportions of AX and AY pairs wherein reactive control was just as, if not more so, advantageous. The authors inferred that reward resulted in enhancing proactive control, which lead to increased cognitive stability, or maintenance of the goal over time. However, this resulted in a tradeoff: by rewarding specific contextual information (the AX pairs), the increase in cognitive stability resulted in the impairment of cognitive flexibility or being able to switch one's goal in response to changing conditions. In consideration of the DMC framework, such findings support the variation of cognitive control based on situational changes (i.e., when reward is present). However, much of this work has relied on cued-task paradigms that, despite allowing for a more direct inspection of proactive control, sacrifice scrutiny of reactive control (Boehler et al., 2014). For instance, Stroop-reward frameworks like the Monetary Incentive Delay paradigm, consist of cues that inform participants whether the next trial will be rewarded or not. This makes it so that the cue prepares people to ready their cognitive control strategy (e.g., "get ready for conflict"). The resulting facilitation of performance is thus theorized to be a top-down process that relies on proactive control (Krebs, Hopf, & Boehler, 2016).

Boehler and associates (2014) argue that a significant issue plaguing the motivation-cognitive control research is distinguishing whether reward impacts proactive versus reactive control. Further, the DMC framework leaves open the question of whether reward effects in one mode occur independent of reward effects in the other (Chaillou et al., 2017). Therefore, establishing paradigms that can examine the exclusive impact of reward on reactive control would be useful. One approach is to manipulate the frequency of conflict within a task such that it becomes more or less predictable. For example, Stroop tasks that entail a higher proportion of incongruent words are said to create a reliance on conflict expectancy (Soutschek, Strobach & Shubert, 2013), a proactive control process that reduces conflict by preparing for it ahead of time. On the other hand, Stroop tasks that use fewer incongruent words (e.g., 50% of all trials are incongruent) remove this reliance on expectancy. Resolving conflict in these situations must be done in the moment, by using reactive control, which is referred to as conflict adaptation (Soutschek, Strobach & Shubert, 2013).

The Stimulus-Reward Association paradigm (SRA; Krebs, Hopf, & Boehler, 2016) is a type of Stroop task that utilizes this latter for a more direct inspection of reactive control processing. Furthermore, the SRA isolates the relationship between reactive control and situational changes by mapping feedback (e.g., "10-cents gained") directly onto the task stimuli (e.g., BLUE), rather than onto a cue preceding the stimuli. The prospect of feedback is thus derived "in the moment" and acts to close the margin between responses to conflict and effects of feedback on performance. Reward benefits in SRA paradigms thus rely more on reactive processes (Krebs, Hopf, & Boehler, 2016). As Krebs et al. (2016) highlight,

> "Although DMC usually assumes that reward motivation generally leads to enhanced proactive control (e.g., Jimura et al., 2010), one of the key points of the model is the flexibility with which control can be adapted to different situations. Given this notion, it seems possible that reactive control might also profit from such motivation, in particular in situations in which proactive control cannot easily be used to enhance performance" (p. 5).

In other words, the situational source of variation, in this case, reward-based feedback, can be examined by linking monetary incentives to specific colors in the SRA task. Better performance (as evidenced by reduced response costs) on rewarded trials in comparison to non-rewarded trials would thus reflect enhanced reactive control in the presence of rewarded feedback. In their 2010 paper, Krebs and colleagues found such a pattern using the SRA task, adding to the small, but growing research highlighting reward-induced facilitation in reactive control (see Bowers et al., 2021; Chaillou et al., 2017 & Boehler et al., 2014). To examine whether reward can indeed be considered a situational factor of reactive control, I used the SRA in my study. However, despite the SRA being uniquely designed to examine reward effects on reactive cognitive control, I argue that it still faces an important shortcoming. This is the conflation of rewarded and informative feedback. I will first discuss the SRA paradigm in more detail below before highlighting this conflation and discussing how I addressed it in my study.

The SRA-Stroop Task: Examining Rewarded Feedback in Reactive Control

Krebs and colleagues (2010) investigated the dynamic between extrinsic reward and reactive control by using an SRA-Stroop task. The authors examined how Stroop performance was affected when certain colors were indicative of reward. Specifically, two of four possible ink colors were associated with reward while the semantic meaning of the word could have been congruent, incongruent, or neutral with the ink color.

Krebs et al. (2010) predicted that potential reward (as indicated by the reward-associated ink color) would facilitate performance. In their study, 20 participants were presented with a version of the Stroop task and were asked to identify the presented color of words across four ink colors ("RED", "YELLOW", "BLUE", or "GREEN"). The ink colors were referred to as the *task-relevant dimension* while the semantic meaning of the word was referred to as *task-irrelevant dimension*. The semantic meaning of a given word could be congruent (GREEN) or incongruent (BLUE). Responses to two of the four possible ink colors were associated with the potential for monetary reward ("+10¢"; *rewarded feedback*), while the remaining two colors were standard Stroop trials (*no-reward*). This design allowed the authors to examine how the presence of reward impacted how people use reactive cognitive control to deal with conflict (i.e., reacting to a incongruent word).

Faster response times (RTs) were observed for *rewarded feedback* trials compared to *no-reward* trials, suggesting an overall speeding up of performance in the presence of reward. Importantly, the authors calculated the difference in RT between congruent and incongruent trials to represent response costs, indicators of how efficient participants adapted to conflict. The response costs for adapting to conflict were reduced for the *rewarded feedback* trials (GREEN, GREEN) compared to the *no reward* trials (YELLOW, YELLOW). This suggests that, when reward is present, people are better at deploying reactive cognitive control to deal with conflict.

In sum, Krebs and associates' (2010) found that reward can facilitate reactive control, depending on the situational stimulus and its relationship to reward. Importantly, their findings suggest that within-trial reward information changes the way stimuli are processed despite the absence of cues and the corresponding preparatory mechanisms triggered by such cues (Krebs, Hopf, & Boehler, 2016). This cements the SRA-Stroop task as a means of examining the impact of situational factors (*rewarded feedback*) on reactive control.

Although the SRA paradigm helps resolve the issue of disentangling reactive from proactive control, it conflates affective and informative aspects of reward. When feedback, in the form of a +10¢ symbol, was presented to participants, it activated both a learning and an affective process associated with performance-contingent feedback. Participants not only learned how to adjust their performance based on the informative feedback, but they may have also experienced an affective, "wanting" feeling in response to the reward aspect of the feedback. Thus, their improved performance could have stemmed from learning about their performance, or the emotional aspect related to receiving reward, or both. This issue is not confined to the

SRA paradigm; it presents a challenge for most cognitive measurement approaches (Smith & Delgado, 2015). Furthermore, the literature on the influences of reward on cognitive control is mixed, with some studies suggesting that reward enhances conflict resolution while others suggest there is no impact (Soutschek, Strobach & Shubert, 2013). Thus, one possible explanation for the discrepant findings could be that paradigms fail to differentiate informative from affective aspects of feedback. While studies have found that both informative feedback (Prochnow, Muckschel, & Beste, 2021) and reward-based feedback (Krebs, Hopf, & Boehler, 2010) enhance cognitive control, little research has measured these two aspects individually within the same study.

Therefore, my study was designed to include two groups that differ based on the type of feedback they received – with one group receiving only informative feedback (correct or incorrect), and the other group receiving rewarded feedback (a monetary reward for correct responses). This approach is beneficial for DMC framework research in that it allows for a deeper understanding regarding different types of situations and corresponding change in reactive cognitive control performance.

