APPROVAL SHEET

Title of Dissertation: Some Determinants of Overjustification and Behavioral Momentum

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Doctor of Philosophy, 2018

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ABSTRACT

Title of Document: **SOME DETERMINANTS OF OVERJUSTIFICATION AND BEHAVIORAL MOMENTUM**

Abbey B. Carreau, Doctor of Philosophy, 2018

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The overjustification hypothesis posits that the delivery of external rewards diminishes an individual's intrinsic interest in the activity associated with the reward (Green & Lepper, 1974). This idea remains widely controversial across psychological perspectives. Cognitive and developmental researchers frequently find evidence of the phenomenon (Deci, Koestner, & Ryan, 2001), whereas behavioral researchers rarely observe the effect (Cameron & Pierce, 2002). Importantly, researchers have generally used methods of investigation common to their own field. This has occasioned consistent differences across perspectives in the rate and aggregate history of reward prior to tests of overjustification. Behavioral momentum literature indicates that baseline rate of reward has a central importance in governing response persistence during disruption (such as extinction, as applied in the overjustification effect). Similarly, baseline rate of reward may affect responding during tests of overjustification under conditions amenable to momentum. Aggregate reward history may have a similar relation to behavioral momentum (and possibly to overjustification), to the extent that heightened stimulus-reward associations may obtain over longer durations of stimulus-reinforcer pairings. Experiments 1 and 2 aimed to examine these parameters of reward delivery to determine how the

overjustification effect may relate to behavioral momentum and to examine the extent to which the overjustification effect, like persistence, may be a function of stimulus-reinforcer relations. Specifically, Experiment 1 examined aggregate reinforcement history and Experiment 2 examined reinforcer and response rates and their relation to these phenomena. Results from Experiment 1 were generally in-line with our hypotheses: in 3 of 4 cases, overjustification effects were observed infrequently in the Reward-History Condition and persistence was stronger in the Reward-History Condition relative to the No-Reward History Condition. These results suggest longer histories of reward may strengthen responding as it relates to these phenomena. Notably, results also provided a novel demonstration of possible interactions between overjustification and behavioral persistence: patterns of responding consistently projected an inverse relation between these phenomena. In 3 of 4 cases, the Reward-History Condition was associated with very *strong* persistence and very *infrequent* overjustification effects. As well, in 3 of 4 cases, the No-Reward History Condition was associated with *low to moderate* persistence and relatively *more frequent* overjustification effects.

Results from Experiment 2 were inconsistent and did not conform to our hypotheses: across conditions, with few exceptions, results indicated strong persistence and infrequent overjustification effects. Although overjustification effects were relatively rare, both studies provided some evidence to suggest the reinforcing efficacy of the stimuli affected the likelihood of obtaining overjustification effects: tests following rewards that provisionally functioned as reinforcers were less likely to result in overjustification effects.

SOME DETERMINANTS OF OVERJUSTIFICATION AND BEHAVIORAL MOMENTUM

By

Abbey B. Carreau

Dissertation submitted to the Faculty of the Graduate School of the University of Maryland, Baltimore County, in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 2018

Dedication

To my Nana, whose smile is contagious.

And to my Frumpy, who is often the cause.

Acknowledgements

I would like to extend the utmost gratitude to Dr. John Borrero for his longstanding support and encouragement. The years of experience under your supervision have taught me what may be accomplished with the right combination of motivation, experience, focus, and determination. I have been fortunate to have an advisor with an infectious enthusiasm for science, an unwavering commitment to his students, and an ingenuity invaluable to problem solving under challenging circumstances. I have learned a tremendous amount from your mentorship. Thank you for shaping my behavior and refining my practice. And for always having my back.

Thank you to the members of my committee, Drs. Iser DeLeon, Steve Pitts, David Schultz, and Susan Sonnenschein. Your feedback and support were essential to this project and to my learning and experience throughout my academic career. A special thanks to Dr. DeLeon whose contributions to my early career development and interest in research cannot be overstated. Through your example I came to truly understand and appreciate what it means to wake up every day and love what you do.

Thank you to Betty Sterner and the Y of Central Maryland for their partnership in this project. And to the YMCA of Nashua for their continued participation. Thank you to my colleagues, Jessica Becraft, Michelle Frank-Crawford, Nicole Hausman, Amber Mendres-Smith, and Barbara Tomlian for their feedback and camaraderie over the years, and to my wonderful research assistants, Nicholas Aimone, Elaine Chen, Manpreet Kaur, Kristin Schneider, and Matthew Spann, who helped to make this possible.

My amazing parents have been extremely supportive of this and every endeavor and have provided endless love and encouragement throughout my life. I appreciate all you have done and continue to do. Thank you to my three superhero sons, Owen, Xan, and Ezra, who have provided inspiration, awe, and endless bits of entertainment and joy. You have taught me more than you could possibly realize, each in your own wonderful way.

Finally, and of course, I'd like to extend thanks to my husband, Micah. When my strength (and patience) faltered, yours endured – thank you. I'm forever grateful to have had such a supportive partner to encourage me along this venture, and the rest.

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Chapter 1: The Overjustification Hypothesis

Behavior analysts often arrange reinforcement[1] contingencies to increase appropriate, adaptive responses in the classroom, home, and other environments. Although the positive effects of reinforcement are well established, the possible detrimental side effects of these contingencies are less understood. Consider the following example:

> Aiden enjoys playing the piano; he practices often and frequently performs. Aiden's mother attempts to promote his skills by providing a small payment on the condition that he practices for one hour each day for a month. To his mother's disappointment, Aiden's interest in playing the piano rapidly diminishes shortly following the payment period.
>
> What might account for his sudden disinterest?

The overjustification hypothesis offers one explanation for Aiden's behavior, proposing that the delivery of external rewards diminishes an individual's intrinsic

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[1] 'Reward' and 'reinforcer' are often used interchangeably in everyday vernacular, although they have important distinctions in research and in practice. Rewards are socially defined and presumed to be of some value, yet the extent to which rewards function as reinforcers on an individual level is unknown. By contrast, reinforcers are defined by their strengthening effect on behavior. Thus, reinforcers may be considered rewards, but rewards may not be considered reinforcers unless their strengthening effect on behavior has been determined.

interest in the activity that produced the reward (Green & Lepper, 1974). This may present behaviorally as a decrease in post-reward responding relative to the level of responding observed prior to the reward period, a noteworthy implication of the overjustification hypothesis, and a primary concern of practitioners using reward systems and researchers investigating the phenomenon. The possible detrimental effects of rewards are not widely agreed upon; the overjustification hypothesis has remained a controversial topic in psychological research for decades, thus warranting closer examination.

Background: The Overjustification Hypothesis

The Cognitive Perspective: Self Determination Theory

What do humans need from their environment to thrive? Self Determination Theory (SDT) explores this fundamental question (Ryan & Deci, 2017). The environment of interest entails the inward experience (psychological motivations and need satisfactions), the outside world (the social context), and their interactions. SDT explores social-contextual interactions and how they support or undermine a person's capacity to satisfy three basic psychological needs for competency, autonomy, and relatedness – critical components that drive psychological, social, and behavioral wellness (Ryan & Deci, 2000, 2017).

SDT proposes that humans are active by nature; we have evolved an inherent motivation to explore, to interact, to grow, and to understand (Ryan & Deci, 2017). This makes up our basic intrinsic motivation. Intrinsically-motivated behavior is characterized by full autonomy: driven by the self and promoted by the inherent value of the behavior alone. Humans are likewise motivated by external factors. In Self

Determination Theory, extrinsic-motivation types are delineated along a spectrum from most-to-least autonomous as follows: external, introjected, identified, and integrated. *Externally-motivated* behavior is driven by access to (or avoidance of) an outcome independent of the behavior itself, such as a reward, the avoidance of punishment, or social praise (Deci & Ryan, 2017). This is the least autonomous motivation-type. *Introjected* behavior is motivated internally but is distinct from intrinsically-motivated behavior. Whereas intrinsically-motivated behavior occurs for the enjoyment and value of the behavior, introjected behavior is driven by the avoidance of negative internal states, such as guilt and fear, or to promote positive states such as self-esteem (Deci & Ryan, 2017). Notably, this motivation is still considered controlled, but will continue in the absence of external rewards or other outcomes due to its internal nature. More autonomous forms of externally-motivated behavior are *identified* behavior, in which the individual recognizes the value of their own behavior, and *integrated* behavior, in which this valued external behavior is integrated into the existing values of the person, accepted as in-line with other values and accepted norms that characterize the self. For example, a student may study because she recognizes the value of doing well in school. After identifying the value of studying, she may integrate this behavior with other, similar values and commitments. For example, studying may be in-line with her larger aim to become a doctor (Vansteenkiste & Ryan, 2004; Vansteenkiste & Ryan, 2013). Again, integrated behavior is distinct from behavior that is truly and completely intrinsically-motivated, as the motivation is still separate from the behavior, yet it is relatively more autonomous relative to the motivations described from the other side of the spectrum.

Extrinsic-motivation types are dynamic, each distinctly affected by social-environmental factors, and each associated with different behavioral and psychological outcomes. Contemporary research stimulates these distinct motivations in investigations aimed to examine associated outcomes and socio-environmental factors that support or hinder their expression (e.g., Deci & Ryan, 2017; Reeve, Jang, Hardre, & Omura, 2002; Roth, 2008; Ryan & Di Demenico, 2016).

Self-Determination Theory conceptualizes a broad framework for research on motivation and behavior, highlighting the idea that humans are inherently active and are inclined toward growth and the continuous integration of experiences into the concept of self. However social-environmental factors are necessary to support growth and well-being, specifically in promoting the satisfaction of the fundamental needs for competence, autonomy, and relatedness. SDT encompasses six "mini-theories" that provide theoretical accounts for the outcomes that emerged from research within the larger model. Accordingly, each mini-theory describes a separate tenet of motivation (Deci & Ryan, 2017).

Mini-Theory: Organismic Integration Theory. Organismic Integration Theory posits that through processes of internalization and integration, people may experience feelings of autonomy even when their behavior is extrinsically rewarded. To illustrate, an individual may receive extrinsic rewards, such as good grades and gold stars, for performing well in school. High performance may be initially promoted by these external rewards. Eventually, the student may internalize this pattern of behavior – she may begin to identify as a "good student" and will continue to behave as such to match her identity perception. Over time, the motivation for high performance in school shifts from external to internal as it becomes integrated with other perceptions of the self. This differs from behavior that is truly intrinsically motivated and inherently satisfying. Instead, this allows for a sense of autonomy to *co-exist* with external rewards and promotes processes of internalization and integration within these conditions (Deci & Ryan, 2000; Vansteenkiste, Niemiec, & Soenens, 2010).

Mini-Theory: Causality Orientations Theory. Causality Orientations Theory purports three causality orientations that influence how individuals regulate their behavior (Deci & Ryan, 1985). The autonomy orientation indicates that individuals behave due to the value of the behavior – it is inherently rewarding. Individuals with this orientation are more likely to perceive external rewards as informational, supporting their autonomy (Hagger & Chatzisarantis, 2011). The control orientation involves a focus on external variables such as social approval, rewards, or other external gains. Thus, behavior toward these external factors is likely to continue only as long as the rewards are in place (Hagger & Chatzisarantis, 2011). Finally, the impersonal/amotivated orientation centers around anxieties involving competence. Research on causality orientations indicate positive outcomes associated with autonomy orientation (e.g., relationship maintaining behavior; Knee et al., 2002; adaptive functioning; Deci & Ryan, 1985) whereas controlling and amotivated orientations have been associated with negative outcomes such as self-handicapping (Knee & Zuckerman, 1998).

It is important to note that these orientations are not stagnant but interact with the environment to determine the motivation expressed in different contexts at any point in time. Accordingly, individuals with controlled orientation tendencies may experience autonomous orientation if the environment is sufficiently supportive of this orientation (Deci & Ryan, 1985; Hagger & Chatzisarantis, 2011).

Mini-Theory: Basic Psychological Needs Theory. Self-Determination Theory indicates three basic needs (autonomy, competence, and relatedness) as the "building blocks" for well-being (Ryan & Deci, 2017). The Basic Psychological Needs Theory describes this concept, examining the contexts and interactions that support or diminish the satisfaction of these needs. Basic Psychological Needs Theory purports that competence, autonomy, and relatedness are universal needs, relevant across cultures, genders, and age, and these variables vary in the way and extent to which they affect need satisfactions (Deci & Ryan, 2000). The theory indicates that all three needs must be met for successful, adaptive functioning and that deficiencies in any of the three will have distinct, negative effects on development. In line with that assumption, studies have indicated positive outcomes associated with basic need-satisfactions such as better days (Ryan & Bernstein, 2010), improved heath (Di Domenico & Fournier, 2014) and increases in overall wellness (Chen et al., 2014; Reis, Sheldon, Gable, Roscoe, & Ryan, 2000).

Mini-Theory: Goal Contents Theory. Goal Contents Theory (Ryan, Sheldon, Kasser, & Deci, 1996) proposes that the content of a goal (i.e., what the person expects to obtain) affects well-being and behavior. Within this framework, intrinsic goals (such as those toward increasing health, affiliation, and development) are likely to satisfy basic psychological needs, as opposed to extrinsic goals, such as those related to social status, wealth, and image (Kasser & Ryan, 1993, 1996). Research stemming from Goal Contents Theory indicates that intrinsic goals have been associated with positive outcomes such as well-being, positive mood, and increased life satisfaction (Kasser, 2002). By contrast, extrinsic goal contents have been associated with a variety of negative outcomes such as risky health and negative self-appraisal (Dittmar, Bond, Hurst, & Kasser, 2014), poor mental health (Kasser, Rosenblum, Sameroff, et. al. (2014), and emotional, job-related exhaustion (Vansteenkiste et al. 2007).

Mini-Theory: Relationships Motivation Theory. Relationships Motivation Theory focuses on the psychological need for relatedness: the need to make social connections with significant others. It further describes high-quality relationships as those that promote individual autonomy and provide support for autonomy of the other. By contrast, poor quality relationships stem from those characterized by control. Research in Relationships Motivation Theory indicates that positive relationship outcomes and successful, adaptive functioning are associated with high-quality relationships that support autonomy (Deci & Ryan, 2014).

Within this theory, relatedness pertains to feeling cared for by others and among others. Accordingly, it is not only important to feel as if others are caring for oneself, but also that the individual experiences contributions to others. A sense of social belonging and integration is fostered through these experiences (Deci & Ryan, 2017, 2014).

The final mini-theory, Cognitive Evaluation Theory (CET), is primarily concerned with the effects of controlling versus informational rewards on intrinsic motivation.   The theoretical framework of Cognitive Evaluation Theory provided the foundation for the early studies and interpretation of the overjustification effect within the cognitive perspective. It provides the theoretical background for how it is conceptualized today within Self Determination Theory.

Mini-Theory: Cognitive Evaluation Theory. Cognitive Evaluation Theory posits that the effects of reward on behavior largely depend upon the reward's influence on an individual's perceived autonomy and competence. Intrinsic motivation is conceptualized as existing within the person, becoming activated when social and environmental conditions promote its expression. The conditions that promote intrinsic motivation are those that promote feelings of competence and autonomy, whereas conditions that undermine intrinsic motivation are those that thwart feelings of competence and autonomy. If an individual considers a reward to be *controlling* their behavior, autonomy is threatened, and internal motivation is diminished. By contrast, if an individual considers the reward fundamentally *informative*, providing feedback regarding the individual's competence, the reward may enhance perceived competence and further increase intrinsic motivation (Deci & Ryan, 1985; Ryan & Deci, 2017, 2000).

Deci (1971) conducted a seminal investigation of Cognitive Evaluation Theory and the overjustification effect testing the hypothesis that individuals who received money for engaging in an activity (autonomy threatening) would experience decreased intrinsic motivation, whereas those who received verbal praise for engagement (competence enhancing) would experience increased intrinsic motivation[2]. The researchers examined the difference in levels of responding before and after reward periods across rewarded and non-rewarded groups, a method commonly employed in overjustification studies. Results suggested rewards differentially affected intrinsic motivation (money decreased responding whereas praise increased responding), perhaps depending upon how the individual perceived the reward and its control over their behavior, a finding in-line with the researchers' hypothesis.

There are some considerations to note in light of their findings and implications for the use of rewards. First, results indicate that detrimental effects of reward may occur when tangible rewards are delivered for engagement (regardless of performance) with a task presumed to be highly intrinsically motivating. These results are not indicative of the detrimental effects of rewards, or reinforcers, more generally (outside of the specific conditions of the experiment). Second, participants were college students receiving course credit for their participation, suggesting that both control and experimental groups were under *additional* external contingencies to some degree. The study may have been more accurately examining the effects of supplemental extrinsic rewards overlaid upon extrinsically motivated responding (Cameron & Pierce, 2002). As a final note, the effects of money on task interest were not statistically significant.

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[2] Money was presumed to diminish autonomy due to its association with services rendered. Historically, money has accompanied work-related activities, presumably tasks that individuals will generally not complete voluntarily, without payment. Thus, if an individual receives money for engaging in a particular activity, the individual may reevaluate their autonomy and alter their perception of the variables controlling their behavior (toward the external reward). Verbal rewards do not have a similar association and are accordingly less likely to be perceived as controlling behavior, allowing the perceived control to remain within the individual.

Cameron and Pierce (1994) raised concerns about Cognitive Evaluation Theory, noting that CET proports that feelings of competence and autonomy produce changes in intrinsic motivation, but these are not measurable and are only assumed to underlie intrinsic motivation due to the measurable outcomes they purportedly produce (i.e., through behavior change). The authors posit that the constructs of competence, autonomy, and intrinsic motivation are all inferred through the behavior they purportedly cause. Further, the authors note that rewards are often labeled as “controlling” or “informational” after the fact, based upon behavioral outcomes (i.e., rewards are labelled as controlling if intrinsic motivation measures decrease and informative if they increase) (e.g., Deci & Ryan, 1985; Rummel & Feinberg, 1988).

In opposition to Cameron and Pierce (1994), other investigations have provided evidence of the overjustification effect framed by Cognitive Evaluation Theory (e.g., Ma, Jin, Meng, & Shen, 2014; Hagger, & Chatzisarantis, 2011; Wiechman & Gurland, 2009). For example, Murayama et al. (2010) asked participants to play a game-like stopwatch task. Some participant received rewards contingent upon performance, whereas other participants did not. Results indicated that the rewarded participants spent less free time on the task during the subsequent free-choice period. These results were matched by fMRI data indicating reduced activity in the anterior striatum and the prefrontal areas (regions involved in reward circuits within the brain) during the post-reward period for the rewarded group only, possibly providing evidence of the neurological processes underlying the undermining effects of reward (see Di Domenico & Ryan, 2017 for a review of emerging neuroscience research in relation to intrinsic motivation).

Early overjustification studies framed by Cognitive Evaluation Theory (Deci, 1975; Deci & Ryan, 1980) provided the foundation for the theory and study of motivation as it is conceptualized today within Self Determination Theory. Although the perception of motivation-types has been both expanded and refined, the tenets of the overjustification effect and its relation to intrinsic motivation remain as they were described in earlier studies: rewards perceived as controlling behavior threaten autonomy and undermine intrinsic motivation. Other disciplines within psychology have explored motivation and potential undermining effects of external rewards and provide separate interpretations. Self-Perception Theory provides an alternative account originating in social psychology.

The Social Perspective: Self-Perception Theory

Like Cognitive Evaluation Theory, Self-Perception Theory within the social perspective suggests that there are two perceivable factors underlying a person's behavior: intrinsic motivation or external rewards (Kelly, 1973). For example, if an individual loses a competition, it may be due to external factors such as not practicing or bad weather, or due to internal factors such as natural ability or talent. Self-Perception Theory purports that if external reinforcement contingencies are sufficiently salient and unambiguously perceived as an explanation for engaging in an activity, individuals will attribute their behavior to outside variables. If not, the individual will attribute behavior to his or her personal disposition and needs (Bem, 1972; Kelly, 1973).

Cognitive Evaluation Theory indicates that the effects of reward on intrinsic motivation depend upon the nature of the reward (i.e., informative or controlling) and the extent to which it may promote or thwart the satisfaction of fundamental needs for autonomy and competence. By contrast, Self-Perception Theory proposes that rewards will detrimentally affect intrinsic motivation when they promote perceptions of external attributions for the causes of behavior, most likely to occur when salient rewards are delivered for valuable activities and when rewards do not signal competence (Lepper, 1981).

Lepper, Greene, and Nisbett (1973) conducted an early overjustification investigation stemming from Self-Perception Theory using methods like those described by Deci (1971) but examining effects of reward *expectancy* on drawing. The researchers randomly assigned children aged 3 to 5 to one of three conditions: (a) expected reward, (b) unexpected reward, or (c) no reward. In this arrangement, only participants in the expected-reward group were working for a sufficiently salient and unambiguous reward that might have been perceived as an extrinsic goal. Accordingly, researchers expected this group would be the only to experience detrimental effects of rewards as predicted by Self-Perception Theory.