As previously discussed, in addition to situational factors affecting reactive control, individual differences in reactive control were relevant to my study. Contrary to proactive control, few studies have examined individual difference factors in reactive cognitive control, and none, to my knowledge, have done so using the SRA-task. I will now discuss individual factors in cognitive control more broadly before proffering an argument for examining their role in reactive control and reward situations.

Individual Factors that Affect Cognitive Control: Cognitive Intrinsic Motivation

A key assertion of the DMC framework is that individual difference factors can influence how cognitive control is used (Braver, 2012). For example, neuroimaging evidence has revealed increased activity related to proactive control for individuals with higher fluid intelligence (the ability to solve novel problems) whereas lower fluid intelligence was associated with activity related to a bias toward utilizing more reactive control (Burgess & Braver, 2010). In addition, Jimura et al. (2010) found that higher levels of trait reward sensitivity, the degree to which reward cues affect a person's emotional and behavioral responses (Locke & Braver, 2008), predicted greater performance gains in response to monetary rewards during a working-memory task. This was because individuals who were highly reward sensitive tended towards a proactive control strategy (while decreasing reliance on reactive control) more so than their less reward-sensitive counterparts. A primary notion from this spate of work is that individual differences, like reward sensitivity, can influence how reward impacts the use of cognitive control. However, like other research in the motivation-cognition literature, the abovementioned work used paradigms that are less geared towards reactive control specifically. Thus, it remains unclear how individual differences impact reactive control directly. Furthermore, there is a wide array of individual difference factors that have yet to be examined in the motivation-cognition literature (Locke & Braver, 2008) with one of these overlooked factors being cognitive intrinsic motivation. Therefore, another driving impetus of my study was to examine how cognitive intrinsic motivation influenced reactive control in reward situations.

Cognitive intrinsic motivation (CIM) reflects an individual's disposition toward exerting cognitive effort and the degree to which they value that effort (Cartwright et al., 2019; Inzlicht, Shenhav, & Olivola, 2018). CIM is typically measured using the Need for Cognition scale (NFC;

Cacioppo, Petty, & Kao, 1984) where those high in NFC place more intrinsic value on cognitive effort expenditure. Sandra and Otto (2018) examined how NFC influences the relationship between extrinsic reward and the deployment of cognitive control resources. Using a task-switching paradigm, they observed that individuals who scored low in NFC mobilized more cognitive resources (increased effort) in the presence of reward. In contrast, those who scored high in NFC actually showed a decrease in effort when they were rewarded for performance. As Sandra and Otto discuss, those who valued cognitive effort to a lesser degree (low NFC) responded more robustly to the presence of reward while those who placed greater intrinsic value on cognitive effort (high NFC) were negatively impacted. The key takeaways from Sandra and Otto's (2018) study are 1) cognitive effort varies across individuals as a function of NFC, and 2) 2) when rewarded, the benefit of investing effort is greater for low NFC individuals. This suggests that the benefits of reward for cognitive effort depend on how much a person values that effort (i.e., their level of NFC). The question that emerges is: How does this dynamic apply to engaging in reactive control in reward situations? To get a vantage point on this relationship, the underlying mechanisms by which reward, and individual differences influence cognitive control must be discussed. Crucially, it is these underlying mechanisms by which I speculate reactive control and cognitive intrinsic motivation to interact.

Cognitive Effort and Cognitive Control

In consideration of individual and situational factors that affect cognitive control, a central underlying mechanism concerns the perceived effort that will be needed to use control to resolve conflict versus the benefit of its outcome (Shenhav, Botvinick, & Cohen, 2013; Westbrook & Braver, 2015). In other words, the price of exerting cognitive control to reduce conflict is underwritten by how effortful that control is (Dixon & Christoff, 2012; Kool et al., 2010). Indeed, differences in cognitive control behavior due to idiosyncrasies in reward sensitivity, one's trait disposition towards reward signals, are driven by such internal cost/benefit estimations during task performance (Braver, 2012). Situational differences, particularly the presence of incentives, affects cognitive control in a similar way. The value of reducing conflict (by exerting control) is increased when doing so is associated with reward (Yee & Braver, 2018). In sum, both individual and situational differences in cognitive control performance may depend upon one's disposition to estimating the value of expending cognitive effort, as such this study attempts to examine how the value one places on exerting cognitive effort (i.e., NFC) impacts reactive control performance in reward situations.

Summary and Hypotheses

In essence, differences between individuals (e.g., reward sensitivity) and differences between situations (e.g., the presence of cues or rewards) elicit distinct patterns of cognitive control (proactive-biased or reactive-biased). However, it is less understood how reward impacts reactive control in particular. The research surrounding enhancement of cognitive control is mixed possibly due to experiments conflating affective and informative aspects of performance-contingent feedback. Therefore, the first goal of my study was to determine whether both the affective and informative aspect of feedback enhances reactive control above and beyond informative feedback alone. Although past research suggests individual differences like reward sensitivity influences whether proactive or reactive control is used in reward situations, little work has examined reactive control directly while considering the role of NFC. Thus, a second goal of my study was to determine how NFC influences reactive cognitive control in situations involving reward.

The two primary research questions were: Does reward facilitate reactive control performance above and beyond informative feedback? Does NFC influence the impact of reward on reactive cognitive control? To answer these research questions, two hypotheses were tested:

> Hypothesis One: Facilitation of reactive cognitive control would depend on whether reward was present for feedback trials. I hypothesized that there would be reduced costs (as evidenced by faster RT when going from congruent to incongruent words) for feedback trials in the *rewarded feedback* group compared to the *informative feedback* group.
>
> Hypothesis Two: For the *rewarded feedback* participants, I expected that NFC would be related to the difference in response cost between feedback and no-feedback trials. Here, I am referring to the difference in RT when going from congruent to incongruent words – the response cost – and comparing this response cost between feedback and no feedback trials. The comparison of response costs between these trial types, as reflected by a calculated difference score (subtracting no feedback response cost from feedback response cost), would be related to NFC.

CHAPTER II

METHOD

Participants

A power analysis estimated that a sample size of 54 participants was needed for this study. To allow for possible exclusion of some participants, 66 participants were recruited using UTC's SONA system. Forty-seven of the participants were female, 18 were male, and one was non-binary. Fifty-eight of the participants were undergraduate students and eight were graduate students. Due to data collection errors, only 61 of the 66 participants reported their age, but the mean age was 21.41. Prescreening measures embedded within SONA allowed for the selection of only right-handed participants. Included in the informed consent process and demographic questions were items indicating any history of colorblindness or other conditions that could affect visual ability. No participants were excluded due to handedness or visual ability. All participants received a total of three SONA credits; one SONA credit because the study took place in-person, one credit for the first 30 minutes of in-person participation, and an additional credit for the remaining task duration (no more than 15 minutes).

The study was characterized by a mixed design with two independent groups (*rewarded feedback* and *informative feedback*), each completing feedback and no-feedback trials where the stimuli were congruent or incongruent.

Measures

Cognitive Intrinsic Motivation (CIM)

Upon arrival to the lab, all participants completed the Need for Cognition scale (NFC, Cacioppo, Petty, & Kao, 1984). The NFC scale is an 18-item questionnaire that measures the extent to which individuals engage with and enjoy cognitively demanding activities (e.g., "I prefer complex to simple problems" and "I prefer my life to be filled with puzzles I must solve"). Responses are provided on a 7-point Likert scale ranging from strongly disagree (-3) to strongly agree (3). Therefore, the lowest possible NFC score was -46 while the highest possible score was 46. The NFC has been shown to have good internal consistency (α = .84) and good test-retest reliability (r = .83) across 8-18 weeks (Kuhrt et al., 2021).

The Stimulus-Reward Association Stroop Task (SRA)

Participants were presented an adapted SRA Stroop task (following Krebs, Boehler, & Woldorff, 2010) using SuperLab 5 on an iMac desktop computer in UTC's Assessing Cognition Lab. Participants had to identify the ink color of words while ignoring their semantic meaning.

Before each trial within the task a small fixation square was maintained in the center of a black screen. Each trial began with a colored, capitalized word that remained on the screen for 300 ms. The word was randomly chosen from the following set: "RED", "YELLOW", "BLUE", "GREEN", or "BROWN". Each trial was separated by a variable stimulus onset asynchrony of 1800-2200 ms (Krebs, Boehler, & Woldorff, 2010). This allowed for a staircase algorithm to be used based on individual performance. Fast and correct responses adjusted subsequent trial presentation so that response windows gradually decreased. In this way, participants were given positive feedback for consistently speeding up their performance.

The words were presented in one of four ink colors ("RED", "YELLOW", "BLUE", or "GREEN"). Participants were instructed to respond as quickly and accurately as possible to all words by pressing the key on the keyboard that was associated with the relevant ink color. Because the goal of each trial was to respond to the presented color of the word, the *task-relevant dimension* was the ink color. The *task-irrelevant dimension* was the actual semantic meaning of the word, which was either congruent (e.g., GREEN) or incongruent (e.g., RED). A neutral word (BROWN) was also included to serve as a baseline for performance. Responses were given with the index, middle, ring, and pinky fingers of the right hand.

Participants were randomly assigned to one of two groups: *rewarded feedback* or *informative feedback*. Participants in the *rewarded feedback* group were told that some of their responses could earn them money based on their performance (speed and accuracy). Participants in the *informative feedback condition* were told that some responses would be followed by a "✓" or "X" depending on their performance.

Responses to two of the four possible ink colors were associated with the potential for monetary reward (*rewarded feedback)* or symbolic feedback (*informative feedback).* The remaining two colors were of the typical Stroop type and had no feedback associated – these were the no-feedback stimuli (see Figure 1). Fast and correct responses to feedback stimuli could earn participants in the *rewarded feedback* group five cents and they were presented with either "+5¢" or "-0¢" after those feedback trials (blue/green colored words; see Figure 2). To maintain similar financial reward for all participants in the *rewarded feedback* group, the staircase algorithm ensured that 50% of correct responses were rewarded, leading to an average reward of $2.00 per block for each subject (Carsten et al., 2019). Participants in the *informative feedback* group were presented with either "✓" or "X" after potential feedback trials (blue/green colored words; see Figure 3). Similarly, the staircase algorithm ensured that 50% of correct responses elicited checkmarks. Notably, after non-feedback trials (red/yellow-colored words) participants in both groups were presented with "#" and all symbols were presented for 500ms.

Figure 1 Feedback and No Feedback Trials

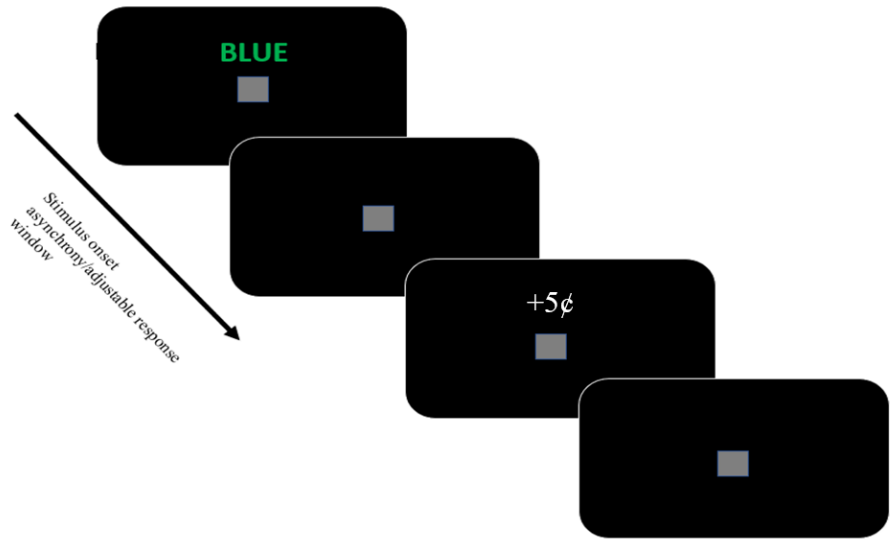


Figure 2 Feedback Trial for Rewarded Feedback Condition

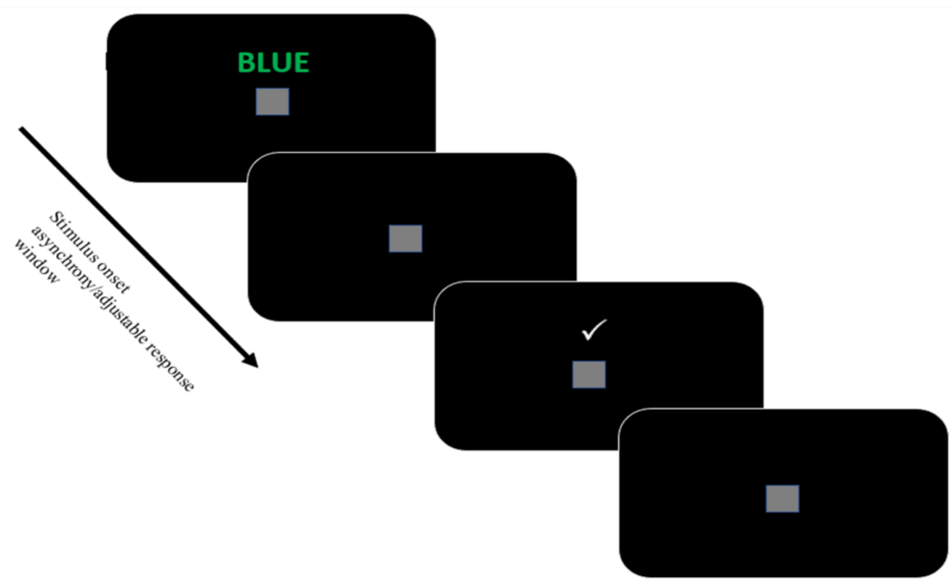


Figure 3 Feedback Trial for Informative Feedback Condition

Following a short training session, participants completed four experimental six-minute blocks, whereby each block had 160 trials. Overall, this resulted in 320 feedback and 320 no-feedback trials across all four blocks. Four 20-second breaks were provided within each block (Krebs, Boehler, & Woldorff, 2010). For the *rewarded feedback* participants, updated dollar amounts were displayed and served as cumulative performance feedback. For the *informative feedback* participants, they were only told that they could take a 20-second break with no additional performance information.