Results were consistent with the researchers' hypothesis: participants in the expected-reward group were the only ones to experience significant detriments in responding from the pre- to post-reward period. Interestingly, responding during the no-reward test condition was highest in the unexpected reward condition (relative to expected-reward and no-reward), suggesting that the effects of rewards, regardless of whether they were expected or unexpected, were inconsistent. Accordingly, these results do not provide unequivocal evidence of consistent negative effects of rewards in general.

Other researchers have examined the effects of reward on intrinsic motivation in the context of Self-Perception Theory. For example, Burger and Caldwell (2007) presented money to some participants after they signed a homelessness petition. Other participants were not paid and were instead told they were helpful. Paid participants were less likely to view themselves as altruistic and were less likely to comply with a later request to participate in a volunteer food drive. By contrast, the participants who had been told they were helpful were more likely to see themselves as altruistic and were more likely to participate in the food drive. This research provides evidence in favor of the negative effects of rewards on later behavior: participants who were paid presumably attributed their behavior to external factors (the money) rather than to attributes within the self, resulting in less altruistic behavior in the subsequent test. By contrast, those who attributed their altruistic behavior to internal factors (i.e., those who were told they were "helpful") were more likely to act in accordance with those attributes in a later test. Other research has obtained similar findings (Burger, 1999; Goldstein & Cialdini, 2007; Grabe & Hyde, 2007) providing evidence that external rewards may undermine responding when individuals attribute the causes of their behavior to external factors.

The predictions of Cognitive Evaluation Theory and Self-Perception Theory are relatively similar, although the theorized underlying psychological processes contributing to the overjustification pheonomenon differ. Both predict that rewards will have detrimental effects on post-reward responding when expected rewards are delivered and when they do not undermine perceived competence (Deci & Ryan, 1985; Lepper & Gillovich, 1981). Some research provides evidence in support of

Cognitive Evaluation Theory (Green & Lepper, 1974; Murayana et al. 2010) as well as Self-Perception Theory (e.g., Burger, 1999; Goldstein & Cialdini, 2007), yet other research stemming from Learning Theory is in contrast to detrimental effects of reward indicated by both Cognitive Evaluation Theory and Self-Perception Theory (Bright & Penrod, 2009; Levy et. al. 2017; Peters & Vollmer, 2014), instead considering any negative effects of rewards to be well explained by the established principles of behavior.

The Behavioral Perspective: Learning Theory

Learning theory suggests behavior is largely determined by the consequences of behavior over time. Here, the future likelihood of operant behavior is selected by consequences in a manner analogous to natural selection in the evolution of a species: Natural selection requires within-species variations in physical attributes. Members of species with an attribute that provides a functional advantage for survival endure over those without the attribute, producing consistent advantageous changes, overtime, in the physical properties of the species. Operant selection by consequences works in a similar manner, originating instead from *behavioral* variation. Behaviors that are selected to survive are those that have historically produced reinforcing outcomes under particular conditions. For example, the future probability of “drinking” may be more likely under conditions of “thirst” due to the reinforcing condition this behavior has historically created (i.e., thirst alleviation). On the other hand, other behaviors that have not historically produced such favorable outcomes will not survive to be exhibited in later conditions of thirst.

In the example above, conditions of satiation and deprivation constitute the motivating operations that establish the value of water and promote the likelihood of drinking. Likewise, satiation and deprivation are two important variables that likely affect overjustification. In tests for overjustification, post-reward examinations necessarily occur after pre-reward observations. This arranges for the possibility that decreases in responding due to satiation effects will be more likely in the post-reward period. This may be especially relevant in between-groups designs that have rewards delivered for one group but not the other. If the rewards function as reinforcers, then the experimental group will have engaged with the activity to a greater extent during the reward period relative to the control group – making post-reward decreases in responding due to satiation more likely in the experimental group relative to the control group. This can be observed in the original Deci (1971) study in which the experimental group spent more time engaging with the activity during the intervening reward period (Time 2 in Table 1) relative to the same intervening no-reward period for the control group, making post-reward decreases in responding attributable to satiation more likely for the experimental group relative to the control group.

Table 1

Results from Deci (1971) indicating mean time spent engaging with puzzle during free-choice periods. Adapted from Deci (1971).

Group	Time 1	Time 2	Time 3	Time 3 – Time 1
Experimental (*n* = 12)	248.2	313.9	198.5	-49.7
Control (*n* = 12)	213.9	205.7	241.8	27.9

Peters and Vollmer (2014) examined the effects of satiation on overjustification-like effects in a series of three studies. In Study 1, they assessed overjustification effects when only one activity was available and observed no decrements in responding from pre- to post- reinforcement. In Study 2, they examined overjustification effects when multiple activities were available, and observed decrements in responding moving from pre- to post- reinforcement. Following the results of Study 2, they conducted Study 3 to examine the effects of extended exposure to multiple activities, as was arranged in Study 2, examined without the provision of rewards. Decreases similar to those observed in Study 2 were observed in Study 3, indicating that post- reward decreases in Study 2 may be attributable to the effects of satiation.

In Learning Theory, past reinforcement and punishment contingencies have a central role in determining the future probability of behavior. Likewise, it is considered that any behavioral side effects of reinforcement are not due to diminished construct of intrinsic motivation, but to operant processes that relate to the established effects of reinforcement and extinction. In-line with this view, findings within Learning Theory generally suggest the delivery and subsequent withdrawal of reinforcers leads to a gradual decrease back to the level of responding observed prior to the reinforcement period, the expected pattern of behavior due to extinction effects (Bright & Penrod, 2009; Fisher, 1979; Peters & Vollmer, 2014). Levy and colleagues (2016) recently provided evidence of this in their quantitative review of the overjustification effect. The researchers examined 65 studies, analyzing differences in baseline levels of responding from pre- to post reward. Results generally indicated post reinforcement responding was just as likely to be higher or lower than pre-reward responding. In other words, improvement effects were obtained equally as often as overjustification effects.

In light of the divergent findings surrounding the phenomenon, behavioral researchers Cameron and Pierce (1994) conducted a meta-analysis of 94 studies on the effects of reward on intrinsic motivation. Their cumulative results suggested only slight negative effects of reward when tangible, expected rewards were delivered regardless of performance. By contrast, verbal rewards, in almost all circumstances, were found to *increase* responding. Overall, they concluded that rewards did not produce detrimental outcomes. However, results may be considered consistent with research from Cognitive Evaluation Theory to the extent that verbal and tangible rewards differentially affected intrinsic motivation (Deci, 1971; Deci & Ryan, 1985, Deci, Koestner, & Ryan, 1999)[3].

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[3] Deci, Koestner, and Ryan (1999) dispute the results of this meta-analysis, suggesting a number of flawed procedures including (but not limited to) the exclusion of a number of thorough, unpublished doctoral theses, and the inclusion of studies using tasks that were not assumed to be of high-interest, most relevant to Cognitive Evaluation Theory. Cameron, Banko, and Pierce (2001) later retort, suggesting there is no definitive line to distinguish tasks of high-intrinsic value from those of lower intrinsic value, and further suggest that these are the very tasks for which rewards are commonly implemented (those that are not already highly motivating), thus the most relevant to the phenomenon.

Collectively, results from both Cognitive Evaluation Theory and Learning Theory seem to suggest tangible and verbal rewards have different effects on responding under some conditions. How might behavioral researchers account for this finding? Carton (1996) notes three variables important to the principles of behavior that are generally uncontrolled across studies incorporating verbal and tangible rewards: (a) the temporal proximity between response and reward, (b) cues regarding reward availability, and (c) the number of reward deliveries. Specifically, tangible rewards are generally delivered after a delay (e.g., following the reward phase, following the reward period, or even after days or weeks) whereas praise has generally been delivered immediately following the target response during the reward period (e.g., Koestner, Zuckerman, & Koestner, 1987; Rummel & Feinberg, 1990). Similarly, researchers often deliver praise a number of times during the reward period, whereas tangible items are more often only delivered one time (e.g., Murayama, Matsumoto, Izuma, & Matsumoto, 2010; Rummel & Feinberg, 1990). Because of these procedural differences, praise may have been more likely to increase responding. Finally, studies involving tangibles often cue its impending unavailability prior to the test phase, whereas the unavailability of praise is generally not signaled (Green & Lepper, 1974; Koestner, Zuckerman, & Koestner, 1987; Ryan, 1982). This may be important as cues have been shown to promote discrimination, and the absence of cues has been shown to promote generalization (e.g., Skinner, 1953), which may partly explain why participants who receive verbal rewards are more likely to continue responding *as if* the contingencies have not changed.

Making sense of the data poses quite a challenge: for every study providing evidence for the overjustification effect, there seems to exist an alternative study to refute the results. The results of several meta-analyses across perspectives similarly highlight this dispute, with results and discussion from one perspective often disputing the results of another. Meta-analyses have examined the effects of reward, in general, on intrinsic motivation, and have also examined a variety of other variables. These have included reward type (praise, tangible), reward delivery (contingent, non-contingent), expectation of reward (expected, unexpected), and performance criteria (engagement, task completion, task performance) among others. Figure 1 provides a summary of findings from several meta-analyses examining the extent to which these variables affect two common measures of overjustification: (a) free-choice engagement and (b) changes in attitude toward the activity. Whereas some consistencies exist (e.g., overjustification effects seem to be more consistent when tangible rewards are expected, but not when verbal rewards are delivered or when rewards are unexpected), there are many inconsistencies – most notably in the overall effects of reward.

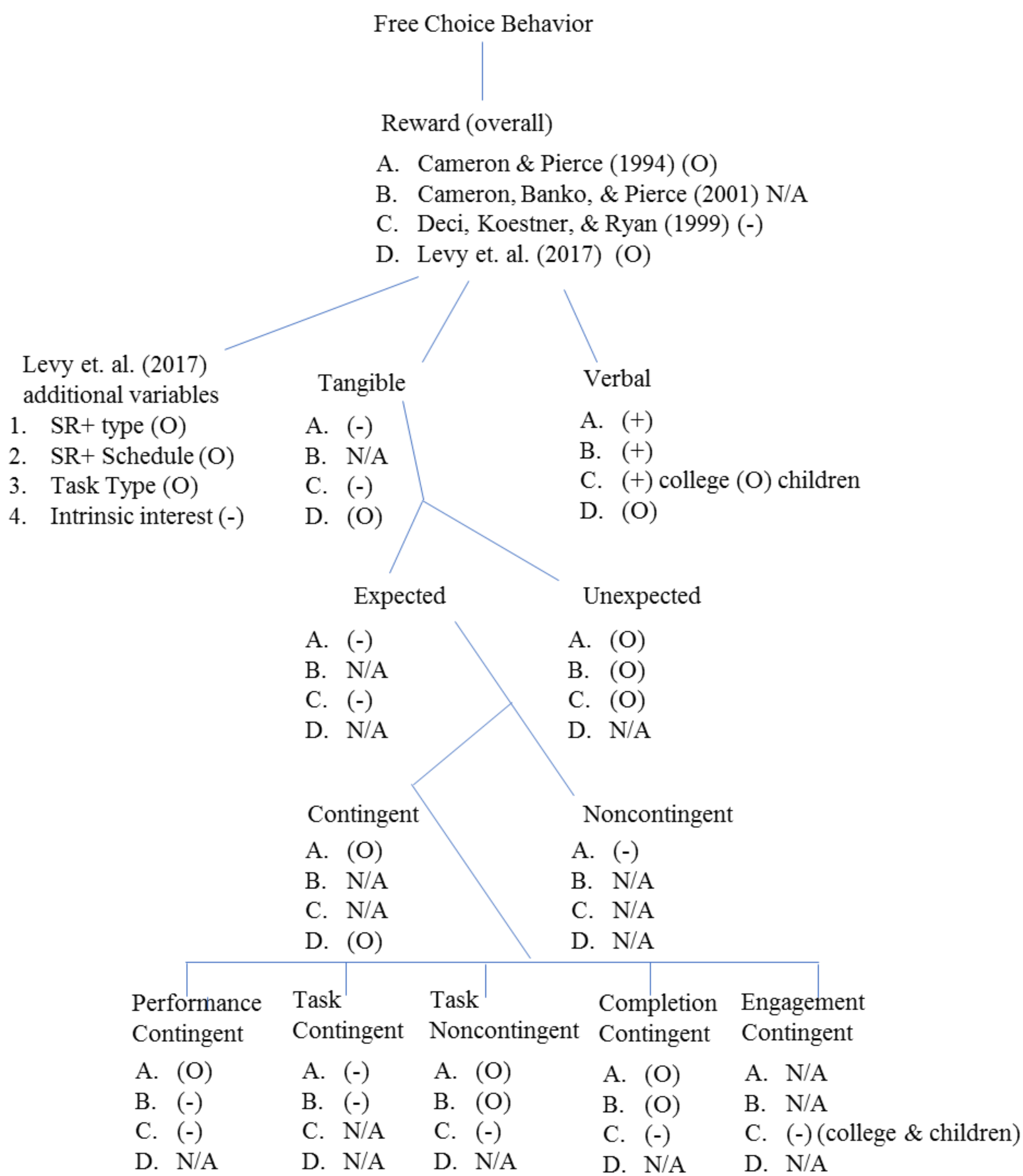

Figure 1. A summary of meta-analyses measuring free-choice behavior in examinations of the overjustification effect. A = Cameron & Pierce (1994); B = Cameron, Banko, & Pierce (2001); C = Deci, Koestner, & Ryan (1999); and D = Levy et al. (2017). O = no effects; - = significant, negative effect of reward

(overjustification effects); + = significant, positive effect of reward, N/A = variable was not examined.

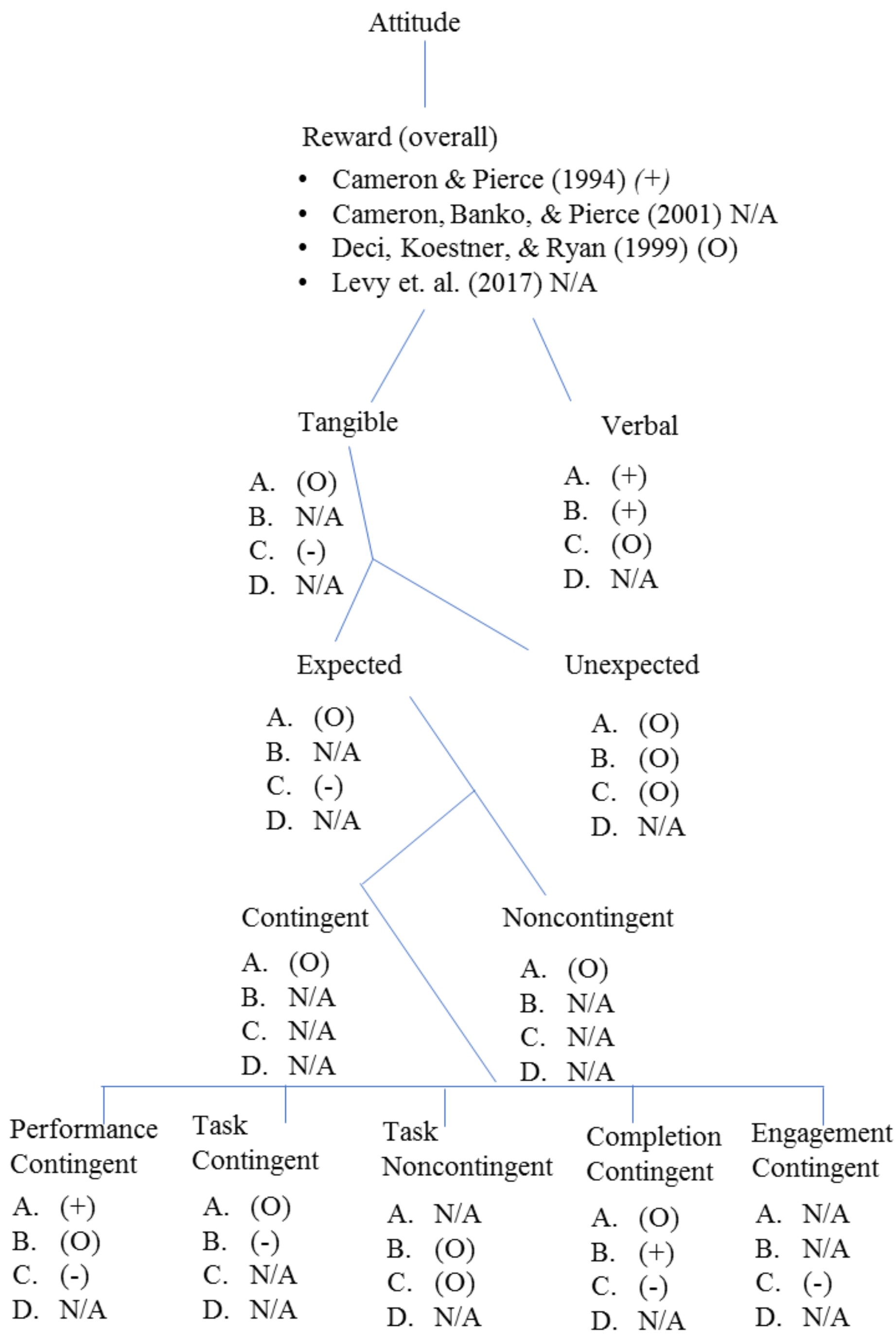

Figure 2. A summary of meta-analyses measuring attitude in examinations of the overjustification effect. A = Cameron & Pierce (1994); B = Cameron, Banko, &

Pierce (2001); C = Deci, Koestner, & Ryan (1999); and D = Levy et. al. (2017). O = no effects; - = significant, negative effect of reward (overjustification effects); + = significant, positive effect of reward, N/A = variable was not examined.

It is no surprise that such controversy exists. Taking a closer look at seminal studies and meta-analyses, the data, in sum, suggest the following:

1. Baseline levels of engagement stay the same or increase following the presentation and withdrawal of verbal praise (Cameron & Pierce, 1994; Cameron, Banko, & Pierce, 2001; Deci, 1971) and;
2. may decrease following the delivery and subsequent withdrawal of tangible rewards when they are expected and delivered regardless of performance, but;
3. not when these rewards are unexpected or delivered contingent upon some performance criteria (Cameron & Pierce, 2002; Deci, 1971; Lepper, Greene, & Nisbett, 1973).

The extent to which specific reward parameters, such as the rate of reward delivery or reward history, influence overjustification effects is unknown. Collectively, the results do not suggest general, detrimental effects of reward. Yet the negative view of rewards was popular during the time of the early overjustification studies and remnants of derision remain today.

The Negative Perception of Rewards in US Society

Research may have real and important effects on societal practices, an ideal outcome when data and practice are in-line and well informed. However, far-reaching societal effects may also be propagated through “bad” data, at worst resulting in widespread misunderstanding, fear, and alarming health practices. An example may be well illustrated by the anti-vaccination movement spurred by the fraudulent study linking MMR vaccinations and autism. The study's author, Andrew Wakefield, published falsified data in a 1998 issue of the Lancet (Wakefield, 1998). The research was later deemed fraudulent and was retracted. Still, the results had influence, and generated a societal fear that ultimately fostered the momentum of an anti-vaccination movement resulting in severe health risks and the reemergence of diseases thought to be eradicated in the US (Time, 2014). Harmful societal practices and beliefs may be similarly generated from "good" data from reputable studies when results are oversimplified or not well understood by the general public. The following provides a discussion of this problem as it relates to the overjustification effect.

A troubling paradox exists concerning common research findings and some prevailing messages regarding the use of rewards. The detrimental effects of rewards have been established under very limited circumstances (i.e., when tangible rewards are delivered regardless of performance), and are only applicable to behaviors for which reward contingencies are not frequently arranged (i.e., responses that already occur at high levels). In accordance with these findings, many researchers support the use of reinforcers in a variety of contexts. Conversely, warnings cautioning against the general use of reward contingencies are also prevalent. Alfie Kohn is among the most notable of proponents for the disuse of rewards. For example, he asserts, "By now it should be clear that the trouble doesn't lie with the type of reward, the schedule on which it's presented, or any other detail of how it's done. The problem is the outdated theory of motivation underlying the whole idea of treating people like pets — that is, saying: Do this, and you'll get that…..The best that carrots — or sticks

— can do is change people’s behavior temporarily. They can never create a lasting commitment to an action or a value, and often they have exactly the opposite effect … contrary to hypothesis." (Kohn, 2018). His views have been especially targeted to parents and mothers; publishing articles promoting the problems with rewards in *Parenting* magazine (2001) and Parents magazines (1993, 2000) among others.