Within the four experimental blocks the presented words were congruent, incongruent, or neutral. Each congruency condition was presented equally across both feedback and no-feedback trials. For the feedback trials, congruent words (BLUE or GREEN) were presented 25% of the time. Incongruent words (BLUE , GREEN, RED, YELLOW, RED, YELLOW) were presented 50% of the time. Finally, neutral words (BROWN or BROWN) were presented 25% of the time. Given that the entire task entailed 640 trials, and half of the trials were feedback trials, the resulting congruency conditions were as follows: 80 congruent, 160 incongruent, and 80 neutral, for a total of 320 feedback trials.

Across the 320 no-feedback trials, congruent words (RED or YELLOW) occurred 25% of the time. Incongruent words (GREEN, BLUE, GREEN, BLUE, YELLOW or RED) were presented 50% of the time. Finally, neutral words (BROWN or BROWN) were presented 25% of the time. Thus, for the trials associated with no feedback, the resulting congruency conditions were as follows: 80 congruent, 160 incongruent, and 80 neutral, for a total of 320 no feedback trials.

Procedure

Participants were recruited through SONA. Only participants who met criteria for the study were permitted to select a day and time to complete this study. Upon arriving to the lab, participants provided initial informed consent before completing any tasks. Participants were then randomly assigned to the *rewarded feedback* or the *informative feedback* group. A condition-specific informed consent was then used to convey the presence or absence of reward for the subsequent Stroop task. *Rewarded feedback* participants were informed that some of their responses would be associated with financial reward but that it depended on their performance, while *informative feedback* participants were told that some of their responses would elicit a "✓" or "X" depending on their performance. All participants then completed the Need for Cognition Scale (Cacioppo, Petty & Kao, 1984) and subsequently the SRA Stroop Task. Finally, participants were debriefed. All participants, regardless of group assignment or actual earned reward on the SRA Stroop task, were provided a digital $10 Amazon gift card and three SONA credits for completion.

CHAPTER III

RESULTS

Though 66 participants completed the study, data from only 61 participants was usable. For two participants, there was a computer power outage during their task that prevented the appropriate completion of data collection. For another participant, there was an error during the random assignment process and the participant received the wrong set of instructions. Further, two other participants failed to adhere to task rules (i.e., "Please respond to all of the colored words"); both used the wrong keys during the task. One failed to respond to 71% of feedback trials while the other failed to respond to 83% of the no feedback trials. Both participants scored over two standard deviations from the sample's average RT, no feedback trial RT and accuracy, and proportion of no responses.

Overall Stroop Performance

After removal of the five outlier participants, as described above, the average RT on Stroop trials overall was 554.26ms (*SD* = 84.49). A paired samples *t*-test indicated that the average RT for feedback trials (blue/green colored words) was significantly faster (*M* = 514.45ms, *SD* = 82.19) than the average RT for no feedback trials (red/yellow colored words) (*M* = 597.88ms, *SD* = 129.89), $t(60) = -5.02$, $p < .001$, $d = 6.26$. The average accuracy for all participants on all trials was 46.32% (*SD* = 7.91%). A paired samples *t*-test indicated that accuracy was greater for feedback trials (*M* = 51.06%, *SD* = 5.51%) when compared to no feedback trials (*M* = 43.34%, *SD* = 10.82%), *t*(60) = 4.98, *p* < .001, *d* = 4.00.

When considering the overall impact of congruency of the Stroop words and presented color, a paired samples *t*-test indicted that the average RT for congruent words (GREEN) was significantly faster (*M* = 541.47ms, *SD* = 82.61ms) than for incongruent trials (GREEN) (*M* = 567.34ms, *SD* = 88.40ms), *t*(60) = -10.83, *p* < .001, *d* = 6.42. Similarly, accuracy was significantly greater for congruent trials (*M* = 51.73%. *SD* = 8.20%) than for incongruent trials (*M* = 43.51%, *SD* = 5.84%), *t*(60) = -10.49, *p* < .001, *d* = 7.45.

Situational Factors: Feedback, Reward, and Congruency

Participants who were randomly assigned to the reward group (*rewarded feedback*) were presented with either "+5¢" or "-0¢" after feedback trials (blue/green colored words). In comparison, participants who were randomly assigned to the no-reward group (*informative feedback*) were presented with either "✓" or "X" after feedback trials (blue/green colored words). The overall average RT for *rewarded feedback* participants was 550.26ms (*SD* = 81.03ms) and it did not significantly differ from the average RT for *informative feedback* participants (*M* = 557.65ms, *SD* = 88.42ms). However, independent samples t-tests revealed a significant difference between the *rewarded feedback* and *informative feedback* participants for feedback trials (blue/green colored words) (*M* = 481.09ms, *SD* = 54.28ms; *M* = 542.75ms, *SD* = 91.56ms, respectively), *t*(53.19) = -3.25, *p* = .002, *d* = .80, but not for no feedback trials (red/yellow-colored words), *t*(59) = 1.24, *p* = .22 (see Figure 4). This indicates that, for general response time (rather than resolving conflict), the presence of financial reward facilitated faster responding.

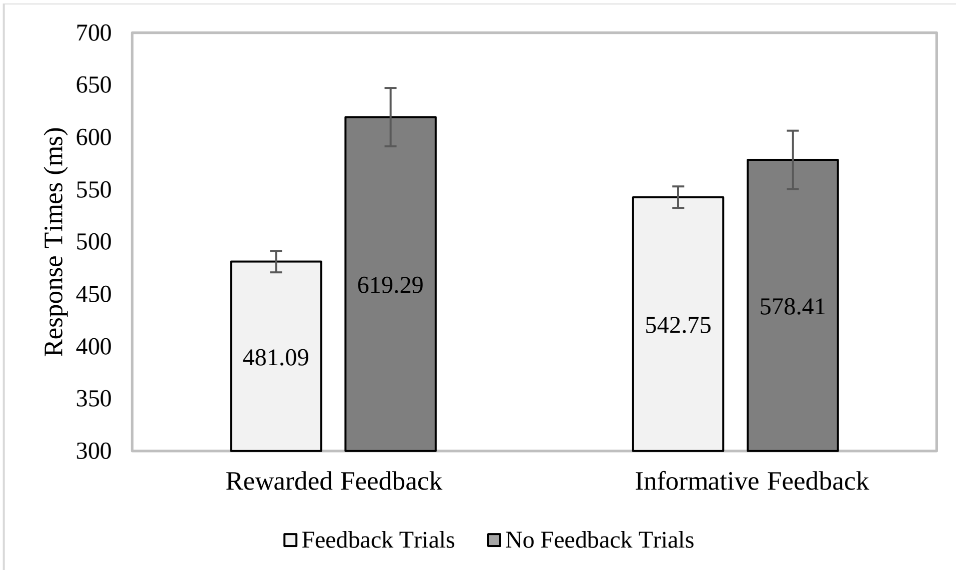


Figure 4 Facilitation due to Reward and Feedback

Congruency also facilitated faster responding, and it did so regardless of the presence of financial reward (see Figure 5). Both the *rewarded feedback* participants and the *informative feedback* participants were significantly faster on congruent trials than incongruent trials, as indicated by paired sampled *t*-tests, $t(27) = -6.23$, $p < .001$, $d = -1.18$, and $t(32) = -10.64$, $p < .001$, $d = -1.85$, respectively. A mixed factor ANOVA revealed that there was not a significant interaction between condition type and congruency, $F(1, 59) = .65$, $p = .42$, partial $\eta 2 = .01$.

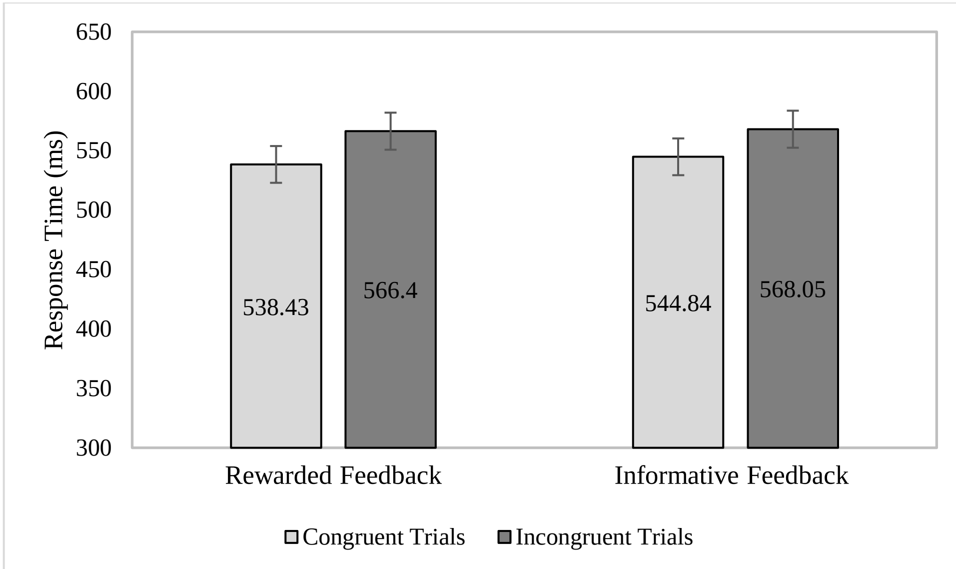


Figure 5 Facilitation due to Congruency

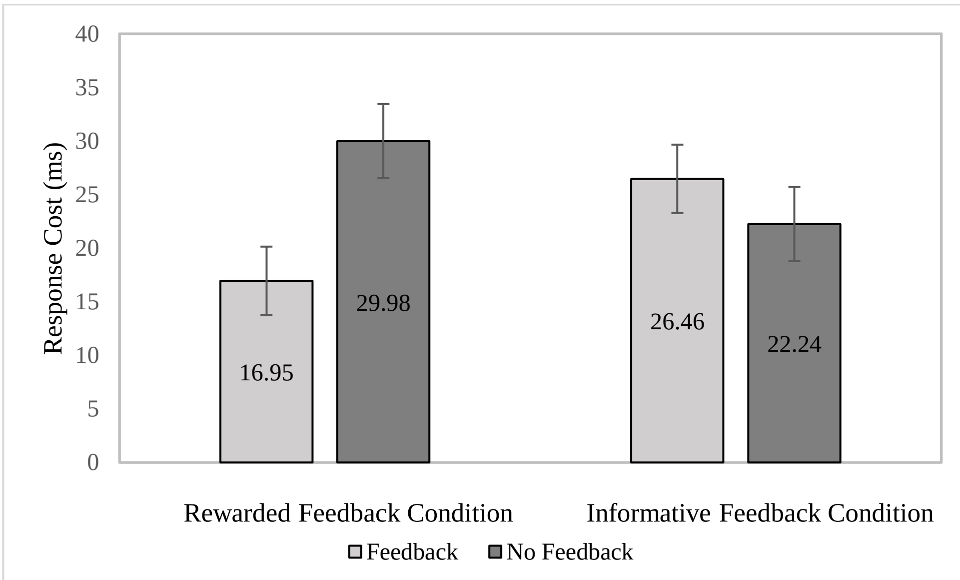
In addition to examining the influence of situational factors (feedback, reward, and congruency) on RT overall, I was particularly interested in investigating how situational factors impact cognitive control on the Stroop task. Specifically, I sought to determine whether feedback, regardless of it being rewarded or informative in nature enhances reactive cognitive control or if facilitation would only be observed when the feedback involves financial reward. I hypothesized that reactive cognitive control facilitation would be present for trials associated with *rewarded feedback* and not for trials associated with *informative feedback.* In other words, I predicted that the response cost for resolving conflict on feedback trials (blue/green colored words) would be lower for the *rewarded feedback* participants compared to the *informative feedback* participants.

To examine this prediction, a 2x2 mixed analysis of variance (ANOVA) was used. The between-subjects factor was condition type (*rewarded feedback* x *informative feedback*) while the within-subjects factor was the trial type (feedback trials x no-feedback trials). Response cost for each trial type was calculated by subtracting the average RT for congruent trials from the average RT for incongruent trials. For *rewarded feedback*, the average response cost for resolving conflict on trials with feedback (blue/green) was 16.95ms (*SD* = 16.86) while the average response cost for resolving conflict on trials without feedback (red/yellow colored words) was 29.98ms *(SD* = 25.99ms). For *informative feedback,* the average response cost for feedback trials was 26.46ms (*SD* = 18.51) and the average response cost for no feedback trials was 22.24ms *(SD* = 19.89ms).

There was a statistically significant main effect of feedback type on response cost for the *rewarded feedback condition*, $F(1, 27) = 5.13$, p = .03, partial η2 = .16, with feedback trials being faster than no feedback trials (M = -13.04ms, SE = 5.75ms). For the *informative feedback condition*, there was not a statistically significant effect of feedback type on response cost, $F(1, 32) = .71$, p = .41, partial η2 = .02.

The results of the mixed ANOVA supported my hypothesis in that there was a statistically significant interaction between condition and trial type, $F(1, 59) = 5.12$, $p = .04$, partial $\eta^2 = .08$ (see Figure 6). In addition, for feedback trials, there was a statistically significant difference in response cost between the *rewarded feedback* group and the *informative feedback* group, F(1,59) = 4.34, $p = .04$, partial η2 = .07, but this was not the case for no feedback trials, $F(1, 59) = 1.76$, $p = .19$.

To examine this interaction more closely, simple main effects were conducted along with the abovementioned mixed ANOVA. These were used to measure the difference in response cost between feedback and no feedback as a function of condition. For feedback trials, response cost was statistically significantly lower in the *rewarded feedback condition*, M = -9.52 (CI 95%, -18.66 to -.38), $p = .04$, compared to the *informative feedback condition*. For no feedback trials, response cost for the *rewarded feedback condition* was not statistically significantly different than the *informative feedback condition*, M = 7.74 (CI 95%, -4.02 to 19.51), *p* = .19 (see Figure 6).