Kohn is not alone in his position. Assertions of the general, detrimental effects of rewards have repeatedly resonated through popular media outlets, proclaiming the harmful effects of rewards in reading incentive programs (e.g., Egan, 1994; Hawkins, 1995) in the classroom (Kohn, 1993, 1996, 2018), in behavior therapy (Deci & Ryan, 1985), and in general (Kohn, 1993, 2018). The misconceptions of reward are particularly prevalent in business philosophy, especially in regard to employee incentive programs (Caldwell, O’Reilly, & Morris, 1983; Kohn, 1990). Daniel Pink, the 2009 best-selling author of *Drive: The Surprising Truth about What Motivates Us*, suggests the following business strategy during a talk entitled *The Surprising Science of Motivation* (now available on-line, currently with 21,549,592 views):

> There is a mismatch between what science knows and what business does. Here is what science knows. One: Those 20th century rewards, those motivators we think are a natural part of business, do work, but only in a narrow band of circumstances. Two: Those if-then rewards often destroy creativity. Three: The secret to high performance isn't rewards and punishments, but that unseen intrinsic drive -- the drive to do things for their own sake (Pink, 2009).

Although it is important to establish activities that are naturally rewarding, it seems similarly important to acknowledge the contributions of external reinforcers in fostering those behaviors. Undoubtedly, Pink is driven, to some extent, by the natural consequences of his actions. At the same time, he may be discounting the external reinforcers likely contributing to his own behavior: it seems improbable that intrinsic drive alone would be enough to establish and maintain his lecturing in the absence of positive feedback from the audience or adequate monetary compensation, for example.

Misconceptions promoting the disuse of rewards and reinforcers are occasionally supported in Introduction to Psychology textbooks (e.g., Coon & Mitterer, 2010; Griggs, 2006). For example, one 2010 textbook suggests that the overuse of rewards may be the cause of student and employee failures, suggesting the following under the heading "Turning Play into Work: "When we are coerced or 'bribed' to act, we tend to feel as if we are 'faking it'. Employees who lack initiative and teenagers who reject school and learning are good examples of this (Coon & Mitterer, 2010, p. 408)." Another textbook acknowledges that the overjustification effect is only applicable when rewards are delivered contingent upon performance, but then warns of the overall limits of operant conditioning: "The overjustification effect imposes a limitation on operant conditioning and its effectiveness in applied settings. It tells us that we need to be careful in our use of operant conditioning so that we do not undermine intrinsic motivation" (Griggs, 2006, p. 137). Although these passages caution against the use of rewards, they generally fail to specify the very specific and limited circumstances under which they may pose a problem.

In some respects, the detrimental effects of reward have been overgeneralized, stretching past the limited circumstances of the phenomenon. This is highly problematic. Reinforcement contingencies are powerful tools for behavior change and skill acquisition, beneficial in the classroom, home, and clinical settings. Avoiding their use may be of great disservice to practitioner, teacher, patient, and student. Overjustification effects do not detract from the utility of programmed reinforcement contingencies within these environments. Reinforcers have been repeatedly demonstrated to effectively establish new behavioral repertories (e.g., Thompson & Iwata, 2000). Reinforcement contingencies are also important for individuals with limited communication or adaptive skills that may inhibit frequent contact with natural reinforcers more easily accessible to those in the typically developing population. Finally, reinforcement contingencies may be necessary to initially promote behaviors that eventually become naturally reinforcing. For example, initially providing reinforcement for high quality rehearsing or training in instrument or sport may lead to proficiencies in these areas. Eventually, these activities may produce natural reinforcers in the absence of contrived reinforcement (e.g., playing a sonnet or scoring a goal).

Contrived reinforcement contingencies produce a variety of positive effects that ultimately allow for an enhanced quality of life for many individuals. Even so, those who commonly arrange reinforcement contingencies in the classroom or elsewhere have a responsibility to understand possible side effects of rewards, as well as their limitations. This leaves researchers with an obligation to examine the conditions under which overjustification effects may be observed and how to decrease their likelihood.

Although there is some cross-discipline agreement regarding some of the conditions that may make detrimental effects of rewards more likely, there is considerable disagreement regarding the prevalence of the phenomenon more generally. Specifically, behavioral researchers rarely find detrimental effects (Bright & Penrod, 2009; Feingold & Mahoney, 1975; Levy et al., 2016) and researchers from the social and cognitive arenas often find evidence of the phenomenon (e.g., Deci, Koestner, & Ryan, 1999; Lepper, Greene, & Nisbett, 1973). The following highlights methodological distinctions that may influence the likelihood of observing overjustification effects, potentially providing an account of conflicting results.

Possible explanations for conflicting results. Researchers from various perspectives often use methods common to their own field. For example, overjustification effects have been commonly investigated using between-groups comparisons within the cognitive and social perspectives. In many of these studies, it was common for levels of behavior to be examined across groups once prior to the reward (or no-reward) period and once after. Other studies, predominantly within the behavioral perspective, have used single-subject designs (Kazdin, 1982), examining behavior before and after reward periods using repeated measures over time, the hallmark of behavior analytic research methods. The level of behavior observed at one observation (as in between-group measures) may vary greatly from the pattern of behavior that is observed across multiple observations over an extended period of time (as in a single-subject design). Further, repeated measures of behavior may depict meaningful variability that is “smoothed” out in cross-sectional analyses common to between-group design. The different samples of behavior observed using these two designs might partly account for the discrepant conclusions.

The specifications of the independent variable often varied across studies, perhaps contributing to the different results across fields. Between-group comparisons necessarily employed *rewards*, socially defined and presumed to be of some value, yet the extent to which rewards function as reinforcers on an individual level is unknown (or unreported). By contrast, studies using single-subject design generally employed *reinforcers*, defined by their strengthening effect on behavior[4]. The reinforcing efficacy of the stimuli presented across these investigations may affect the likelihood of observing overjustification effects.

Results from Cameron, Banko, and Pierce (2001) suggest the detrimental effects of rewards may be more likely for responses associated with higher initial interest. Some researchers have incorporated tasks of varying intrinsic interest (assumed or established), which may additionally contribute to the variability (e.g., Bright & Penrod, 2009; Deci, 1971). Further, results may partly depend upon reward type, independent of informational or controlling cues (e.g., verbal or tangible rewards, conditioned or unconditioned reinforcers), or the category of task included (e.g., play, leisure skills, or academic-type tasks) independent of initial interest level.

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[4] Due to this distinction, the term “reward” is used throughout the manuscript in reference to studies that used rewards, “reinforcer” is used in reference to studies that used reinforcers, and “rewards/reinforcers” is used in reference to both.

Other factors contributing to the discrepant findings across fields may stem from systematic procedural differences in relation to reward presentation. As Carton (1996) noted, overjustification effects are less often observed in studies using praise relative to those using tangible rewards (e.g., Boal & Cummings, 1981; Koestner, Zuckerman, & Koestner 1987; Rummel & Feinberg, 1990; Vallerand, Gauvin, & Halliwell, 1986). Similarly, overjustification effects are often less likely in behavioral studies relative to those from the cognitive and developmental perspective (Bright & Penrod, 2009; Deci, Koestner, & Ryan, 1999; Feingold & Mahoney, 1975; Lepper, Greene, & Nisbett, 1973). Perhaps importantly, behavioral studies and studies using praise often involve higher rates of reinforcement, larger aggregate reinforcement histories, or both, suggesting that these procedural differences may have some importance in obtaining overjustification effects.

Carton (1996) suggests consistent differences in the parameters of reward delivery (rate, cues, immediacy) in studies using praise and those using tangible rewards may have resulted in relatively higher rates of responding prior to the test of overjustification in studies using praise, perhaps contributing to the different findings across these studies. It is also possible that rates of reward may produce relatively increased response *persistence* under specific circumstances, resulting in sustained responding during tests of overjustification (the withdrawal of the reward), *regardless of the rate of responding prior to the test of overjustification*. We can find evidence of this effect in research on response persistence in the context of behavioral momentum theory (BMT).

Research in behavioral persistence provides ample evidence to suggest that rate of reinforcement is positively related to behavioral persistence in the face of a challenge. A *challenge* is a procedural manipulation designed to disrupt a previously established level of responding. One commonly studied “challenge” is extinction, or the withdrawal of reinforcement, (as is also employed in tests of overjustification effects). To illustrate, researchers examining behavioral persistence often examine responding (e.g., pigeons’ key pecking) across two alternating components of a multiple schedule, one associated with relatively more reinforcement. Results consistently indicate that responding persists in the face of a challenge to a greater degree in the component associated with relatively more reinforcement, regardless of pre-disruption levels of responding (e.g., Dube, McIlvane, Mazzitelli, & McNamara, 2003; Harper, 1999; Nevin, Tota, Torquato, & Shull, 1990). For example, a pigeon earns 6 reinforcers per min in the presence of a blue stimulus, and 2 reinforcers per min in the presence of a yellow stimulus. If reinforcers are withheld across components (extinction), BMT suggests that the pigeon will peck *more* in the presence of the blue stimulus than in the presence of the yellow stimulus.

Overjustification and behavioral persistence have an important similarity: both phenomena are fundamentally interested in the effects of reward (overjustification) / reinforcement (persistence) on later responding during a challenge or disruption. Research in persistence has indicated that reinforcement rates are a critical component in determining response-strengthening effects. Accordingly, rate of reward/reinforcement may play a similarly critical role in obtaining overjustification effects. This may further help to explain why such discrepant results have been obtained across behavioral and non-behavioral studies on the overjustification effect, which consistently employ vastly different rates of reward/reinforcement.

Overjustification and behavioral persistence also have important differences: (a) changes in behavior during disruption are examined relative to different comparison "starting points" (i.e., relative to a reinforcement period in tests of behavioral persistence, and relative to a no-reward period in tests of overjustification), and (b) the phenomena are examined under different conditions, generally using a multiple schedule arrangement (described below) in behavioral persistence, and a single schedule arrangement in overjustification. Thus, possible relations between these two phenomena have been, to my knowledge, historically unexamined. However, by arranging the conditions necessary to examine both phenomena simultaneously we may be able to observe processes of behavioral persistence as they relate to overjustification.

Background: Behavioral Momentum Theory

Behavioral momentum theory (BMT) uses the framework of classical mechanics and Newton's second law of motion to describe the relation between reinforcement rates and response persistence in the face of challenges to responding. To illustrate, the second law of motion suggests the change in an object's velocity (change in acceleration) is positively related to its force and is inversely related to the object's mass. For example, pushing a cart results in the cart's acceleration. Pushing the same cart with five times more force results in the cart accelerating five times faster. Now suppose you fill the cart with heavy rocks, doubling its mass. Pushing the filled cart with the same force now results in a relative decrease in acceleration (by half).

BMT proposes a similar framework in relation to response persistence. Here, the change in responding in the face of disruption ("velocity") is directly related to the magnitude of the challenge ("force") and is inversely related to the rate of reinforcement in the context of the behavior (the stimulus-reinforcer relations determining behavioral "mass"). Importantly, response-reinforcer relations determine response rates, stimulus-reinforcer (Pavlovian) relations determine a behavior's resistance. By and large, BMT indicates that resistance to change is positively related to the rate or magnitude of reinforcement in the setting where the behavior occurs, *regardless of baseline response rate* (Grimes & Shull, 2001; Mace et al., 2010; Nevin, Tota, Torquato, & Shull, 1990; Shahan & Burke, 2004; for exceptions, see Nevin, Grace, Holland, & McLean, 2001).

In basic nonhuman research, behavioral persistence is most often tested in a multiple schedule arrangement in which two reinforcement schedules are alternated, each associated with a distinct stimulus. Table 2 illustrates a multiple schedule arrangement, adapted from Nevin et al. (1990) and Mace et al. (2009). Each condition is associated with a discriminative stimulus (a colored light), and reinforcement is differentially programmed for responses to the left (alternative) and right (target) keys. Conditions A and C are associated with an equal overall rate of reinforcement, relatively higher than that of Condition B. In Condition C, reinforcement is delivered contingent upon target responding. In Condition A, only a third of the overall reinforcement is allocated to the target response resulting in a relatively lower target response rate. Condition A is associated with a relatively lower rate of reinforcement for the target response. Differences in momentum and overjustification effects between Condition A and C may be attributed to differences in response rates, as the rate of reward is constant across these conditions. Differences in outcomes across Condition A and Condition B may be attributed to differences in reinforcement rates, as the rate of target responding should be similar across these two conditions.

As a separate example from the pigeon laboratory, one component may be associated with a blue light and a high rate of reinforcement (e.g., contingent reinforcement with superimposed non-contingent, free, reinforcement). The alternating component may be associated with a red light and a lower rate of reinforcement (e.g., an identical schedule of contingent reinforcement without superimposed non-contingent reinforcement). Components are presented independently for a specified duration (e.g., 2 min) before the next component is presented, often with only a short break in between. An initial "baseline" level of responding is established for both components, often resulting in a lower level of responding in the component with the high rate of reinforcement (due to a degradation of the response-reinforcer contingency through the delivery of non-contingent reinforcers). Following stable responding, a "disruptor" is programmed equally across components. In past research, challenges or disrupters have included decreases in the value of reinforcers (Dube & McIlvane, 2001; Nevin, 1974), the introduction of alternative reinforcement (Mace et al., 1990), or the withdrawal of reinforcement (extinction, Nevin, Tota, Torquato, & Shull, 1990).

Table 2

Example, Multiple Schedule Arrangement

Condition	Reinforcement/hr alternative response	Reinforcement/hr target response	Overall reinforcement/hr
A	45 L GREEN	15 R GREEN	60
B	0 L RED	15 R RED	15
C	0 L WHITE	60 R WHITE	60

Response persistence within each component is determined by examining responding during the disruption period relative to responding during its associated baseline. Loosely speaking, we are interested in determining which of these two conditions will produce more persistent behavior, or behavior that is more likely to continue to occur at “pre-disruption” levels, even in the face of disruption. Generally, results suggest the component associated with a higher rate of reinforcement is associated with greater persistence during the disruption period (Nevin, Tota, Torquato, & Shull, 1990).

To demonstrate the effects of reinforcer rate on behavioral persistence, Nevin et al. (1990) delivered food contingent upon pigeons' pecking on identical variable-interval 60-s schedules (VI 60) (reinforcement delivered every 60 s, on average, following a key peck) in two components of a multiple schedule. In Component 1, pigeons pecked on a green disk. In Component 2, pigeons pecked on a red disk. "Free" additional reinforcers were presented in Component 2, but not in Component 1, making the overall reinforcement rate relatively greater, and the response rate relatively lower, in the second component (again, by degrading the contingency with "free" reinforcers). The researchers applied extinction equally across components and measured the relative extent to which responding continued in the two components. Results were consistent with the predictions of BMT: response persistence was greater in the component associated with the greater rate of reinforcement (Component 2). These data lend support to the notion that stimulus-reinforcer relations determine persistence independent from the rate of responding (governed by response-reinforcer relations).

This general finding has been replicated extensively across nonhuman species such as rats (Harper, 1999; Shahan & Burke, 2004), pigeons (Nevin, Tota, Torquato, & Shull, 1990), and goldfish (Igaki & Sakagami, 2004), and has since extended to human research in laboratory, clinical, and educational settings (Ahearn et al., 2003; Cohen, 1996; Dube, Mazzitelli, Lombard, & McIlvane, 2000; Dube, McIlvane, Mazzitelli, & McNamara, 2003; Mace, 1990; Parry-Cruwys et al., 2011). (For a review of basic nonhuman research, see Nevin & Grace [2000]. As well, Dube, Ahearn, Lionello-DeNolf, and McIlvane [2009] provide an overview of behavioral persistence research for persons with intellectual and developmental disabilities).

In a highly cited example of persistence applied to human behavior, Mace et al. (1990) examined persistence of behavior exhibited by participants with intellectual disabilities. In Part 2 of the study, the experimenters provided reinforcement for sorting different colored dinnerware in successive components of a multiple schedule. In one component, reinforcers were delivered on a VI 60-s schedule for sorting red dinnerware. In the alternating component, reinforcers were also delivered on a VI 60-s schedule, now for sorting blue dinnerware. Here, additional "free" reinforcers were also superimposed according to a variable-time, 30- s schedule (VT 30 s). In other words, a free reinforcer was delivered every 30 s, regardless of the person's behavior. Results demonstrated that responding was more resistant to distraction (the introduction of a video as an alternative source of reinforcement) in the component with the higher rate of reinforcement, though baseline levels of responding were initially lower in this component. These results provide additional evidence that response persistence is governed by rates of reinforcement in the context of the behavior, independent of baseline response rates, and also provide an example of the relevance of behavioral persistence as it may apply to human behavior.

Whereas the association between reinforcer rate and response persistence is well established in the behavioral persistence literature, the effects of aggregate reinforcer history have been largely unexplored. Here, aggregate reinforcement history refers to the duration of exposure to a schedule of reinforcement. Thus, five VI 30-s reinforcement sessions will produce a smaller aggregate reinforcement history relative to 200 sessions using the same reinforcement schedule. Aggregate reward history may have a similar relation to behavioral persistence (and perhaps, by association, to overjustification), to the extent that longer reinforcement histories, or longer durations of exposure to reinforcement, may produce heightened stimulus-reinforcer associations (through repeated reward deliveries in a particular context), perhaps resulting in stronger persistence. Dube, Ahearn, Lionello-DeNolf, and McIlvane (2009) pointed to this possibility, noting that in most basic research over 50 baseline sessions are conducted prior to tests of behavioral persistence. By contrast, momentum studies involving humans with intellectual and developmental disabilities have provided considerably less exposure and have found more variability in the magnitude of persistence. They further note an exception (Dube et al., 2000) indicating very strong effects in which over 100 baseline sessions were conducted prior to tests of behavioral persistence (Dube et al., 2009), perhaps pointing to the importance of reward history in obtaining effects of large magnitude.

Past research has well established the importance of reinforcement history on current responding, indicating that responding at any point in time is affected not only by present contingencies, but also by past contingencies that are no longer in play (i.e., the history of reinforcement, see Weiner, 1969 for an early demonstration of this phenomenon) and by the stimuli associated with that reinforcement. For example, nonhuman research has demonstrated that the presence of stimuli previously correlated with high or low rates of reinforcement may continue to influence later responding under different reinforcement schedules, even following six months without experimental exposure. That is, relatively lower rates of responding are exhibited in the context of the stimuli previously associated with low rates of reinforcement, and higher rates of responding are exhibited in the context of the stimuli previously associated with high rates of reinforcement (Ono & Iwabuchi, 1997).

As illustrated above, reinforcement history may have very durable effects on responding, especially when reinforcement histories are associated with discriminative stimuli or contextual "cues" that signal the availability of reinforcement (see St. Peter Pipkin & Vollmer, 2009 for a review of research). This concept is central to the processes governing behavioral persistence and may also have important implications for the overjustification effect in light of the aforementioned similarities between the phenomena. It is possible, for example, that reinforcement delivered under specific contexts may strengthen responding more generally, resulting in not only more persistent behavior as it is examined in behavioral persistence studies, but also more robust responding in the face of extinction as it may be applied in tests of overjustification (thus making overjustification effects less likely).

Overjustification and Momentum: Possible Relations and Design Considerations

Overjustification effects are generally examined using single-schedule arrangements (i.e., one reward or reinforcement schedule is presented). We may garner new and valuable information by examining these effects under an arrangement that more closely approximates a multiple-schedule arrangement (i.e., with alternating schedules, each using a different rate of reward/reinforcement), allowing for a direct comparison of rate of reward and history effects on post-reward responding. This type of arrangement will also allow for the examination of a possible relation between overjustification and behavioral persistence, a relation that is not observable in overjustification investigations as they are commonly designed.

In their review of human studies in behavioral persistence, Dube et al. (2009) note how researchers have designed studies to examine response persistence modeled after the basic, nonhuman research from which it originated, but adapted to apply to the needs of conducting research with human participants. For example, a critical component of this research involves examining disrupted responding across contexts associated with dense versus lean reinforcer deliveries. This is generally programmed in alternating components within sessions in basic research, but may be adapted to human research by programming high and lower reward environments in separate, alternating sessions that may be more relevant to the natural course of one's day (i.e., humans do not often change environments and reinforcement schedules in such rapid succession, but rather stay in one environment for a longer period of time before transitioning to another, for example, a student moving from one class to another). Prior human research has also adapted the basic paradigm through the introduction of the disruption immediately following periods of reinforcement, rather than during the reinforcement periods.

The research methods in the current study were designed with these considerations in mind, using procedures modified from basic behavioral persistence research to apply more naturalistically to human behavior and to allow for a simultaneous examination of behavioral persistence and overjustification. Specifically, the methods will involve (a) alternating sessions across two different contexts, rather than alternating schedules within a session, and (b) programming the disruption (extinction) following the reward[5] period, rather than during the reward period.