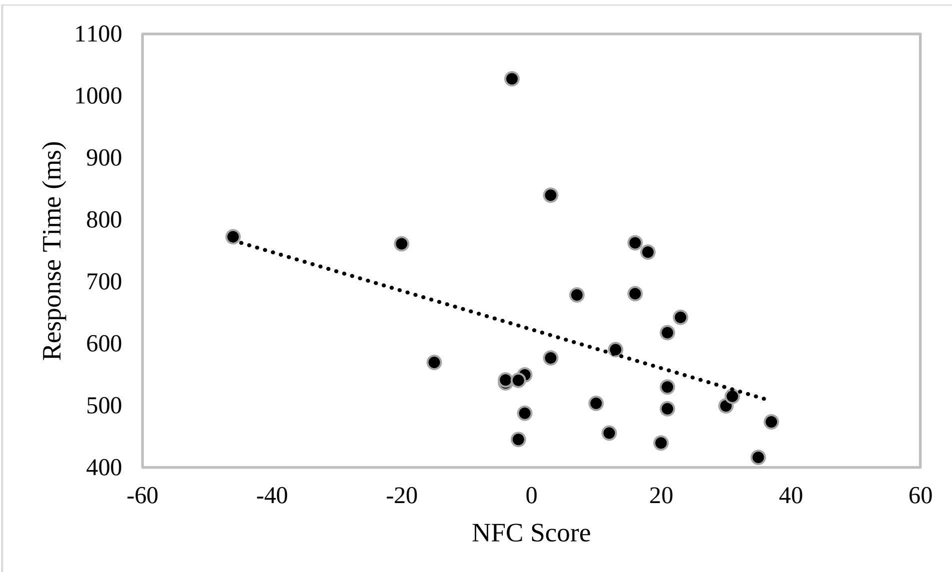


Note. Significance of the interaction effect, p = .04

Figure 6 Facilitation of Cognitive Control

Individual Factors: Cognitive Intrinsic Motivation

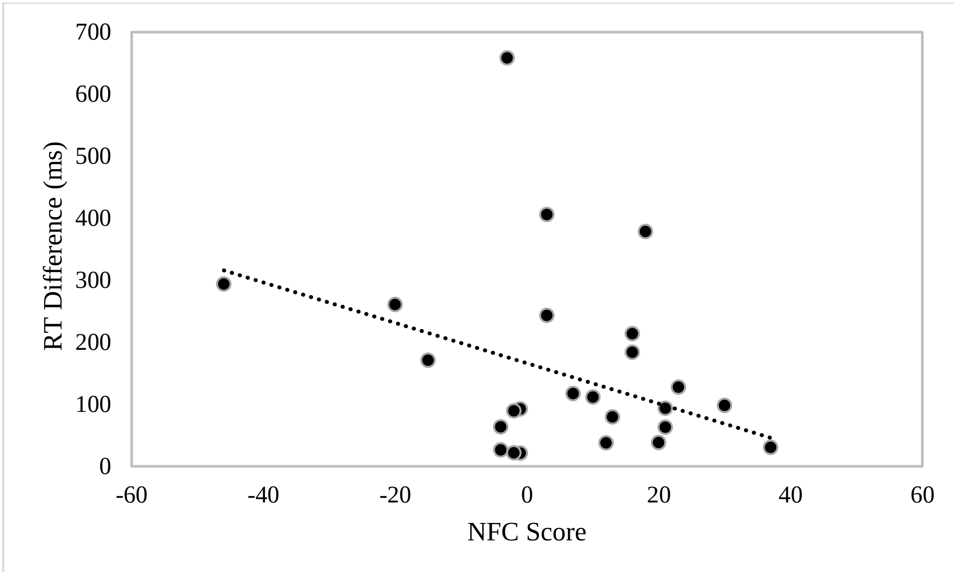
NFC in the current sample demonstrated good internal consistency (*a* = .91). NFC averages for *rewarded feedback* participants (*M* =8.54, *SD* = 3.41) and *informative feedback* participants (*M* =12.03, *SD* = 2.85) were not statistically significantly different, *t*(59) = -.79, *p* = .43. There were no observed relationships between NFC and overall performance (RT or accuracy) for *rewarded feedback* participants. However, when focusing on trial type (feedback trials or no-feedback trials) for *rewarded feedback* participants, NFC was associated with some aspects of performance. A Pearson's correlation revealed a moderate negative relationship between *rewarded feedback* participants' NFC and their average RT on no feedback congruent trials (RED/YELLOW), $r = -.39$, $p = .04$. In other words, as NFC increased, RT for no feedback congruent trials decreased (see Figure 7). Furthermore, another Pearson's correlation between NFC and RT for all no feedback trials (red/yellow colored words) demonstrated a marginally significant negative relationship, $r = -.36$, $p = .06$. That is, as NFC increased, RT for no feedback trials decreased; responses were made more quickly.



Note. $p = .04$

Figure 7 NFC and No Feedback Congruent Trials

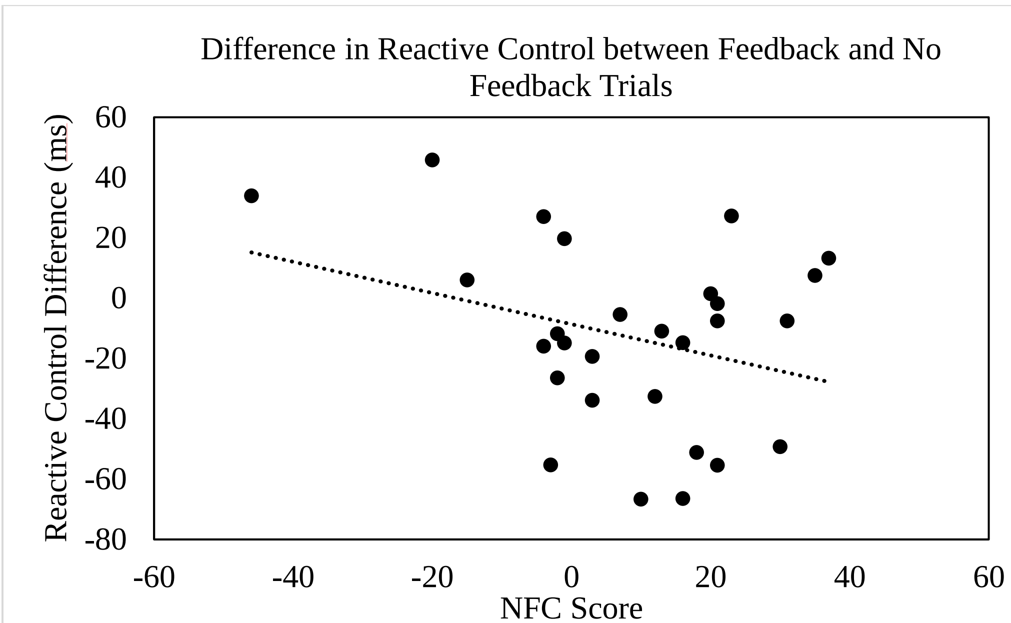
I also examined how *rewarded feedback* participants' NFC related to their difference in RT between feedback trials (blue/green colored words) and no feedback trials (red/yellow colored words). Because the difference score was not normally distributed (W = .83, $p < .001$), a Spearman's correlation was used to examine this relationship. The correlation revealed a marginally significant negative relationship between NFC and the mean difference in RT between feedback and no feedback trials, $r = -.36$, $p = .06$. In other words, as NFC increased, the difference in general RT between feedback and no feedback trials decreased (see Figure 8).