Aims and Hypotheses

Behavioral persistence research suggests the baseline rate of reinforcement affects response persistence: it has been repeatedly demonstrated that stimulus-reinforcer relations, or the rate of reinforcement in the context of the behavior, governs response persistence during disruption. Rate of reinforcement may similarly affect responding during disruption as it is examined in tests of overjustification (i.e., during the withdrawal of reinforcement following a reinforcement period). It stands to reason that the duration of exposure to a reinforcement schedule, or the aggregate reinforcement history, may have a similar relation to behavioral persistence (and, perhaps by association, to overjustification), producing a heightened stimulus-reinforcer association over longer durations of stimulus-reinforcer pairings. Experiments 1 and 2 aimed to assess these parameters of reward delivery to examine how overjustification effects may relate to behavioral persistence and to examine the extent to which overjustification, like persistence, may be a function of stimulus-reinforcer relations under some conditions. Specifically, Experiment 1 examined aggregate reward history and Experiment 2 examined reward rates and their relation

[5] The term “reward” is used in reference to the procedures of Study 1 and Study 2. These rewards inconsistently functioned as reinforcers.

to these phenomena. Results from these studies may have implications for the appropriate use of rewards, especially in mitigating potential overjustification effects. Data that suggest effective (and ineffective) ways to deliver rewards to both (a) maintain their purpose (increasing appropriate responses) and (b) decrease the likelihood of unwanted side effects (such as overjustification effects) would be especially relevant to the design of reward systems in the classroom where they are commonly used to increase academic and skill-based responses. Data may also indicate a relation between these phenomena, perhaps allowing for a further description of overjustification effects in terms of behavioral persistence.

Aims and hypotheses: Experiment 1. The aim of Experiment 1 was to examine the effects of aggregate reward history on overjustification and behavioral persistence, and the extent to which the overjustification effect, like persistence, may be a function of stimulus-reinforcer relations.

Overjustification effects are more often observed in investigations using between-groups designs relative to those employing single-subject methods (e.g., Bright & Penrod, 2009; Deci, Koestner, & Ryan, 2001; Feingold & Mahoney, 1975; Lepper, Greene, & Nisbett, 1973). These two methods often differ in the manner of providing rewards/reinforcement: between-groups designs generally employ shorter reward periods, often involving a delivery of a reward one time at the end of the reward period. By contrast, single-subject methods commonly involve repeated reinforcer deliveries over a longer period of time. Thus, inherent differences in reward/reinforcement histories may partly account for the discrepancies in obtaining overjustification effects across between-group and single-subject investigations.

Considering this, it was hypothesized that overjustification effects in Experiment 1 may be more likely following shorter reward periods and may be less likely following lengthier reward periods. By contrast, behavioral persistence may be comparatively stronger following lengthier reward periods given past research suggesting greater reinforcement may be associated with greater response persistence once reinforcement is withdrawn (e.g., Furomoto, 1971; Nevin, Tota, Torquato, & Shull, 1990).

Chapter 2: Experiment 1

Method

Participants and setting

Four children, ages 3-5 who attended a local preschool participated. Participant and parent demographic data were collected during parental consent procedures and are summarized in Table 3. Columns 1 and 2 refer to the participant, whereas the remaining columns reflect information about the parents and family. Participation was not determined by race, religion, or socio-economic status. Two additional participants were terminated from Experiment 1: one participant moved out-of-state prior to completing the study and one participant refused to select items during the stimulus preference assessments.

Table 3

Experiment 1: Summary of Participant Demographic Information

Participant gender	Participant race/ethnicity	Employment status	Total family income	Marital status
Male (75%)	Caucasian (100%)	Employed (100%)	$0-$39,999 (0%)	Single (0%)
	African American (0%)	Student (0%)	$40,000-$79,999 (0%)	Married (100%)
Female (25%)	Hispanic (0%)	Unemployed- (0%)	$80,000-$110,999 (25%)	Separated or divorced (0%)
	Other (0%)		>$110,999 (75%)	Widowed (0%)

All experimental sessions were 1 min and took place in quiet rooms with a table, chairs, and session materials present. As noted previously, behavioral persistence depends upon stimulus – reinforcer relations, to the extent that resistance to disruption is positively related to the rate of reinforcement in the environment in which the behavior occurs. Thus, disparate contexts were arranged for each condition, and each context was associated with a different theme (i.e., jungle or ocean). These contexts were presented using presentation boards covered with theme-specific posters depicting context-specific environment and animals living in the environment.

For example, the “ocean” presentation board depicted a blue ocean with fish, an octopus, and a whale. The “jungle” presentation board depicted a green jungle with trees and vegetation, monkeys, and a giraffe. The experimenter wore different baseball caps (a green cap for the jungle and a blue cap for the ocean) affixed with miniature animals (an octopus and dolphin for the ocean context; a giraffe and elephant for the jungle context) to further distinguish the two areas.

Materials

Materials included the presentation boards, hats, and miniatures specific to each context, one high-preferred academic or skills-based task (the significance of task preference is described in further detail below), and one high-preferred edible reward (e.g., jelly beans or M&Ms). Tasks and edible rewards were identified through Stimulus Preference Assessments conducted during pre-experimental procedures.

Data collection

Data were collected using DataPal, a computer-based data-collection program that allows real time data collection of duration and frequency data. The experimenter collected primary data and a trained observer collected secondary data (to assess inter observer agreement). Duration data were collected on target task engagement, and frequency data were collected on target responding and reward delivery.

Dependent measures

Overjustification effects are exemplified by a decrease in responding following the withdrawal of reward relative to responding that occurred prior to its introduction. Thus, for each condition the frequency of responding during no-reward test components *following* reward delivery was compared to the mean frequency of unrewarded responding *prior to* reward delivery (i.e., during baseline). Difference scores were calculated by subtracting these frequencies (post reward– pre-reward) (the specifics of this comparison are discussed in further detail below). Difference scores that fell below the baseline mean to an extent beyond what might be expected from typical response variability (i.e., one standard deviation below the mean) were considered to reflect overjustification effects, whereas difference scores that fell above the baseline mean to an extent beyond what might be expected from typical response variability (i.e., one standard deviation above the mean) were considered to reflect improvement effects.

For example, mean responding across conditions during the pre-reward baseline period may be 10 with a standard deviation of 3 ($M = 10$, $SD = 3$). By comparison, 5 responses may be observed during a post-reward test component. The difference score would be calculated by subtracting 10 from 5, resulting in difference scores of -5 (5 - 10 = -5). This difference would be indicative of an overjustification effect because the absolute value is larger than the standard deviation observed during baseline ($SD = 3$), suggesting this difference is larger than what might be expected from typical response variability. Proportional scores were additionally calculated in a supplementary analysis to allow for comparisons across participants. For these calculations, the frequency of responding during each test component was divided by the mean frequency of responding during baseline. So, in the example above, 5 would be divided by 10 for a proportion of 0.5.

Behavioral persistence is exemplified by continued responding in the face of a challenge (here, the withdrawal of reward following a reward period). Persistence during no-reward test components was expressed proportionally, relative to responding during the previous reward component to control for differences in levels of responding across conditions during the reward phases. Thus, for each condition, the level of responding during each baseline component was expressed as a proportion of the level observed in the immediately preceding reward component. For example, if 10 responses are observed during the reward component and 2 responses are observed during the no reward test component, a persistence proportion of 2/10 (0.20) would be determined. Proportions indicate the change in response strength from rewarded responding to non-rewarded responding, as a measure of persistence. Here, 0.20 may indicate behavior persisted at 1/5 its initial strength as observed during the reward period. Thus, higher proportions indicate greater persistence.

Interobserver agreement (IOA)

IOA was assessed by trained independent observers using DataPal. IOA was assessed for participant behavior (frequency of responding) as well as experimenter behavior (reward delivery) for procedural integrity purposes. Partial-interval agreement was calculated by dividing each session into 10-s intervals and dividing the lower number of recorded responses (or duration) by the higher number of recorded responses (or duration). For Lester, IOA was assessed during 33% of sessions during Phase A, 33% of sessions during Phase B, and 100% of session during Phase C, with 81% (range, 73% to 98%) (Phase A), 82% (range, 78% to 95%) (Phase B), and 91% (range, 81% to 100%) (Phase C) agreement for target responding, 84% (range, 78% to 89%) (Phase A), and 95% (range, 91% to 100%) (Phase B) agreement for reward delivery, and 95% (range, 93% to 100%) (Phase A), 94%

(range, 92% to 98%) (Phase B), and 100% (Phase C) agreement for engagement. For Elliot, IOA was assessed for 38% of sessions during Phase A, 52% of sessions during Phase B, and 50% of sessions during Phase C, with 83% (range, 80% to 85%), 90% (range, 86% to 95%), and 89% (range, 85% to 97%) agreement for target responding; 90% (range 88% to 98%) and 100% agreement for reward delivery; and 98% (range, 93% to 100%), 100%, and 100% agreement for engagement. For Ace, IOA was assessed for 50% of sessions during Phase A, 36% of sessions during Phase B, and 50% of sessions during Phase C, with 80% (range, 75% to 100%), 87% (range, 80% to 98%), and 95% (range, 90% to 100%) agreement for target responding; 90% (range, 87% to 100%), and 85% (range, 80% to 99%) agreement for reward delivery; and 100%, 79% (range 70% to 90%), and 96% (range, 94% to 100%) agreement for engagement. For Laila, IOA was assessed for 33% of sessions during Phase A, 67% of sessions during Phase B, and 50% of sessions during Phase C, with 82% (range, 80% to 85%), 97% (range, 93% to 100%), and 100% agreement for target responding; 84% (range 78% to 95%) (Phase B) and 77% (range, 70% to 90%) (Phase C) agreement for reward delivery; and 99% (range, 98% to 100%) , 100%, and 98% (range, 96% to 100%) agreement for engagement.

Pre-Experimental Design and Procedures

Activity Stimulus Preference Assessment

A six-item activity Stimulus Preference Assessment was conducted two times for each participant. The six activities included in the assessment were selected based upon teacher suggestion and experimenter observation of tasks likely to be both mastered and preferred by the participant. On each trial, two activities were presented to the participant and she was told, “Choose one.” Immediately following selection, the participant was given access to the chosen activity for 30 s and the remaining activity was taken out of view. If the participant attempted to select both tasks, indicated that neither was desired (e.g., by pushing one or both tasks away, saying “no,” or shaking his or her head), or if 30 s elapsed before a selection was made, the tasks were briefly taken away and represented. The participant was then again asked to “choose one.” If no selection was made or if 30 s elapsed without a selection following the second presentation, the tasks were taken away and the next pair of tasks was presented.

Each task was paired with every other item one time. A preference hierarchy (ranking) was determined from the final selection percentages and mean selection percentages were calculated across the two Stimulus Preference Assessments. Past research suggests that activities associated with high levels of intrinsic motivation are more vulnerable to overjustification effects relative to those associated with lower levels of intrinsic motivation (Cameron et al., 1994). Accordingly, moderate- to high-preferred activities (those associated with a mean selection percentage of at least 60%) were selected for inclusion in the subsequent experimental procedures, based on the assumption that those activities would be associated with relatively greater intrinsic motivation.

Edible Stimulus Preference Assessment

Two six-item edible preference assessments were conducted for each participant in the manner described above with the exception that the items included were edibles purported to be preferred by the participant (as reported by parents, classroom staff, or both).

Experimental Design and Procedures

An ABCABC reversal design (Kazdin, 1982) with an embedded multielement comparison was used to examine the effects of reward history on behavioral persistence and overjustification effects. Two conditions were alternately presented within each phase. Each condition was assigned to a separate context associated with different themes (i.e., jungle or ocean). In this arrangement, Phase A = Baseline, Phase B = Reward or No Reward History, and Phase C = Test Phase. Table 4 provides a visual description of the sessions/components within each phase for each condition. Sessions during Phase A were up to 6 min, made up of alternating 1-min components (described below). Sessions during Phase B were 1 min. Sessions during Phase C were 5 min, composed of five sequential 1-min components (rationale described below). Sessions were conducted 3 to 5 days per week over several weeks.

Table 4

Experiment 1: Description of sessions/components for each phase and condition.

Phase	Condition 1 (e.g., Ocean Context)	Condition 2 (e.g., Jungle Context)
A - Baseline	No Reward	No Reward
B – Reward/No Reward History	Reward	No Reward
C-Test Series (by component)	Reward ↓ Reward ↓ No Reward (Test 1) ↓ No Reward (Test 2) ↓ No Reward (Test 3)	No Reward ↓ Reward ↓ No Reward (Test 1) ↓ No Reward (Test 2) ↓ No Reward (Test 3)

Phase A – Baseline

As stated, overjustification effects have been determined to be most prevalent for behaviors that are initially associated with a high level of intrinsic motivation. Level of task engagement during a baseline period may be considered a behavioral measure of intrinsic motivation to the extent that it reflects responding in the absence of any programmed extrinsic rewards. Accordingly, the purpose of Phase A – Baseline was to determine an initial level of responding within each environment in the absence of any reward deliveries. This phase was used to ensure the activity was associated with a moderate to high degree of engagement (and likely to be susceptible to overjustification effects), and to examine any possible effects of context on responding. Mean level of responding during the baseline phases was used as the pre-reward comparison to later post-reward levels of responding during tests of overjustification.

Behavioral persistence depends upon the relation between reinforcement and associated contexts, or more technically, upon discriminative stimuli. Thus, for this and all phases, each condition was assigned to a separate context (i.e., jungle or ocean) that remained constant for the initial presentation of all phases. During baseline, a high-preferred activity (e.g., sorting colors) was presented and the experimenter told the participant, "Here is an activity for you." Sessions were up to 6 min, with the context and condition switching every minute (by changing hats and presentation boards). Data were collected on duration of activity engagement and frequency of target responding.

Phase B–Reward history or no reward history[6]

The purpose of Phase B was to program the independent variables (i.e., to provide a reward history for activity engagement in one condition, and no reward history for activity engagement in the other). To that end, Condition 1 from the previous phase was now assigned as the Reward History condition. The context previously associated with Condition 1 remained constant during Phase B. Condition 2 from the previous phase was now assigned as the 'no Reward History Condition.' The context associated with Condition 2 also remained constant during Phase B. The two conditions, Reward History and No Reward History, were alternately presented within Phase B, keeping the level of exposure to the tasks and contingencies equal across conditions. Sessions were 1 min.

Condition 1: reward history. Prior to the start of each session, the experimenter asked the child, "What area are we in?" The experimenter pointed out the animals (e.g., Look! There are our jungle friends: Marvin the monkey and Gerry the giraffe!) and asked the participant to wave and say hello. If the participant did not correctly label the area initially, the experimenter asked again. If incorrect, the experimenter pointed out additional features of the area (e.g., look at the lion poster and the giraffe on my hat!) and told the participant, "We are in the jungle/ocean area!" The experimenter then told the participant; "Here is an activity for you. You will earn X (high-preferred edible) for _______ (engaging with the target activity)."

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[6] The labels Reward-History and No-Reward History refer to the contingencies programmed during Phase B. *Both* conditions are presented with a brief reward history during the subsequent test phase.

The experimenter provided the high-preferred activity used in baseline and delivered a high-preferred edible on a dense VI schedule. The high-preferred edibles were delivered into a bowl within the participant's view. The participant was presented with the bowl of earned edibles to consume at the end of each session. Data were collected on duration of task engagement and frequency of target responses and rewards delivered.

Condition 2: No reward history. Prior to the start of each session, the experimenter asked the participant to indicate the context in the manner previously described for Condition 1. The experimenter then told the participant; "Here is an activity for you. You will not earn X (high-preferred edible) for _______ (engaging with the target activity)." No rewards were delivered. Data were collected on duration of activity engagement and the frequency of target responding and rewards delivered (for procedural integrity purposes only, as no rewards were delivered during this condition).

Phase C: Test of Behavioral Persistence and Overjustification

The purpose of Phase C was to test the effects of reward history and no reward history on overjustification and behavioral persistence. Sessions during this phase were designed to test persistence and overjustification effects simultaneously and in close temporal proximity to the independent variables associated with each condition implemented in phase 2 (i.e., reward history for Condition 1, and no reward history for Condition 2). To that end, two test series were presented, one for Condition 1 and one for Condition 2, and each test series included five sequential 1-min components including (in the order presented): (a) the continuation of the independent variable associated with the condition (i.e., a reward period for Condition 1, a no reward period for Condition 2), (b) a reward period (necessary to test the effects of reward on responding), (c) a no-reward test period (test 1), (d) another no-reward test period (test 2), and (e) a final no-reward test period (test 3). Refer to Table 4 for a visual description of the order of components for each test series for each condition during this phase. Prior to Component 1 of any condition, the experimenter asked the participant to indicate the condition-specific context using the same procedures as described for Phases A and B. Reward and no-reward components were then conducted as described for reward and no-reward sessions of Phase B.

As stated, behavioral persistence and overjustification are measures of disrupted responding, arranged here by the withdrawal of reward in Components 3, 4, and 5 of each test series. However, the two phenomena are measured relative to different "starting points." By contrast, overjustification effects reflect differences in unrewarded responding moving from pre- to post- reward. Thus, to measure overjustification effects, responding during each test component was compared to mean responding (across conditions) during the previous baseline phase (Phase A).

Stimulus Reassignment (Reversal)

The conditions associated with each context were reassigned during the ABC reversal to replicate any effects of the independent variable using a different context. The second presentation of each phase was otherwise conducted as described. In an effort to minimize potential carry over effects, sessions within the second A phase were repeated until response levels were similar to those obtained during the initial A phase, or until 20 sessions were conducted without producing response levels approximating those of the initial baseline.

Results: Pre-Experimental Procedures

Activity and Edible Stimulus Preference Assessments

Table 5 depicts the items selected for inclusion in subsequent experimental procedures. Parenthetical percentages indicate mean selection percentages associated with these items across both Stimulus Preference Assessment presentations.

Table 5

Experiment 1: Activities and Edible Items Selected for Experimental Procedures

Participant	Activity	Edible
Lester	Tangoes (80%)	Popcorn (70%)
Elliot	Sticker Match (90%)	Jellybeans (80%)
Ace	Sticker Match (60%)	Vanilla Cookie (100%)
Laila	String Beads (70%)	Popcorn (100%)

Results: Experimental Procedures

Session-by-session results. Session-by-session (Baseline Phases) and component-by-component (Test Phases) data are illustrated in Appendix A. Baseline data indicated similar responding across all baseline contexts for all participants. The Reward History/No Reward History phases indicated that for Lester, reinforcement effects were obtained across both phases, but rewarded responding was less differentiated during the second presentation of this phase relative to the first. For Elliot, a reinforcement effect was indicated during the first part of the Reward History/No Reward History phase, but there was no reinforcement effect later in the phase. A reinforcement effect was obtained during the second presentation of this phase. For Ace, a reinforcement effect was obtained across both Reward History/No Reward History phases. For Laila, there was no reinforcement effect during the first reward-history phase, but there was a reinforcement effect observed during the second. Reinforcement effects are noted here due to their importance to behavioral persistence. That is, reinforced responding establishes the undisrupted levels of responding to which disrupted responding (i.e., responding under extinction) is compared. If rewards are not functioning as reinforcers, responding is not aptly disrupted when they are removed.

Overjustification effects

Overjustification effects were determined by comparing the frequency of responding during each test component (3, 4, and 5) *relative to the mean baseline frequency* (Phase A). Specifically, difference scores were calculated for each test component by subtracting mean responding from all sessions during baseline from the frequency observed during the given test component. The difference score derived from each test was compared to the standard deviation from baseline to determine if it fell outside of typical response variability. Accordingly, positive difference scores larger than the standard deviation from baseline are indicative of improvement effects (an increase in responding from pre-to post reward) whereas negative scores with absolute values larger than the standard deviation are indicative of overjustification effects (a decrease in responding from pre-to post reward). No effects of reward are indicated for difference scores within the standard deviation to the mean during baseline. To illustrate, the following depicts how difference scores were calculated for Lester for the first test series within the Reward History Condition (ocean context). Lester's mean response frequency during the initial baseline phase was 6.17, *SD* = 1.34 (Figure A1, Phase A). This was compared to the frequencies of responding during *each* test component (Components 3, 4, and 5) of the ocean test series in Phase C. Those frequencies were 7 (Test 1), 7 (Test 2), and 8 (Test 3) (Figure A1, Phase C, test components circled in blue). To calculate difference scores, the mean responding during baseline (6.17) was subtracted from each of these frequencies resulting in the following difference scores: 7-6.17 = 0.83 for Test 1 (Figure 1, bar 1); 7-6.617 = 0.83 for Test 2 (Figure 1, bar 2), and 8-6.17 = 1.83 for Test 3 (Figure 1, bar 3). One test (Test 3) resulted in a difference score with an absolute value larger than 1.34 (the standard deviation during baseline), indicative of an improvement effect. Tests 1 and 2 resulted in difference scores falling within the range of expected variability.

The same approach was used to determine difference scores for the No-Reward History Condition (Figure 2). Overall, improvement effects were observed in

3 of 6 test components and overjustification effects were observed in 1 of 6 test components during the Reward History Condition (Figure 3, asterisks denote difference scores with absolute values larger than the standard deviation during baseline). By contrast, improvement effects were observed in 1 of 6 test components and overjustification effects were observed in 1 of 6 test components during the No-Reward History Condition (Figure 4).

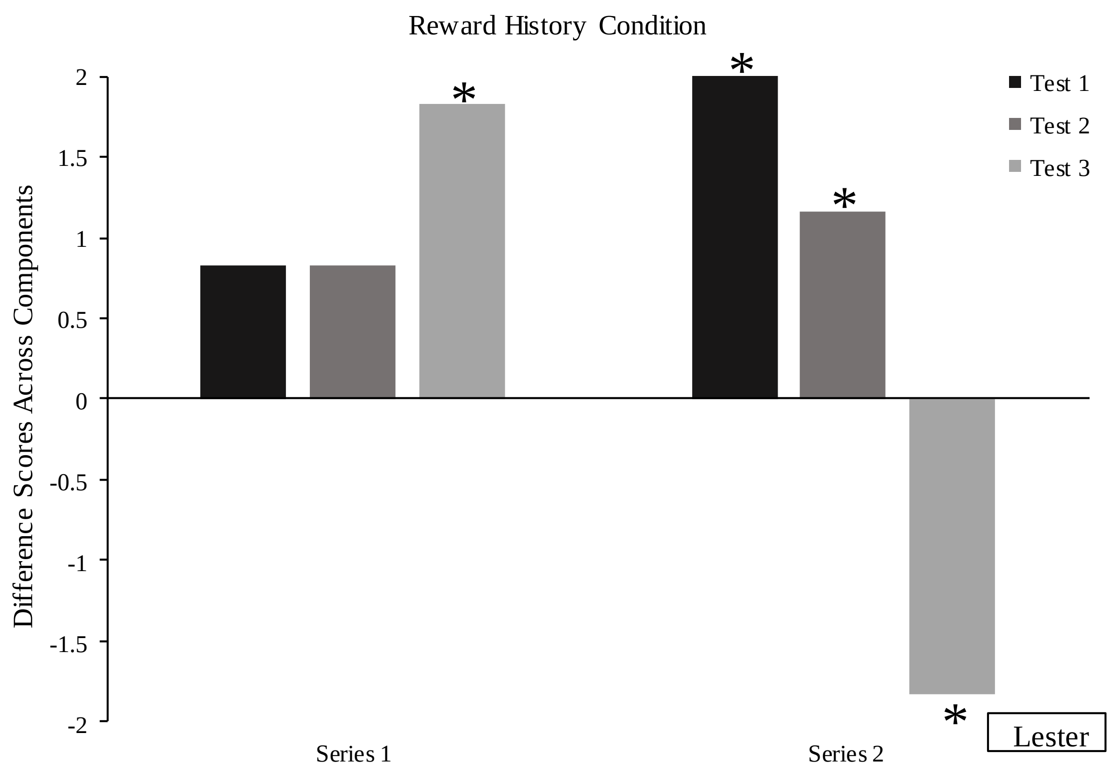

Figure 3. The three bars on the left illustrate difference scores from the first test series (initial Phase C) of the reward condition. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

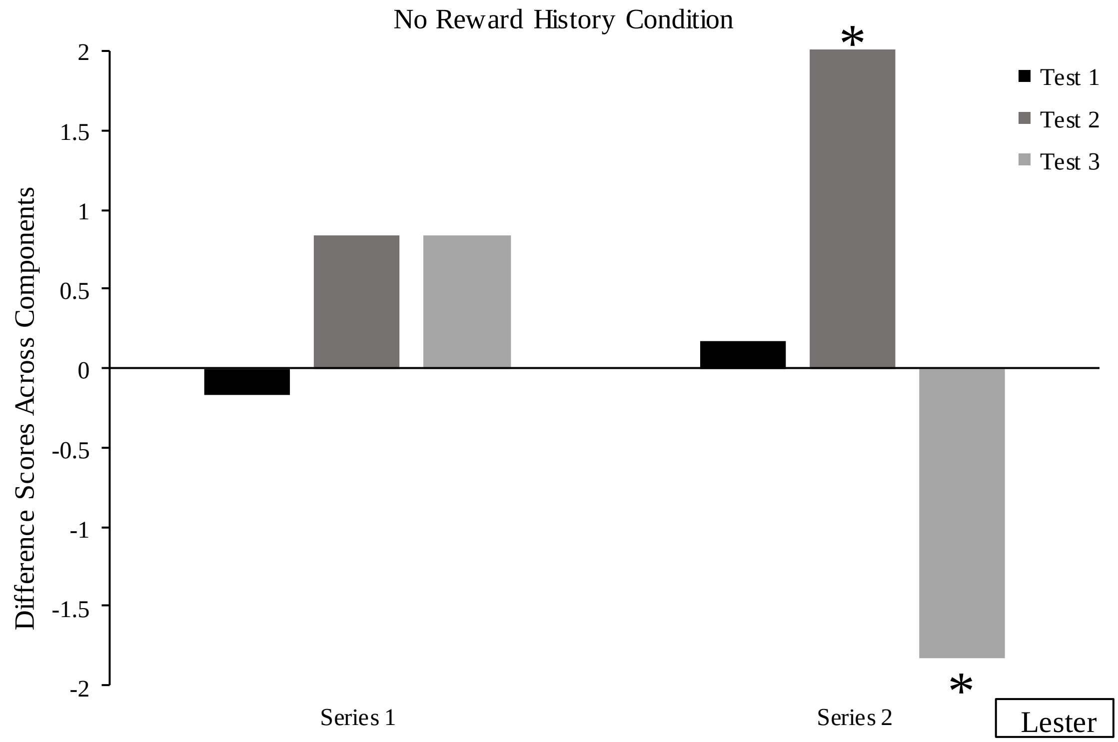

Figure 4. The three bars on the left illustrate difference scores from the first test series (initial Phase C) of the no-reward condition. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

Figure 5 shows mean difference scores for Lester, averaged across all components within the Reward-History Condition (black bar) and No-Reward History Condition (striped bar). For both conditions, the absolute value of the mean difference score was not larger the standard deviation across both baseline phases (*SD* = 1.45), indicating no overjustification or improvement effects, on average.

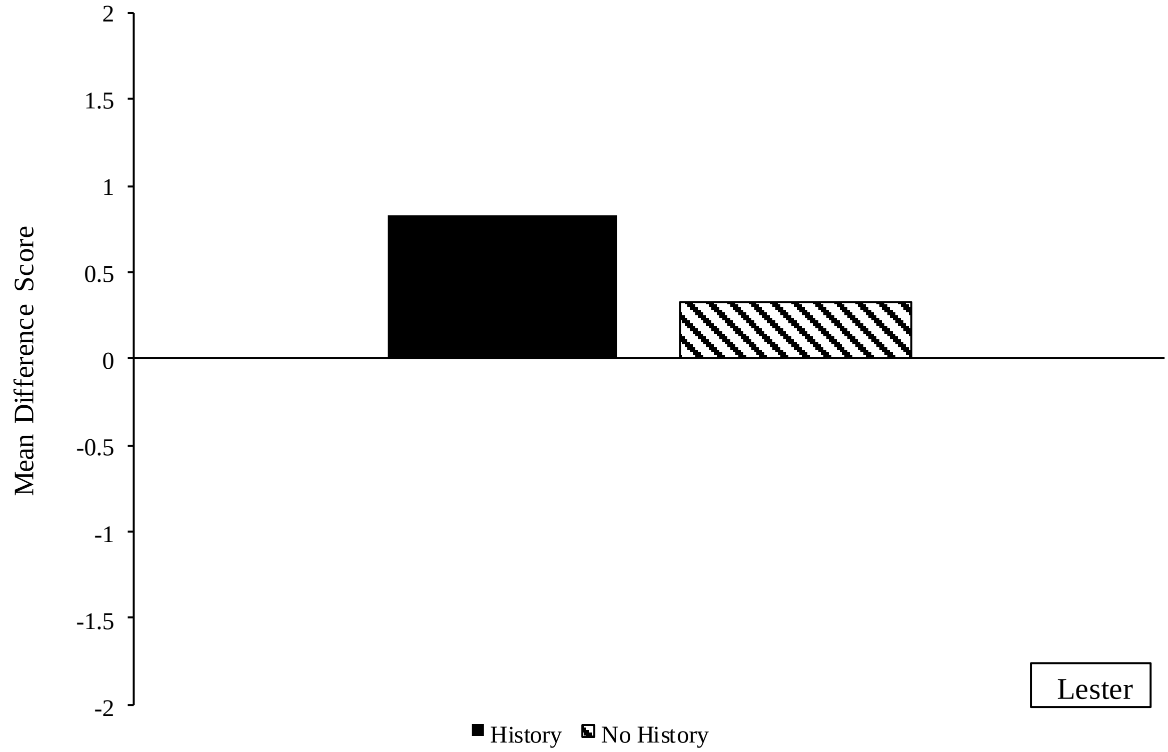

Figure 5. Mean difference scores across all test components during the Reward History Condition (black bar) and No-Reward History Condition (striped bar). Asterisks denote mean difference scores above the standard deviation across baseline phases.

Figures 6 and 7 illustrate the results of the overjustification analysis for Elliot. During the Reward History Condition (Figure 6), improvement effects were observed in 3 of 6 test components and overjustification effects were observed during 1 component. By contrast, during the No-Reward History Condition (Figure 7), overjustification effects were observed in 2 of 6 test components whereas improvement effects were observed during 1 component.

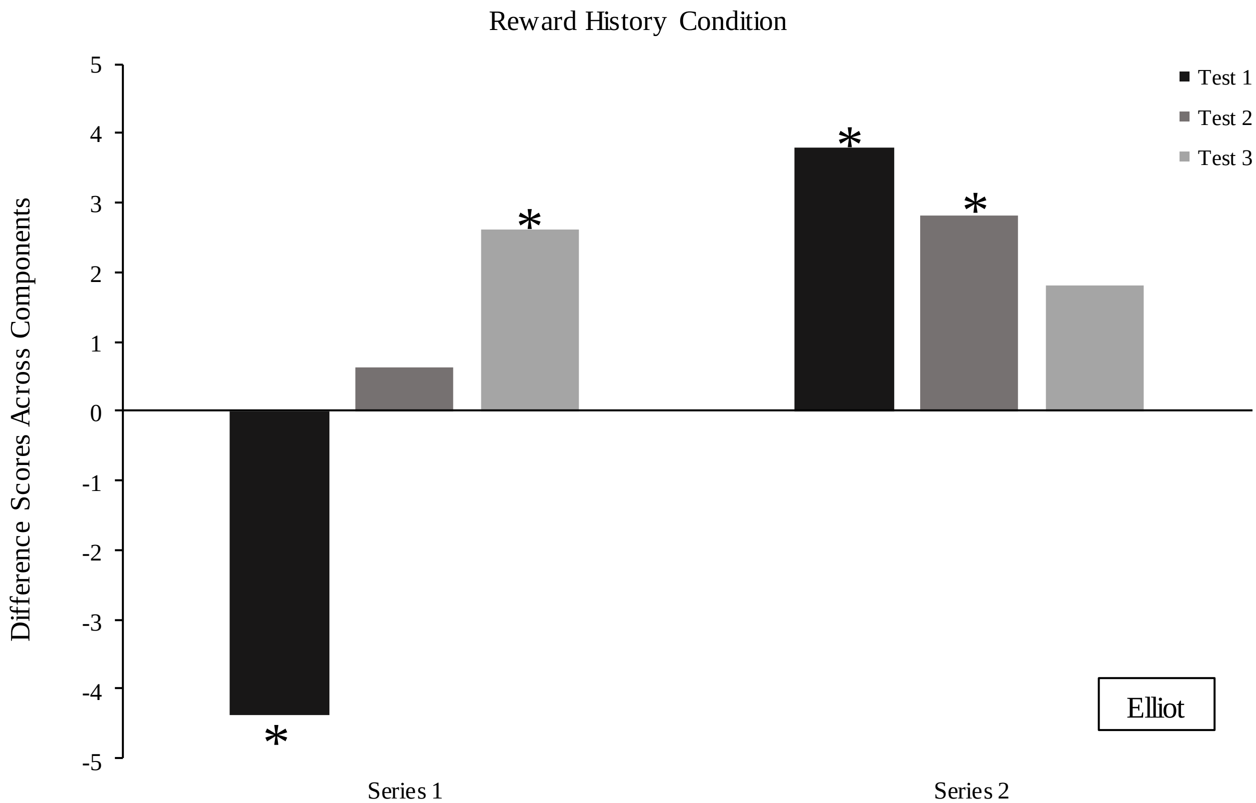

Figure 6. Component difference scores during the Reward History Condition for Elliot. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

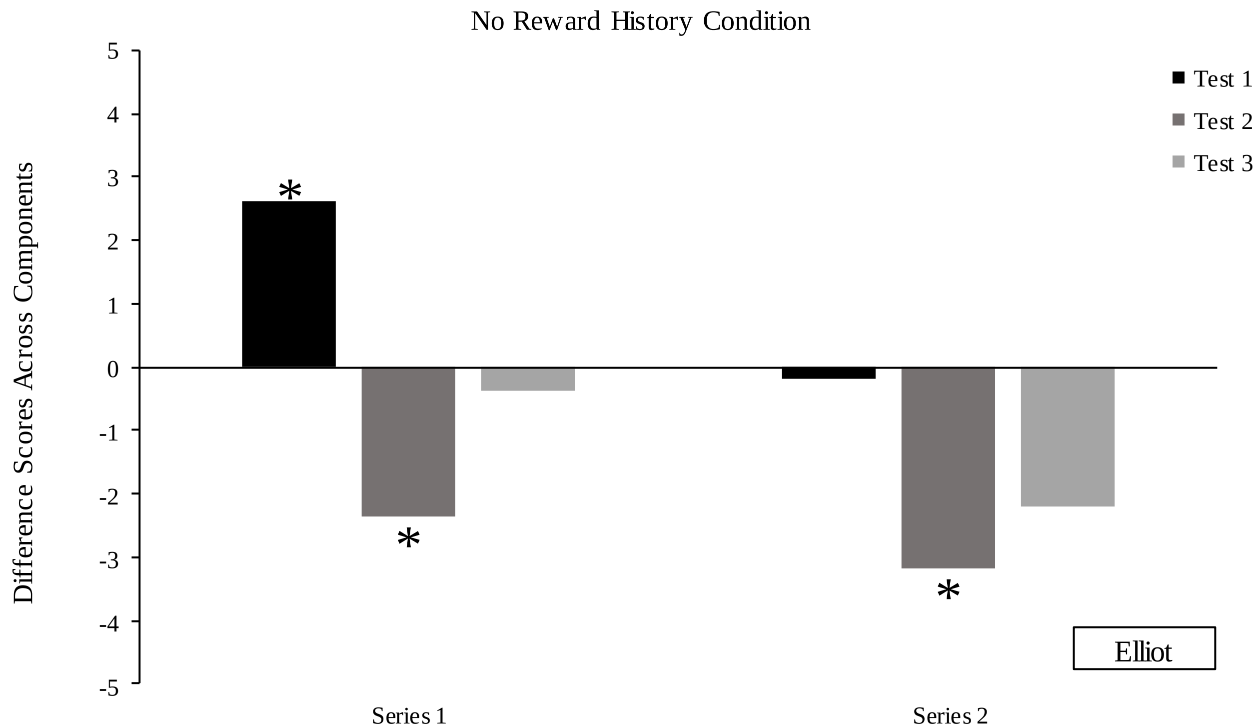

Figure 7. Component-by-component difference scores during the No-Reward History Condition for Elliot. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal. Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

Figure 8 illustrates mean results of the overjustification analysis across conditions, for Elliot. For both conditions, the absolute value of the mean difference score was not larger than the standard deviation across both baseline phases (*SD* = 3.07).

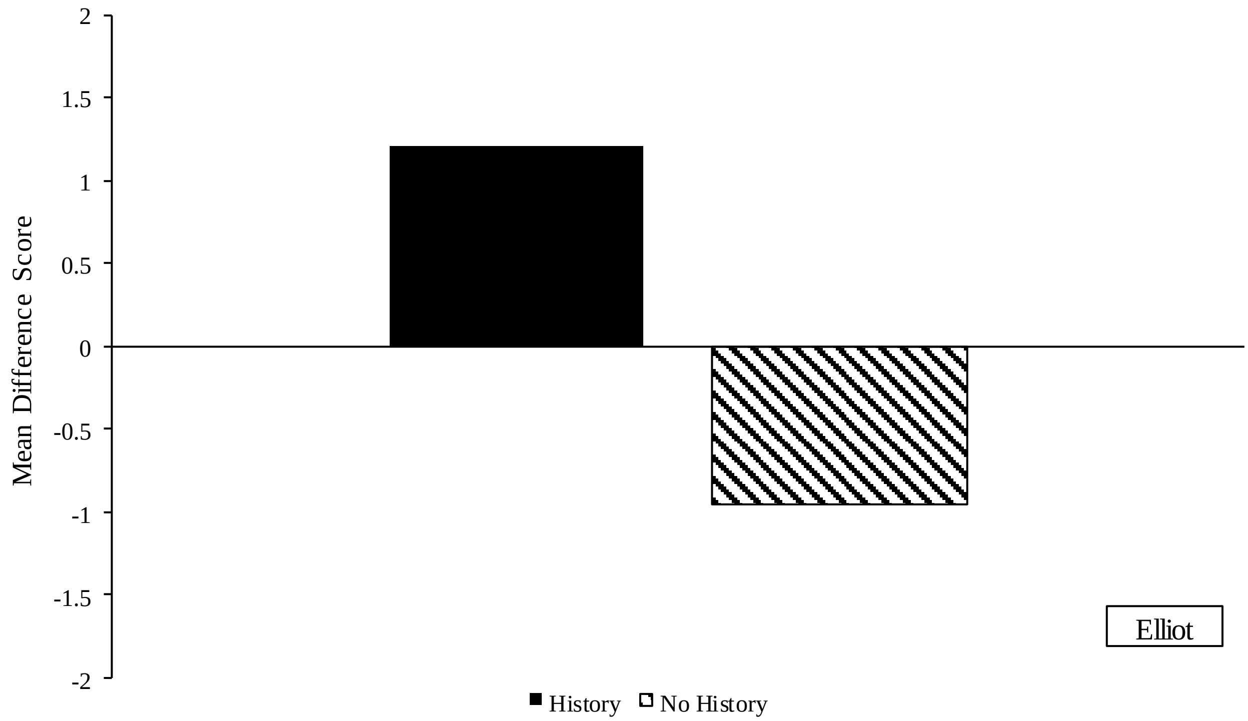

Figure 8. Mean difference scores during the Reward History Condition (black bar) and No-Reward History Condition (striped bar). Asterisks denote mean difference scores larger than the standard deviation to the mean across baseline phase.

Figures 9 and 10 illustrate the results of the overjustification analysis for Ace. Improvement effects were observed during 4 test components of the Reward History Condition whereas overjustification effects were observed during 0 test components (Figure 9). By contrast, during the No-Reward History Condition, overjustification effects and improvement effects were observed in 2 of 6 test components (Figure 10).