Note. $p = .06$

Figure 8 NFC and Difference between Feedback and No Feedback Trials

A primary goal of this study was to investigate whether the individual factor of CIM relates to *rewarded feedback* participants' reactive cognitive control on the Stroop task. I hypothesized that CIM would be negatively related to the difference between response cost for feedback trials and the response cost for no-feedback trials. To examine this prediction, I subtracted the average response cost for no-feedback trials from the average response cost for feedback trials. This produced mean difference values for each *rewarded feedback* participant and were normally distributed as evidenced by a non-significant Shapiro-Wilks test (W = .97, $p = .62$). The average difference in response cost was -13.04ms (*SD* = 30.45ms). These values and NFC scores for *rewarded feedback* participants were then submitted to a Pearson's correlation analysis. There was a marginally negative relationship between trial type response cost and NFC scores, $r = -.31$, $p = .11$ (see Figure 9). Although the *p*-value exceeded the .05 threshold, the negative relationship can be considered serious due to the small sample size. This indicates that, as CIM increases, the difference in response cost between blue/green and red/yellow trials decreased. Interpretations of this finding are outlined in the discussion.



Note. $p = .11$

Figure 9 NFC and Difference in Reactive Control between Feedback and No Feedback Trials

CHAPTER IV

DISCUSSION

My study had two primary goals. The first goal was to provide a deeper understanding of situational factors that influence reactive cognitive control. I used an adapted Stroop paradigm (SRA-Stroop task) that is designed to measure reactive cognitive control. Other cognitive control paradigms are less equipped to delineate between proactive and reactive control. Krebs, Hopf, and Boehler (2010) used this paradigm to demonstrate that reward is a situational factor that affects reactive cognitive control. However, the combination of scarce use of this paradigm and lack of differentiation between affective and informative aspects of feedback warranted a more nuanced approach. Therefore, I replicated previous SRA-Stroop research while adding a between-subjects design wherein half of the participants received a non-rewarded version (*informative feedback*) and the other half received a rewarded version (*rewarded feedback*). This design enabled me to discern the relative difference in reactive cognitive control facilitation between informative and affective aspects of feedback.

I predicted that the combination of affective and informative aspects of feedback (i.e., *rewarded feedback*) would suppress response costs associated with resolving conflict to a greater extent than when only the informative aspect of feedback was present. This prediction was supported as evidenced by a larger reduction in response costs when feedback was present (blue/green colored words) for the *rewarded feedback* participants compared to the *informative feedback* participants. This has two implications for the role of situational factors in cognitive control (per the DMC framework, Braver, 2012). First, the pattern of results replicates previous work and helps to cement reward as a situational source of variation in reactive cognitive control. While reward-based facilitation of cognitive control had been thought to primarily impact proactive control (Botvnick & Braver, 2015), the results presented here add to the small but growing set of findings that suggests that reactive control may be facilitated as well.

Second, the results suggest that reactive cognitive control may be impacted differently depending on the presence of an affective aspect in feedback, compared to just an informative aspect. This could have implications for contemplating the ways in which feedback facilitates cognitive control. When a performance contingent stimulus is used (e.g., a +5¢ reward or a "✓") two experiences are potentially activated, a motivational experience called "wanting" and a positive reinforcement experience called "learning" (Chaillou et al., 2017). While wanting corresponds to the cognitive representation of obtaining reward (Berridge & Robinson, 2003), learning represents the reinforcing feeling of receiving feedback for a desired behavior (Pessiglione et al., 2008). However, the specific influences of each of these experiences is not fully understood (Chaillou et al., 2017). The current results, however, shed light on the different effects of wanting and learning on cognitive control. For instance, the facilitation of cognitive control in the *rewarded feedback* group versus the *informative feedback* group suggests that a wanting component may modulate reactive cognitive control to a greater extent than a learning component alone.

The second primary goal of this study was to shed light on the relationship between situational and individual factors in reactive cognitive control. Past research has indicated that individual factors, such as working memory capacity, influence whether proactive or reactive cognitive control is typically used (Burgess & Braver, 2010). However, little work has focused on how reactive cognitive control in rewarded situations may depend on individual differences (e.g., CIM), and whether the situational factor of reward interacts with these individual differences. Given that individuals lower in CIM have been shown to mobilize relatively more cognitive resources in the presence of extrinsic reward (Sandra & Otto, 2018), I speculated that this would have implications for reactive cognitive control when reward was possible. There were some aspects of performance that seemed to be related to CIM as measured by the NFC scale. For instance, as NFC increased, RT for no feedback congruent trials decreased for the *rewarded feedback* group. Additionally, as NFC increased, the difference in general RT between feedback and no feedback trials marginally decreased. This means individuals who place greater value on expending cognitive effort were less impacted, with respect to their response speed, by the absence of reward (red/yellow-colored words in comparison to blue/green colored words).

This finding may relate to how CIM influences an individual's perception of task demands. Individuals who did not value expending effort (lower NFC) may have perceived the SRA-Stroop task as more taxing overall and may have focused their effort on the trials most likely to earn them extrinsic reward. On the other hand, individuals who did value expending effort (higher NFC) may have opted to distribute their cognitive resources more evenly across both feedback and no feedback trials. If this is true, the findings would align with resource models of the motivation-cognition relationship (see Botvinick & Braver, 2015). The core premise of these models is that the willingness to mobilize cognitive resources becomes depleted over the course of highly cognitively demanding situations. Thus, individuals who place less value on expending effort may be more selective to utilize their resources for situations when reward is present. Future research should investigate whether this pattern extends to individual's ability to actually resolve stimulus conflict.

In partial support of hypothesis 2, a marginally negative relationship was observed between NFC and the difference in response cost between feedback (blue/green) and no feedback (red/yellow) trials. As NFC increased, the difference in reactive control speed between feedback and no feedback trials decreased. One interpretation of this finding falls in line with the resource model perspective that I previously discussed. Individuals who place less value on expending cognitive effort are more influenced by rewarded feedback in using reactive control. For these individuals, there was a larger difference in reactive control speed between trials that had the potential for reward versus those that did not. This could suggest that reward is offsetting the cost of cognitive control therefore driving selective performance for feedback trials. On the other hand, high NFC individuals who place more value on expending effort may be less influenced by the presence of reward. For these people, reward is having less of an “offset effect” and their performance across feedback and no feedback trials is more stable.

Limitations

It should be noted that there were several limitations to my study. First, the use of feedback between the *rewarded feedback* and *informative feedback* conditions could be improved. Cumulative performance updates were provided for the *rewarded feedback* participants. Cumulative updates were not provided for the *informative feedback* participants. *Rewarded feedback* participants could thus track their performance over the course of the task whereas *informative feedback* participants could not. It should be cautioned then that differences in feedback effects on reactive cognitive control could have stemmed from these cumulative updates. Thus, future work may shed light on feedback effects on reactive control by considering the role of cumulative updates.

Furthermore, for feedback trials (blue/green colored words) participants were presented with feedback even when they made an error (-0¢ or "X"). Although this feedback did not result in a reward loss for the *rewarded feedback* participants and the "X" was not intended to produce a negative learning experience, it may have been interpreted that way (Nieuwenhuis et al., 2005).

Another limitation was the length of the session. The entire task was 640 trials and lasted on average for 25 minutes. Several participants voiced complaints about how boring or difficult the task was after they had finished. Thus, fatigue effects could have confounded aspects of performance and the resulting data. Another consideration was the sample having been primarily Caucasian, female, undergraduate students. Although the findings here may apply to young and middle-aged adults, it is less certain how feedback, reactive control, and motivation may interact in older adult populations.