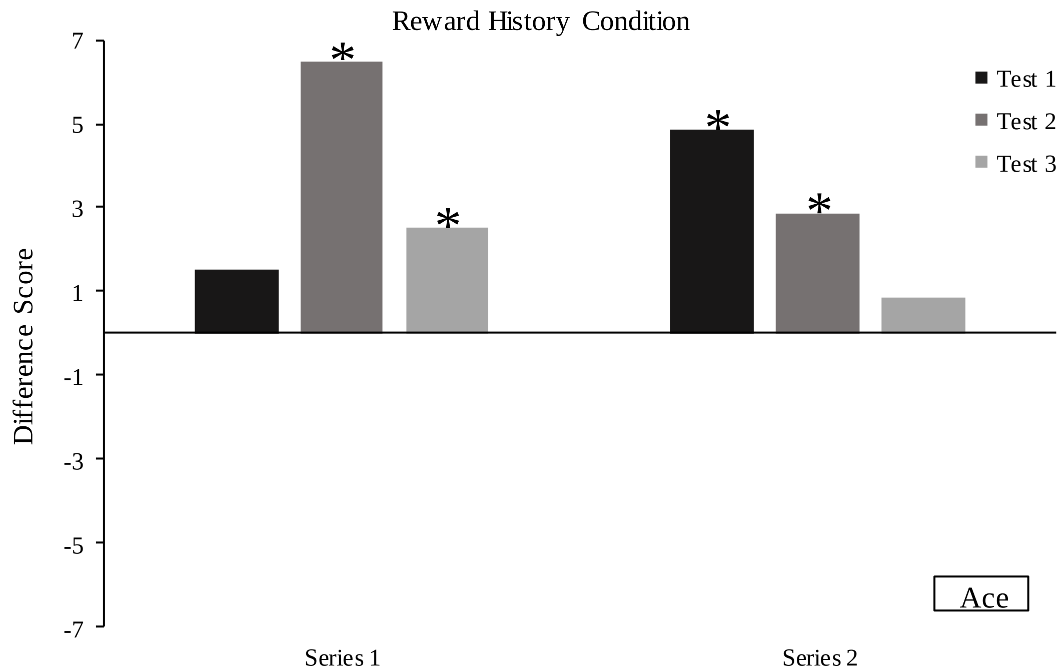

Figure 9. Component-by-component difference scores during the Reward History Condition for Ace. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series. Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

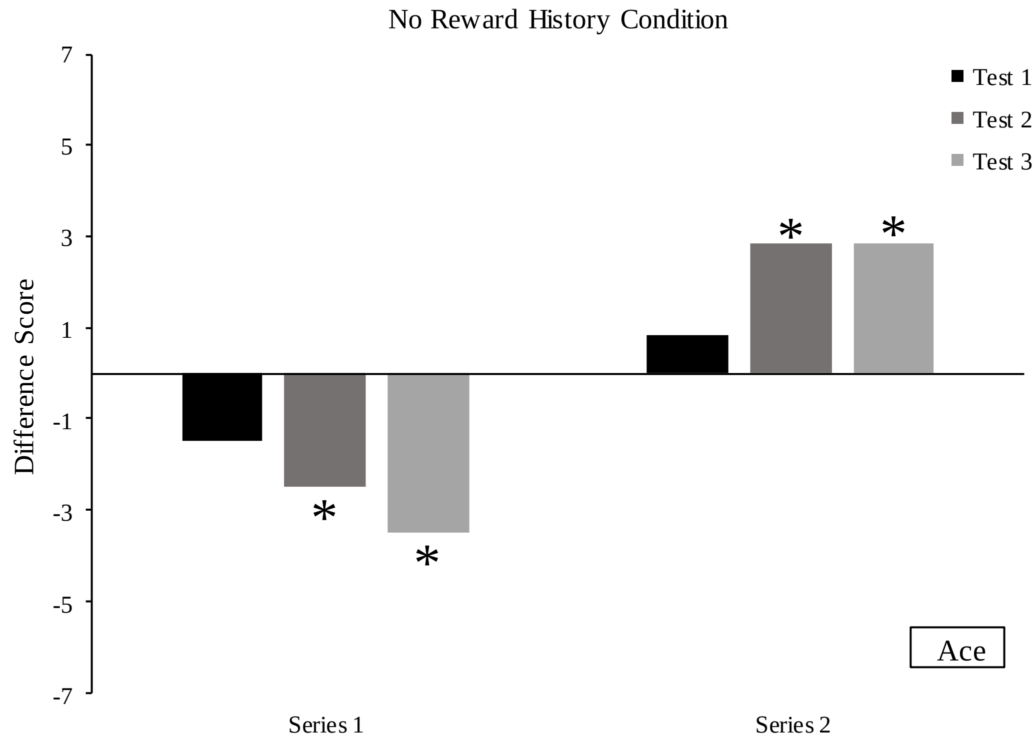

Figure 10. Component-by-component difference scores during the no-Reward History Condition for Ace. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series. Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

Figure 11 illustrates mean results of the overjustification analysis across conditions for Ace. During the reward-history condition the absolute value of the mean difference score was larger than the standard deviation across baseline phases (*SD* = 1.79), indicative of a mean improvement effect. During the No-Reward History

Condition the mean difference score was not larger than the standard deviation across baseline phases.

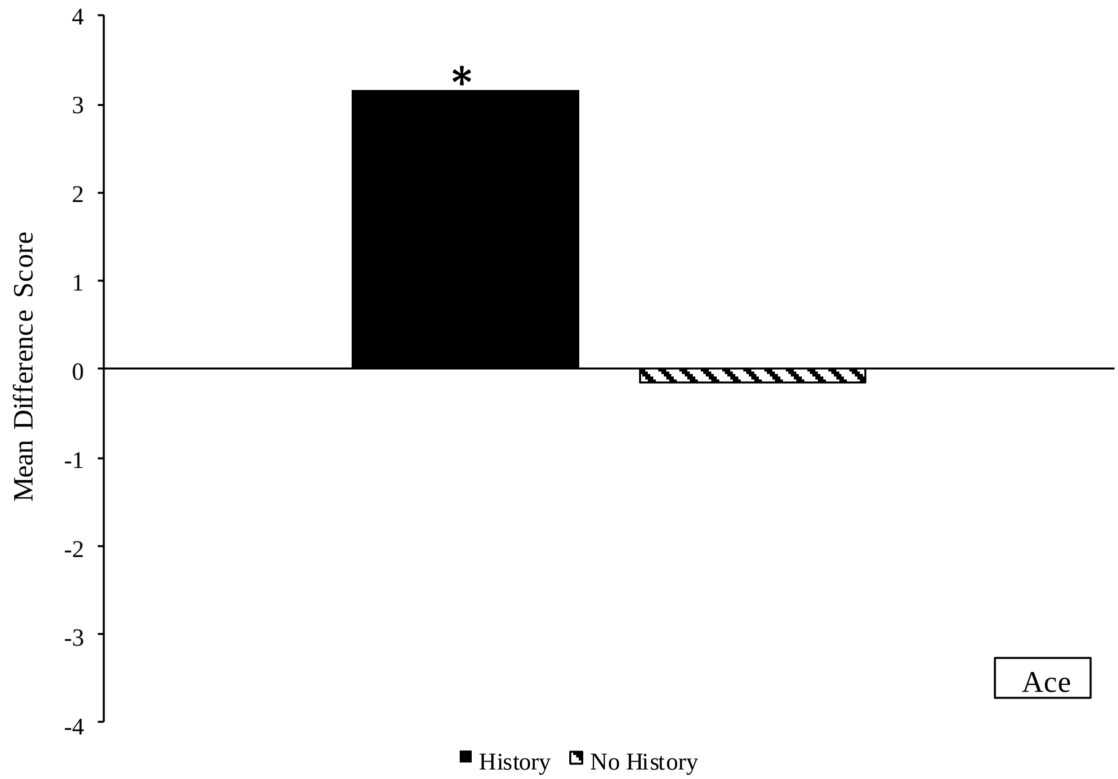

Figure 11. Mean difference scores during the Reward History Condition (black bar) and No-Reward History Condition (striped bar). Asterisks denote mean difference scores larger than the standard deviation to the mean across baseline phase.

Figures 12 and 13 illustrate the results for Laila. Overjustification effects were observed in 4 of 6 components during the Reward-History condition (Figure 12). During the No-Reward History Condition overjustification effects were observed in 4 of 6 components and improvement effects were observed during 2 of 6 test components (Figure 13).

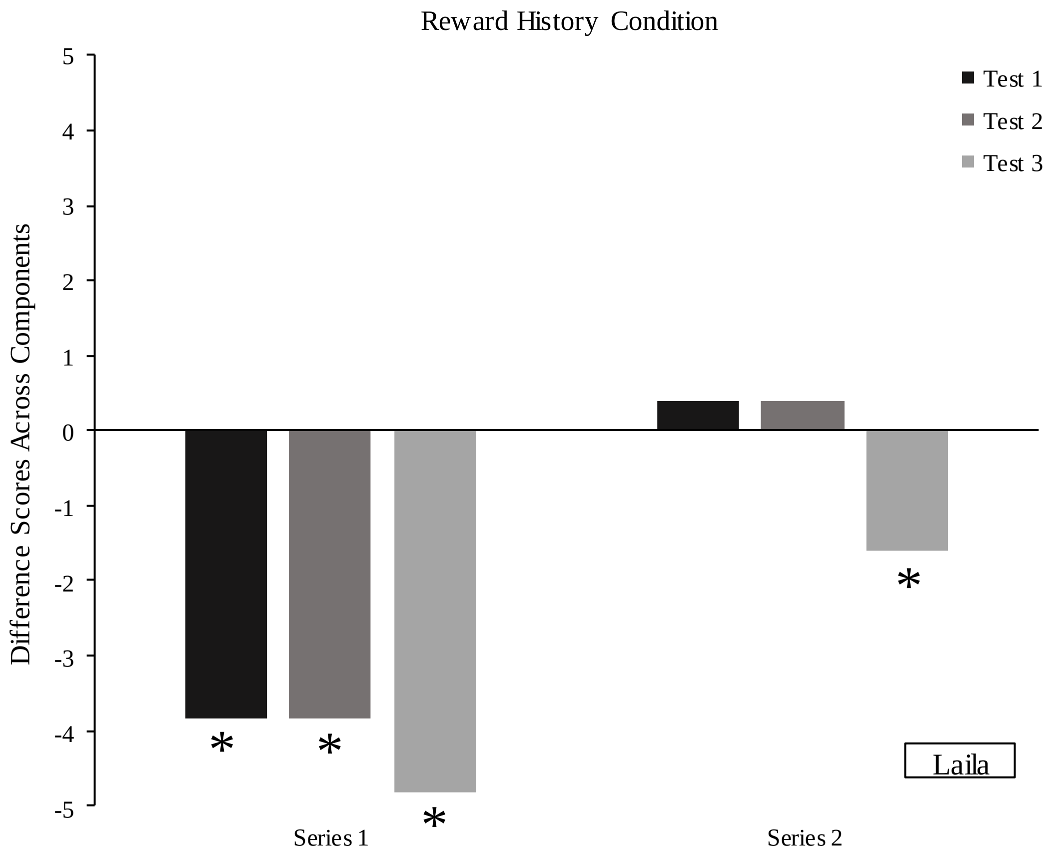

Figure 12. Component-by-component difference scores during the Reward History Condition for Laila. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

Figure 13. Component-by-component difference scores during the Reward History Condition for Laila. The three bars on the left illustrate difference scores from the first test series (initial Phase C). The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Asterisks denote difference scores with absolute values larger than the standard deviation during baseline.

Figure 14 shows mean results of the overjustification analysis across conditions for Laila. During the reward-history condition, the absolute value of the mean difference score was larger than the standard deviation derived across the two baseline phases.

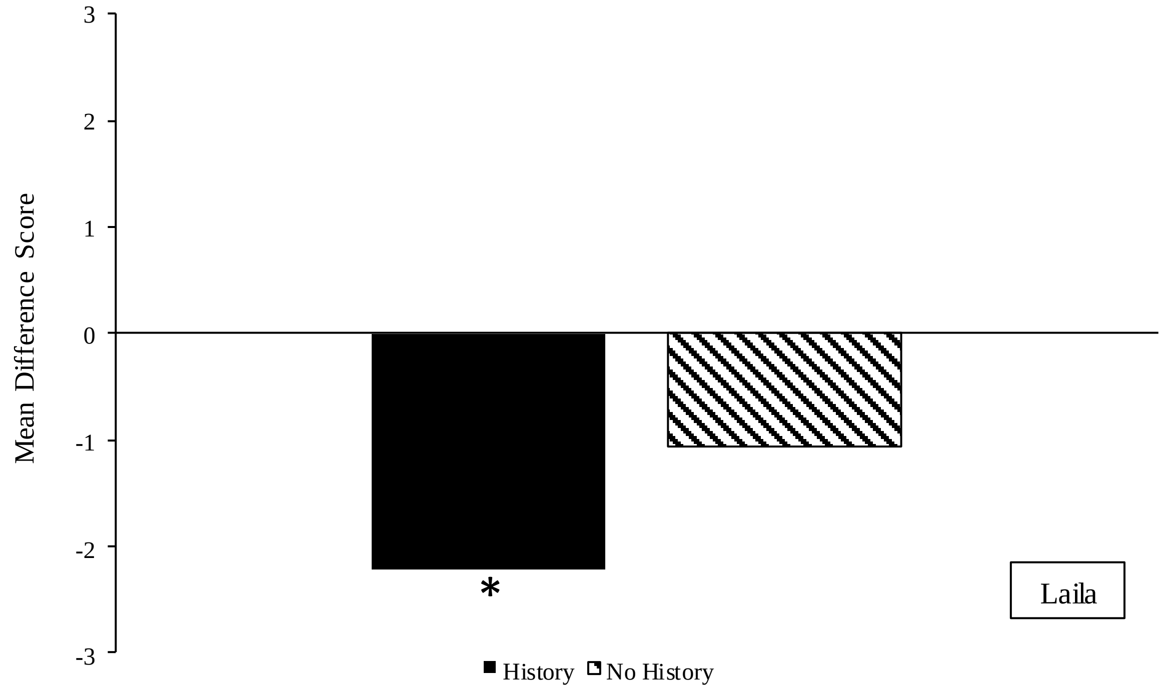

Figure 14. Mean difference scores during the Reward History Condition (black bar) and No-Reward History Condition (striped bar). Asterisks denote mean difference scores larger than the standard deviation to the mean across baseline phase.

Additional Overjustification Analysis

The overjustification measures above involve calculations of differences scores to compare pre- and post-reward responding for each participant (i.e., post-reward responding minus pre-reward responding). Proportional calculations may control for individual differences (across participants) in pre-reward responding, allowing for a comparison of overjustification effects and improvement effects across participants. Figure 15 illustrates the results of individual differences scores for each participant, converted to proportions to allow for this comparison.

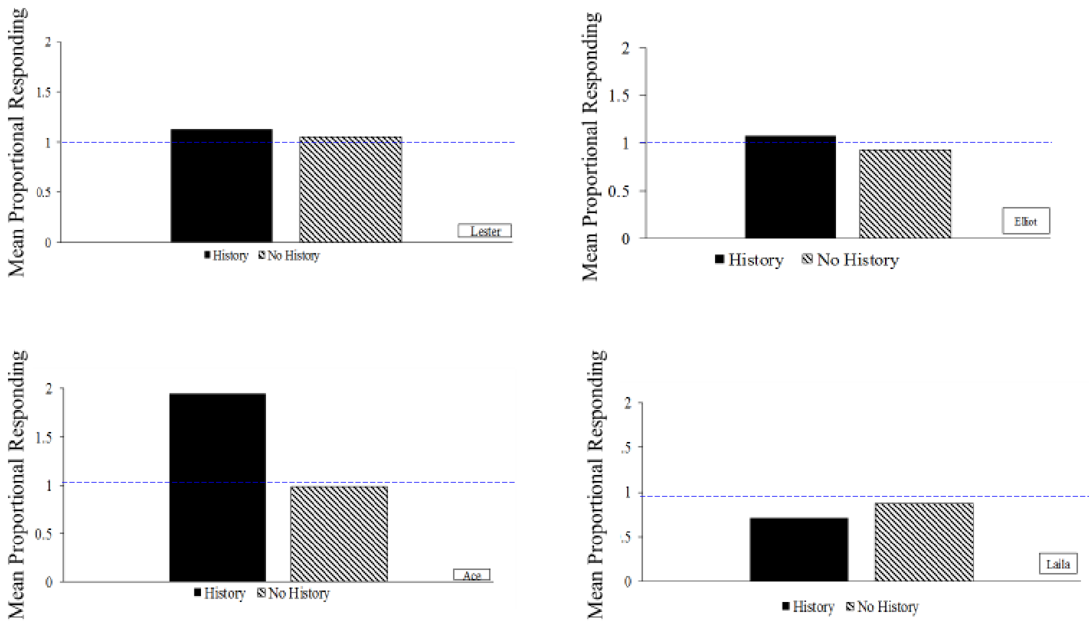

Figure 15. Mean proportional responding (post reward frequency divided by pre-reward frequency) during the Reward History Condition (black bars) and the No-Reward History Condition (striped bars). Scores above the dotted lines designate a mean increase from pre- to post- reward, whereas scores below the line denote mean a decrease.

These results indicate that mean proportional responding was similar in the Reward History Condition for Elliot and Lester, was lower for Laila, and substantially higher for Ace. By contrast, mean proportional responding was similar across participants in the No-Reward History Condition.

Behavioral Persistence

Overjustification effects were measured by comparing post-reward levels of responding (during the no-reward test components) to pre-reward sessions (during no-reward baseline sessions). Behavioral persistence, by contrast, was assessed by comparing the frequency of responding during the no-reward test components within Phase C (Components 3, 4, and 5) to responding during the previous reward component (Component 2) of the same series. That is, behavioral persistence was expressed as a proportion of the immediately preceding, undisrupted, reward component. For example, Lester responded 6 times during the reward component of the initial reward-history test series (ocean context) (Figure A1, Phase C, data point circled in red). This frequency was compared to the frequency of responding during *each* test component (components 3, 4, and 5) of the ocean test series in Phase C. Those frequencies were 7 (Test 1), 7 (Test 2), and 8 (Test 3) (Figure A1, Phase C, test components circled in blue). To calculate persistence for each of these test components, the response frequency from *each* test component was divided by the frequency of responding observed during the reward component (i.e., 6) resulting in the following persistence ratios: 7/6 = 1.2 for Test 1 (Figure 16, bar 1); 7/6 = 1.2 for Test 2 (Figure 16, bar 2), and 8/6 = 1.33 for Test 3 (Figure 16, bar 3). This was repeated for the remaining test series.

Categories of persistence strength have not been formally identified in prior research. The following categories of persistence strength (illustrated in Table 6) were developed for this study to facilitate discussion of these data.

Table 6

Experiment 1: Categories of Persistence Strength

Value	Strength
= / > 0.90	Very Strong
0.80 – 0.89	Strong
0.70 – 0.79	Moderately Strong
0.60 – 0.69	Moderately Weak
0.50 – 0.59	Weak
< 0.50	Very Weak

Figures 16 and 17 illustrate the results of the persistence analysis by test component for Lester. Figure 16 shows results from the Reward History Condition. Figure 17 shows results from the No-Reward History Condition. For both conditions, persistence strength was strong in one test component and very strong in five test components.

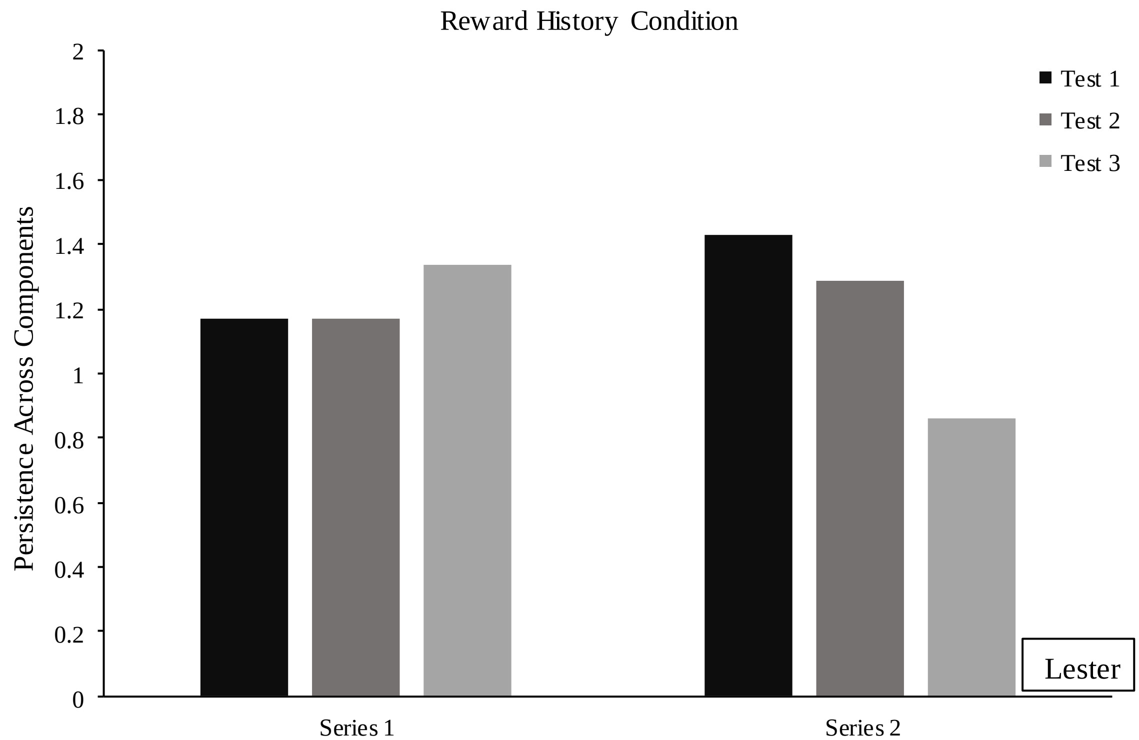

Figure 16. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the Reward History Condition for Lester. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

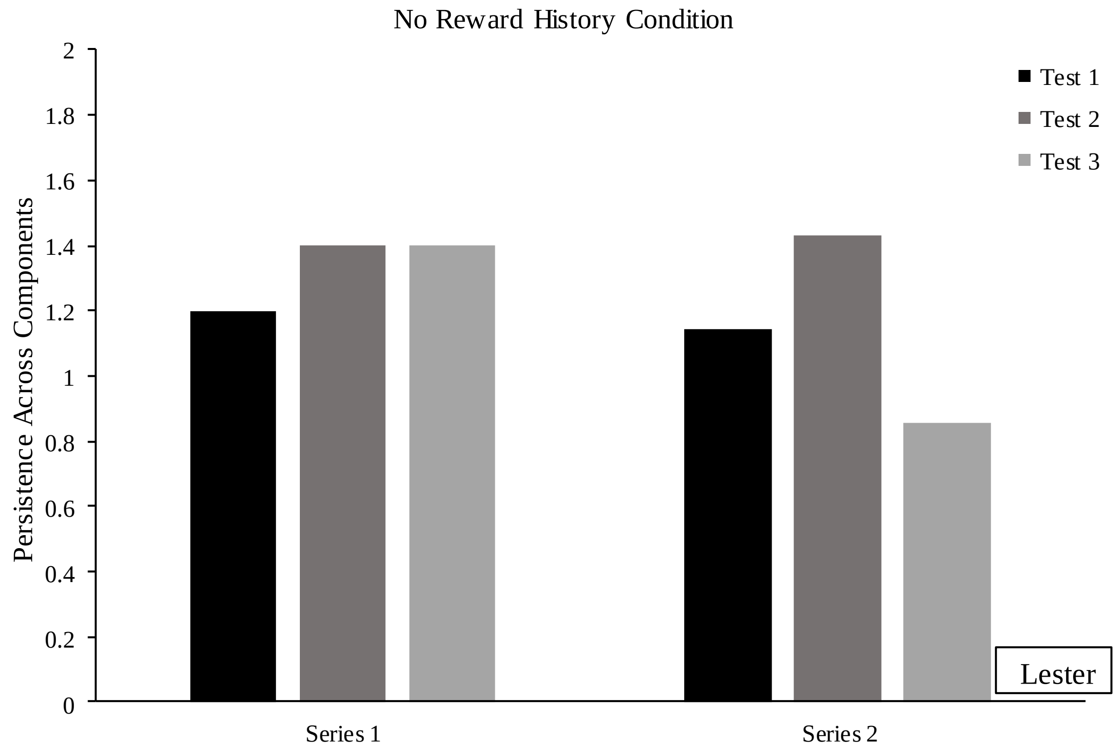

Figure 17. Persistence ratios (illustrated on the y-axis) obtained for all test components (across the x-axis) during the No-Reward History Condition for Lester. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Figure 18 illustrates mean persistence strength across all components within the reward-history condition (black bar) and No-Reward History Condition (striped bar) for Lester. Mean results indicate persistence was very strong across conditions (M = 1.20, Reward History Condition; M = 1.24, No-Reward History Condition).

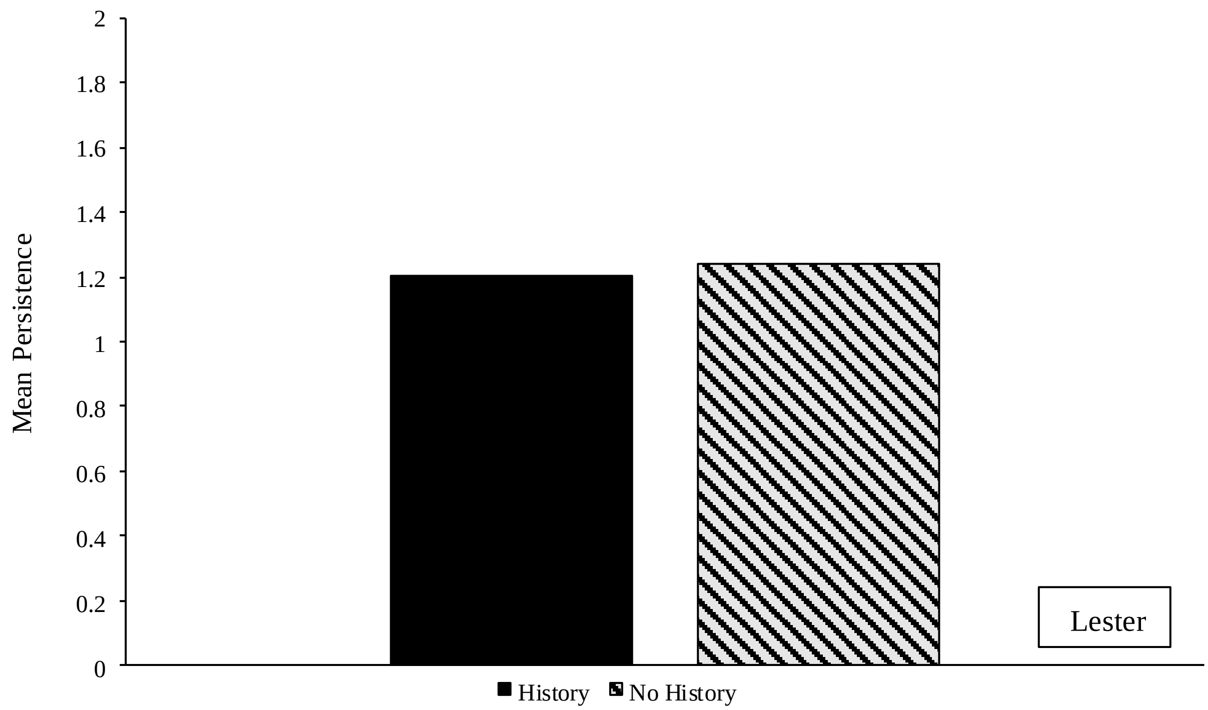

Figure 18. Mean persistence during the Reward History Condition (black bar) and No-Reward History Condition (striped bar) for Lester.

Figures 19 and 20 illustrate the results of the persistence analysis by test component for Elliot. During the reward-history condition (Figure 19), persistence strength was moderately strong during one test component, strong for two test components, and very strong for three test components. During the No-Reward History Condition (Figure 20), persistence strength varied from weak to very strong. Two components were associated with weak persistence, one with moderately weak persistence, one with moderately strong persistence, and two with very strong persistence.

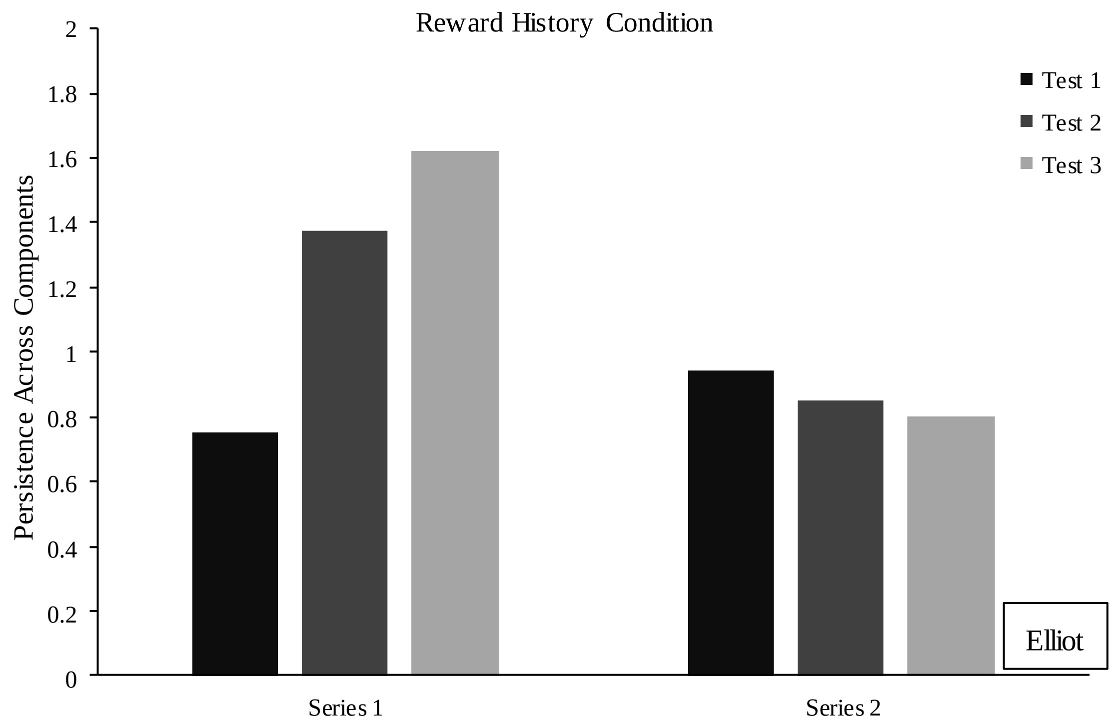

Figure 19. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the Reward History Condition for Elliot. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

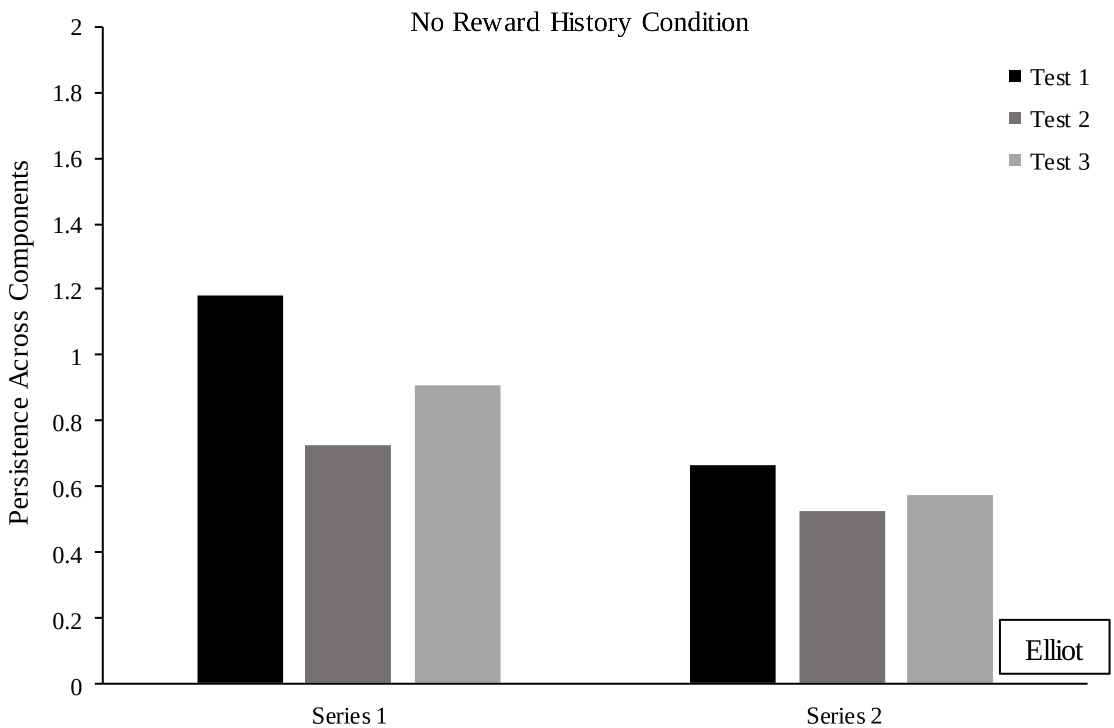

Figure 20. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the No-Reward History Condition for Elliot. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Mean results for Elliot are depicted in Figure 21. Results indicate persistence was very strong in the Reward-History Condition (M = 1.05), and moderately strong in the No-Reward History Condition (M = 0.76).

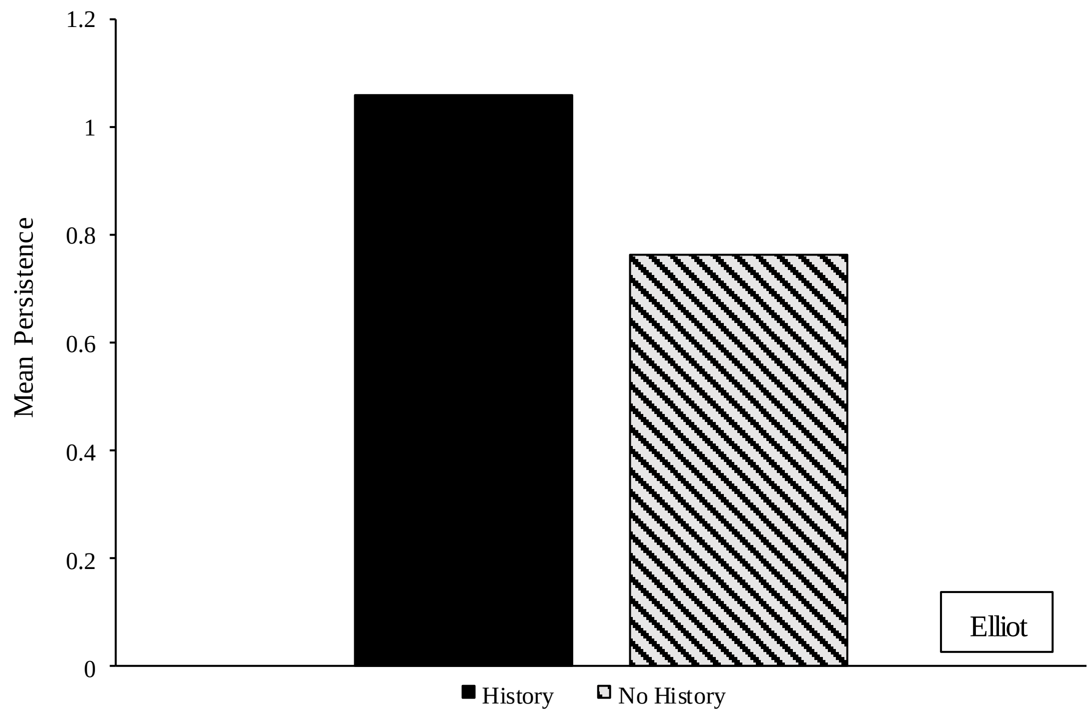

Figure 21. Mean persistence during the Reward History Condition (black bar) and No-Reward History Condition (striped bar) for Elliot.

Figures 22 and 23 illustrate the results of the persistence analysis by test component for Ace. During the Reward-History Condition (Figure 22), persistence strength was moderately weak in one component and very strong in five components. By contrast, during the No-Reward History Condition persistence strength was very weak during three test components, weak during one test component, and moderately strong during two test components (Figure 23).

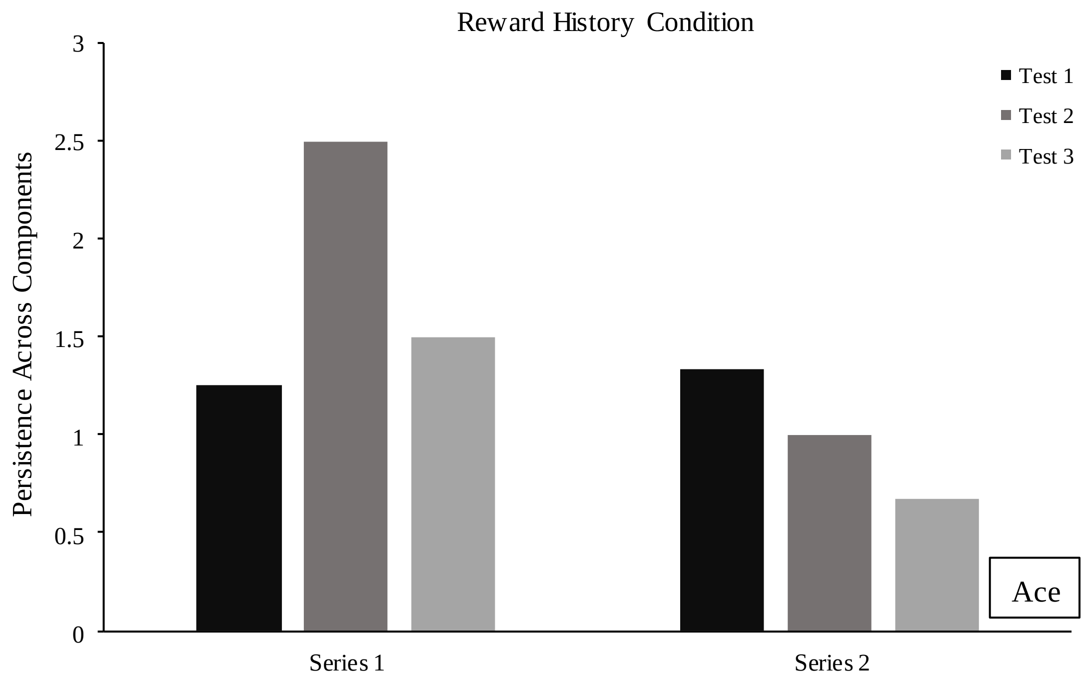

Figure 22. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the Reward History Condition for Ace. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

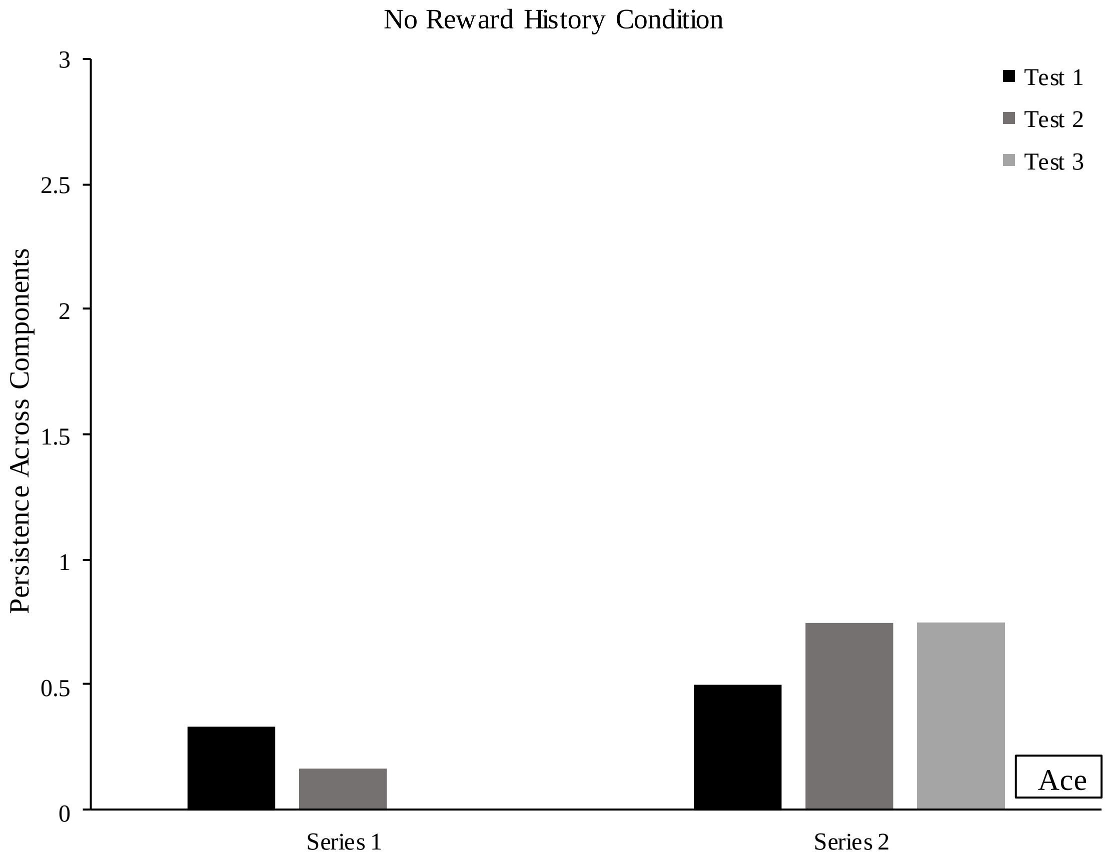

Figure 23. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the Reward History Condition for Ace. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Mean results for Ace are depicted in Figure 24. Results indicate persistence was very strong in the Reward-History Condition (*M* = 1.38) and very weak in the No-Reward History Condition (*M* = 0.42).