Additionally, the individual difference factor of cognitive intrinsic motivation was examined in a small sample (N = 28). Although the relationships between CIM and reactive control could be considered moderate, the limited statistical power likely drove the observations of marginal significance. Thus, further work should examine the role of CIM using larger samples.

Overall Conclusions

This study suggests that feedback-based facilitation of reactive cognitive control may depend on the presence or absence of reward. This study also suggests that CIM, as measured by Need for Cognition, may influence how cognitive effort, as well as reactive control, is distributed across challenging situations when reward is present. I will now consider potential implications of these findings.

I observed that people lower in NFC were more selective in where they exerted effort when they went from reward to non-reward situations. This could have implications for how we think about tasks in the academic setting that tax executive functioning. What this finding could suggest is that the less students value working hard, the worse they may perform when that effort does not get them an extrinsic benefit. Furthermore, if students begin to associate certain tasks with being rewarded, they could stop trying as hard on that task when reward is no longer available.

The inspiration for this study came from my experience working in in-patient centers with at-risk youth and in applied behavior analysis. The goals of these programs are to teach children about identifying things, learning parts of speech, knowing colors and shapes, and to ultimately build a fundamental understanding of the world and how to interact with it. Crucially, most of this is taught through associative learning - pairing reward with a response. One thing that I really became interested in was how such token systems for at-risk youth, or reinforcement schedules for children with autism, account for individuality.

The first thing to consider when using these approaches is that children rely on reactive cognitive control to inhibit and control their behavior (Chevalier & Blaye, 2016; Kray et al., 2015). Given that reward appears to enhance reactive cognitive control, we should consider how that could affect children's reliance on it. By rewarding reactive cognitive control, we could be selecting for those types of strategies and negatively influencing how children naturally develop towards more proactive strategies. This might be a particularly relevant issue when we are combining early intervention with associative learning and reward-based reinforcement.

Earlier I discussed that people who were more intrinsically motivated exerted more sustained effort, even when reward was not immediately available. However, people who were not as intrinsically motivated were less apt to exert sustained effort when reward was not present. This could have tremendous consequences for students who are highly intrinsically motivated. If they are being rewarded for their effort in one particular situation, they will be more likely to try just as hard in situations when there is no reward. On the other hand, for learners who are not as intrinsically motivated, things may be different. If they are being rewarded for effort in a certain context, they could be less likely to try as hard in non-rewarded contexts. To think about it another way, for more intrinsically motivated learners, they might keep trying hard after reward has been retracted. But for less motivated learners, their effort might retract along with the reward. The implication here is that we need to account for how much an individual enjoys a task already before we decide to use reward. For some individuals, we could be biasing effort, and the resulting learning, to be confined to rewarded circumstances.

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APPENDIX A

IRB APPROVAL

THE UNIVERSITY OF TENNESSEE
CHATTANOOGA

Institutional Review Board
Dept 4915
615 McCallie Avenue
Chattanooga, TN 37403
Phone: (423) 425-5867
Fax: (423) 425-4052
instrb@utc.edu

situation or adverse event happens during your investigation, please notify the UTC IRB as soon as possible. Once notified, we will ask for a complete explanation of the event and your response. Other actions also may be required depending on the nature of the event.

Please refer to the protocol number denoted above in all communication or correspondence related to your application and this approval.

For additional information, please consult our web page http://www.utc.edu/irb or email instrb@utc.edu.

Best wishes for a successful research project.

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

1. What is your gender?

Male
Female
Other

2. What is your grade level?
   Undergraduate
   Graduate

3. What is your ethnicity?
   Hispanic or Latino
   American Indian or Alaska Native
   Asian
   Black or African American
   Native Hawaiian or Other Pacific Islander
   Caucasian or White
   Multiracial
   Other
   Prefer not to say

4. What is your age?

   ____

1. How difficult did you find the task?

APPENDIX C

EXPLORATORY QUESTIONNAIRE

Not at all	2	3	4	5	6	An extreme amount
❑	❑	❑	❑	❑	❑	❑

2. Reflecting on the task you just completed, please indicate how much you agree or disagree with the following statements:

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I enjoyed doing this activity very much.	❑	❑	❑	❑	❑	❑	❑
This activity was fun to do.	❑	❑	❑	❑	❑	❑	❑
I thought this was a boring activity.	❑	❑	❑	❑	❑	❑	❑
This activity did not hold my attention at all.	❑	❑	❑	❑	❑	❑	❑
I would describe this activity as very interesting.	❑	❑	❑	❑	❑	❑	❑
I thought this activity was quite enjoyable.	❑	❑	❑	❑	❑	❑	❑
While I was doing this activity, I was thinking about how much I enjoyed it.	❑	❑	❑	❑	❑	❑	❑
I put a lot of effort into this.	❑	❑	❑	❑	❑	❑	❑
I did not try very hard to do well at this activity.	❑	❑	❑	❑	❑	❑	❑
I tried very hard on this activity.	❑	❑	❑	❑	❑	❑	❑
It was important to me to do well at this task.	❑	❑	❑	❑	❑	❑	❑
I did not put much energy into this.	❑	❑	❑	❑	❑	❑	❑
I did not feel nervous at all while doing this.	❑	❑	❑	❑	❑	❑	❑
I felt very tense while doing this activity.	❑	❑	❑	❑	❑	❑	❑
I was very relaxed in doing these.	❑	❑	❑	❑	❑	❑	❑
I was anxious while working on this task.	❑	❑	❑	❑	❑	❑	❑
I felt pressured while doing these.	❑	❑	❑	❑	❑	❑	❑
I think I am pretty good at this activity.	❑	❑	❑	❑	❑	❑	❑

I think I did pretty well at this activity, compared to other people.	❑	❑	❑	❑	❑	❑	❑
After working at this activity for awhile, I felt pretty competent.	❑	❑	❑	❑	❑	❑	❑
I am satisfied with my performance at this task.	❑	❑	❑	❑	❑	❑	❑
I was pretty skilled at this activity.	❑	❑	❑	❑	❑	❑	❑
This was an activity that I could not do very well.	❑	❑	❑	❑	❑	❑	❑
I believe I had some choice about doing this activity.	❑	❑	❑	❑	❑	❑	❑
I felt like it was not my own choice to do this task.	❑	❑	❑	❑	❑	❑	❑
I did not really have a choice about doing this task.	❑	❑	❑	❑	❑	❑	❑
I felt like I had to do this.	❑	❑	❑	❑	❑	❑	❑
I did this activity because I had no choice.	❑	❑	❑	❑	❑	❑	❑
I did this activity because I wanted to.	❑	❑	❑	❑	❑	❑	❑
I did this activity because I had to.	❑	❑	❑	❑	❑	❑	❑

3. If you have any comments or concerns, please type them in the space provided below:

____

You have completed all of the experimental tasks. Thank you for completing the study. Your participation will contribute to the understanding of the relationship between cognition and motivation. You may now get the researcher.

VITA

Robert Jacob Robbins earned his Bachelor of Science in Psychology with a minor in Cognitive Science at The University of Southern Indiana in Evansville, IN. He then pursued a Master of Science: Research Psychology program at the University of Tennessee at Chattanooga and worked in the Assessing Cognition Lab. He will graduate in May 2022 with his Master of Science in Psychology after which he will pursue a Doctoral degree in School Psychology. His research interests include executive function, beliefs and perceptions, motivation, identity, and mental health literacy.