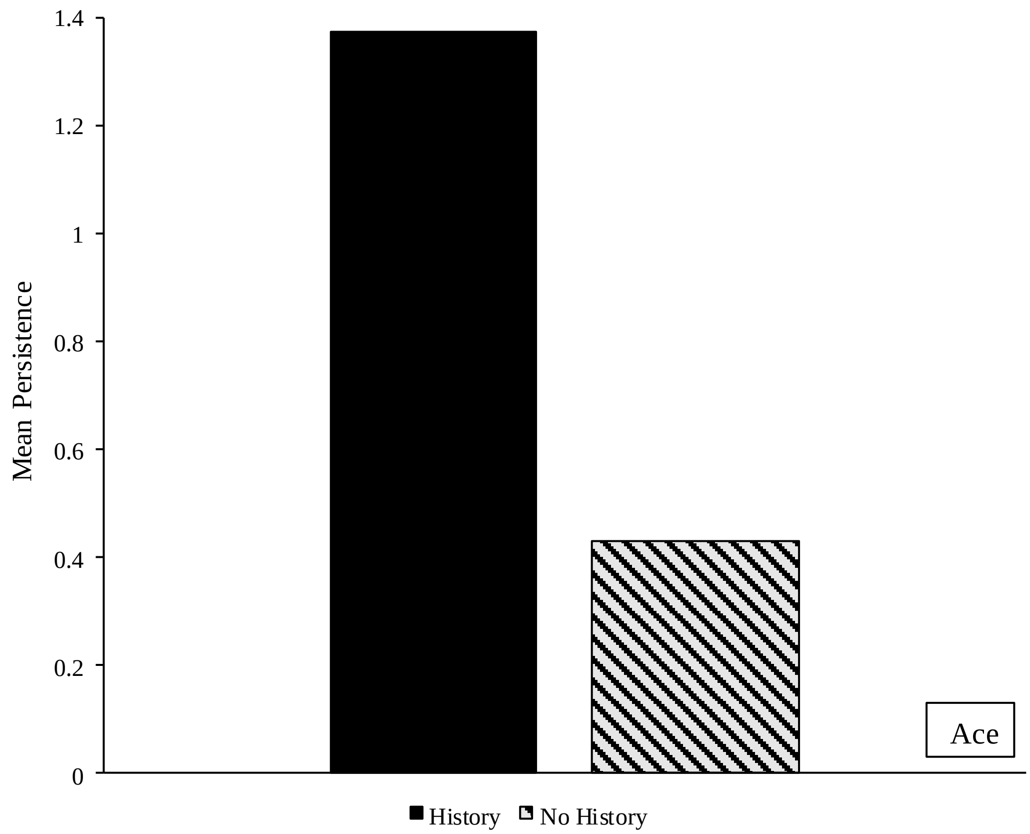

Figure 24. Mean persistence during the Reward History Condition (black bar) and No-Reward History Condition (striped bar) for Ace.

Figures 25 and 26 illustrate the results of the persistence analysis by test component for Laila. Persistence strength varied considerably across both conditions. In the reward condition, persistence strength was very weak in one component, weak across three components, and very strong across two components (Figure 25). In the the No-Reward History Condition, persistence strength was very weak in one component, moderately weak in one component, strong in one component, and very strong in three components (Figure 26).

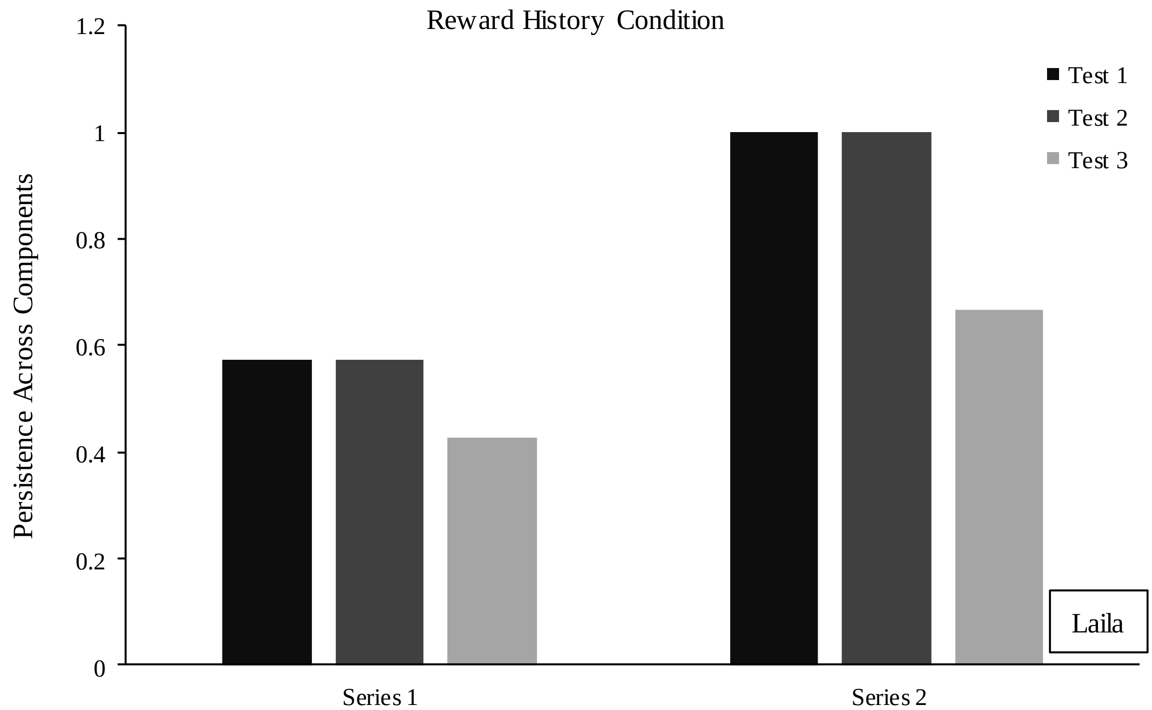

Figure 25. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the Reward History Condition for Laila. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases

in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

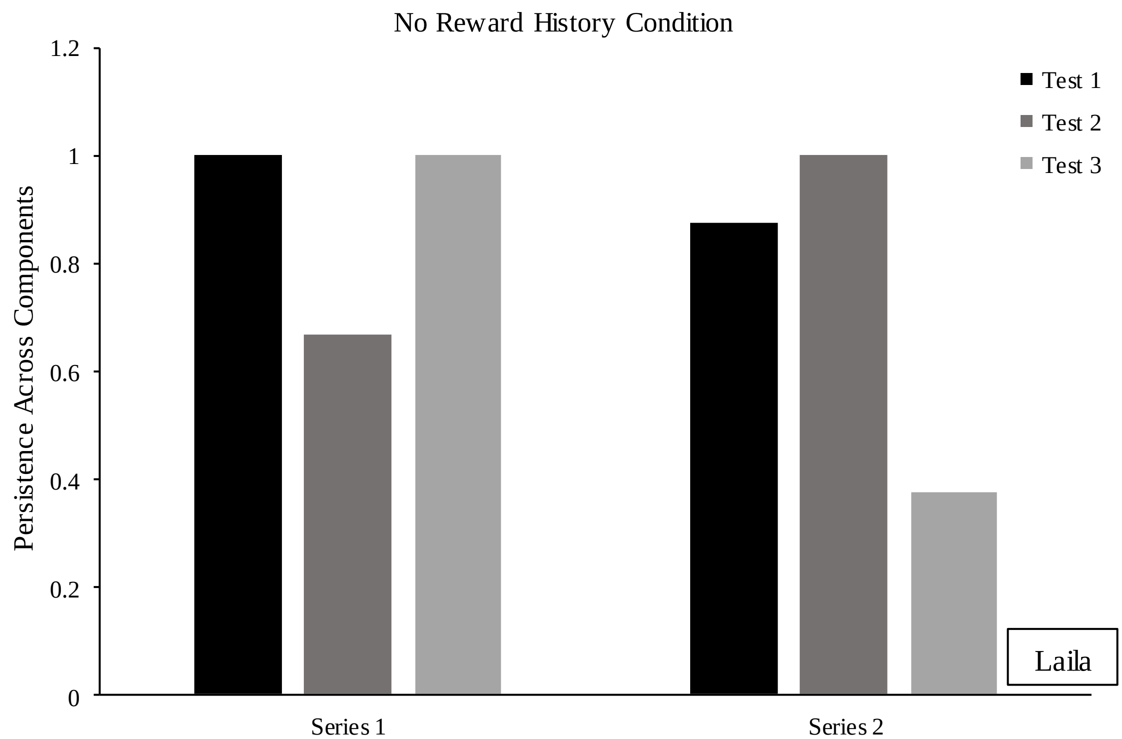

Figure 26. Persistence ratios (illustrated on the *y*-axis) obtained for all test components (across the *x*-axis) during the No-Reward History Condition for Laila. The three bars on the left illustrate persistence ratios from the first test series. The black bar indicates results from Test 1 (Component 1), the dark grey bar indicates results from Test 2 (Component 2), and the light grey bar indicates results from Test 3 (Component 3). The bars on the right illustrate the same information for the second test series (presented in the Phase C reversal). Persistence ratios reflect the frequency of responding observed in each test component divided by the frequency of responding observed in the previous reward component of the same series. Increases in the strength of persistence are indicated as the ratio approaches 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Mean results for Laila are depicted in Figure 27. Results indicate mean persistence was moderately strong in the Reward-History Condition (M = 0.71) and strong in the No-Reward History Condition (M = 0.82).

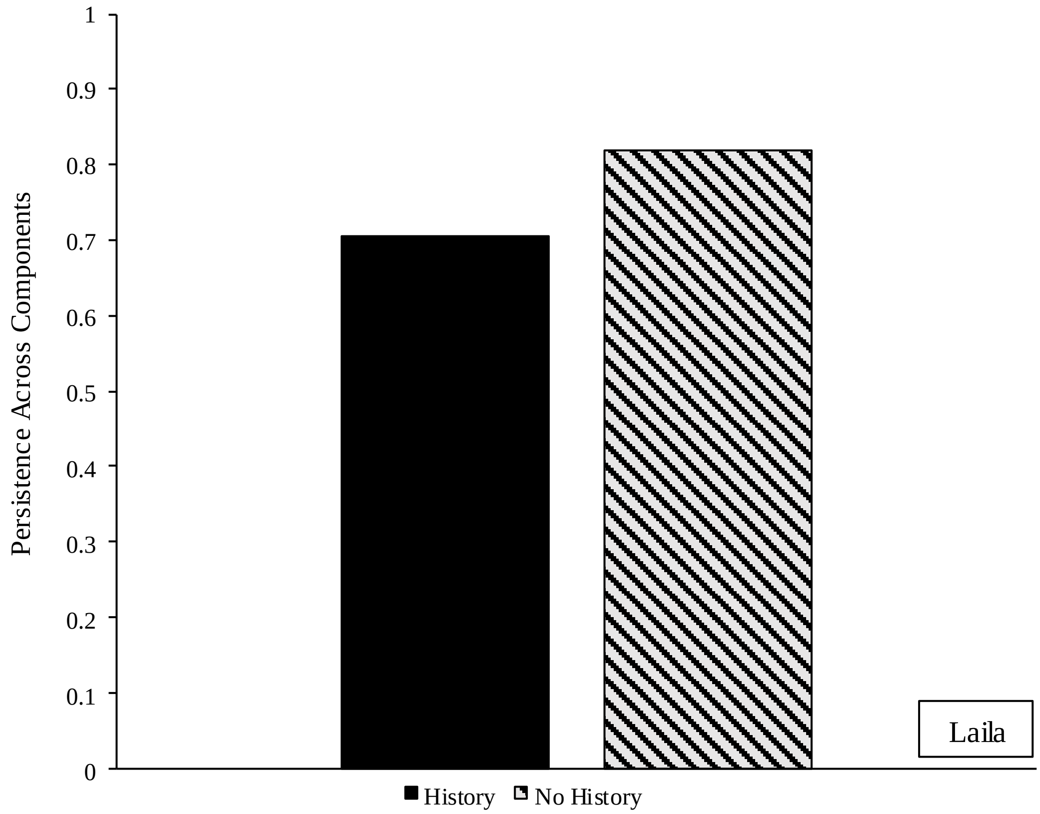

Figure 27. Mean persistence during the Reward History Condition (black bar) and No-Reward History Condition (striped bar) for Laila.

Discussion

The aim of Experiment 1 was to examine the effects of aggregate reward history on overjustification and behavioral persistence, and the extent to which overjustification effects, like persistence, may be a function of stimulus-reinforcer relations. I hypothesized that longer exposures to a reinforcement schedule within extended reward histories may produce heightened stimulus-reinforcer associations, thus producing strengthened persistence and diminishing the likelihood of overjustification effects.

Figure 28 provides an illustration of the frequency of overjustification effects observed across conditions for each participant. For Lester and Laila, no differences were observed across conditions in the frequency of overjustification effects: overjustification effects were equally infrequent for Lester, and equally frequent for Laila. When differences occurred (Elliot and Ace) results indicated overjustification effects were more frequent in the No-Reward History Condition. Figure 29 provides an illustration of the frequency of improvement effects observed across conditions for each participant. With the exception of Laila, results indicate improvement effects were more frequent in the Reward-History Condition.

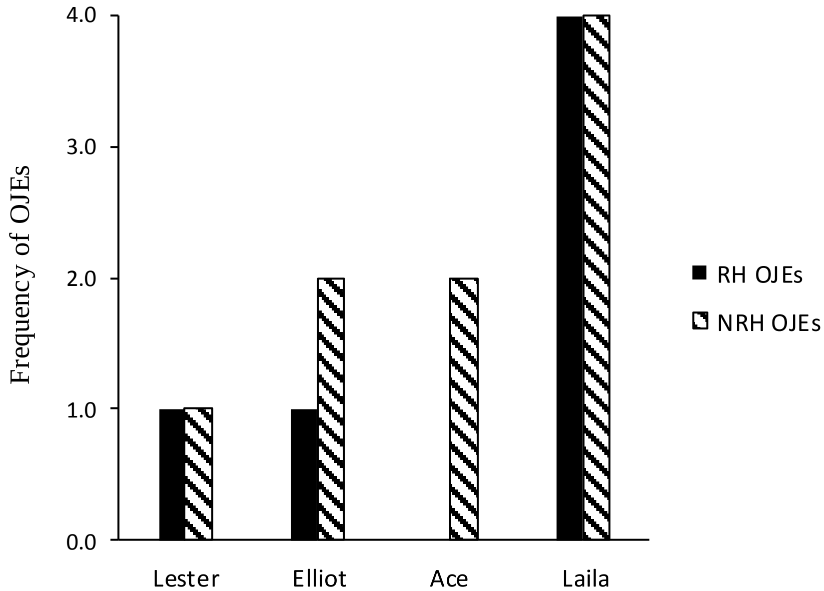

Figure 28. Overall frequency of overjustification effects during the Reward History Condition (black bar) and No-Reward History Condition (striped bar), for all participants.

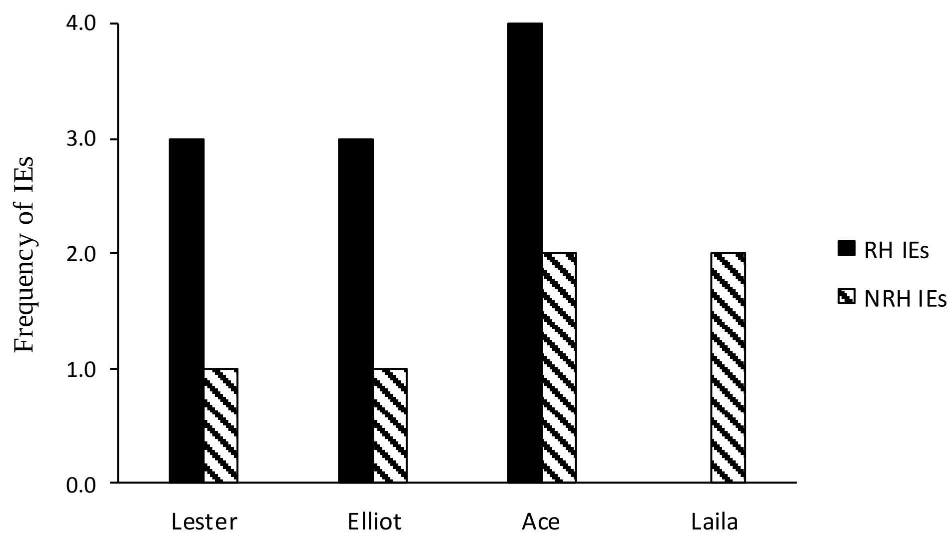

Figure 29. Overall frequency of improvement effects (IEs) during the Reward History Condition (black bar) and No-Reward History Condition (striped bar) for all participants

The first hypothesis posits that overjustification effects may be more likely following shorter reward periods and may be less likely following lengthier reward periods. The results of this study were largely in line with that hypothesis: with the exception of Laila, results suggested overjustification effects occurred less frequently in the Reward History Condition relative to the No-Reward History Condition. Notably, this finding is conceivably in contrast to the general concept of overjustification: if rewards are detrimental to later responding in the absence of reward, as proposed by the overjustification hypothesis, one might expect *longer* histories of reward to result in *greater* detriments in responding following the withdrawal of reward. Instead, for most participants, reward history more frequently resulted in improvement effects on responding following the withdrawal of reward during tests of overjustification.

The second hypothesis posits the Reward-History Condition would also be associated with greater response persistence. In line with this hypothesis, persistence was relatively stronger (on average) in the Reward-History Condition relative to the No-Reward History Condition for two participants (Elliot and Ace). Lester had strong persistence across conditions, and Laila had relatively weaker persistence in the Reward-History Condition, and relatively stronger persistence in the No-Reward History Condition. Figure 30 illustrates mean persistence and obtained overjustification effect across conditions and participants.

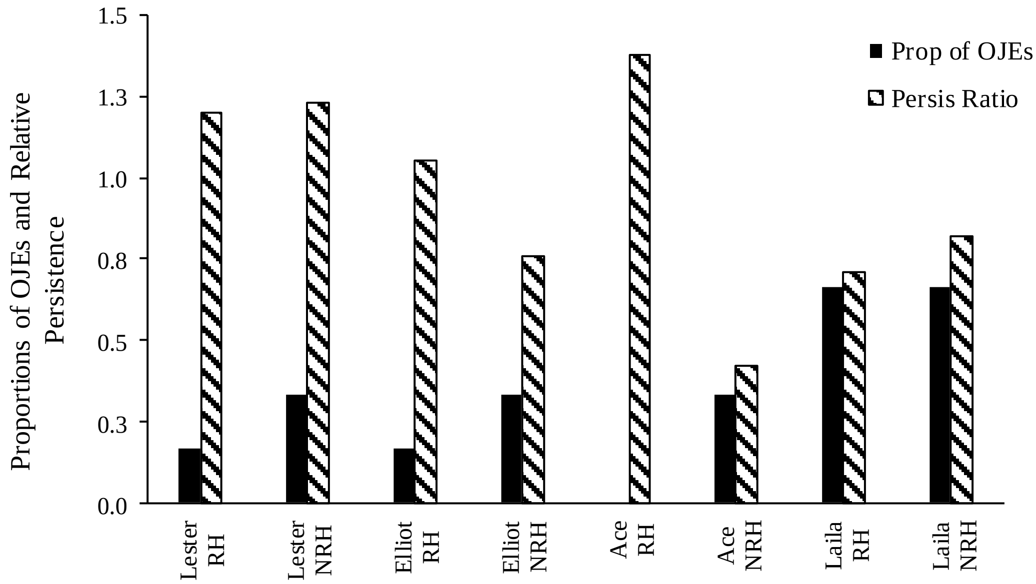

Figure 30. Proportion of overjustification effects (black bars, proportion of all 6 test-components per condition) and mean relative persistence (striped bars) across Reward History (RH) and No-Reward History (NRH) Conditions for each participant.

Generally, persistence results were in line with what our hypothesis would predict regarding the effects of persistence on overjustification effects. In 3 of 4 cases (all but Laila), the Reward-History Condition was associated with very strong persistence and very infrequent overjustification effects. As well, in 3 of 4 cases (all but Lester) the No-Reward History Condition was associated with low to moderate persistence and relatively more frequent overjustification effects overall.

Collectively, these patterns of responding provide some evidence of a relation between persistence and overjustification under the conditions of this study, and further indicate that reward history may affect these phenomena in the directions hypothesized. An exception can be noted for Laila, for whom the opposite pattern was observed (i.e., weaker persistence and more frequent overjustification effects in the reward-history condition).

Overall, overjustification effects did not occur frequently across conditions and participants. During the Reward-History Condition, overjustification effects were observed in only 6 tests out of 24 (across participants). Overjustification effects were relatively more likely during the No-Reward History Condition but were nonetheless observed less than half of the time (i.e., in 9 of 24 tests across participants). Results also indicated that with the exception of three tests for Laila and one test for Ace, persistence was generally strong to very strong within the Reward-History Condition (across participants). Patterns of responding suggest that within the conditions of this study: (a) overjustification effects were infrequent, (b) reward histories may provide some protection against overjustification effects, and (c) the protective value of reward histories in minimizing overjustification effects may work in part through increases in persistence strength.

It is interesting to note that rewards did not sufficiently strengthen responding across all participants and reward history phases (i.e., they were not always reinforcers). A notable pattern emerged in relation to reinforcement effects and overjustification effects: overjustification effects within the Reward-History Condition were relatively more robust when reinforcement effects were obtained during the preceding reward history phase. This effect was consistent across participants: For Lester, a greater reinforcement effect was obtained during the first reward history phase relative to the second. Accordingly, overjustification effects were only observed during the second reward-history phase. For Elliot, a greater reinforcement effect was obtained during the second reward history phase relative to the first. Again, overjustification effects were observed only during the first reward-history phase. For Ace, clear reinforcement effects were observed across *both* reward-history phases. Accordingly, no overjustification effects occurred during tests following either reward-history phase. Finally, for Laila, reinforcement effects were not observed during the first reward-history phase, but were during the second (to some degree). Although overjustification effects occurred across test phases, they were more frequent and more robust following the first reward-history phase relative to the second. Overall, these consistent patterns across participants indicate that overjustification effects may be less likely when immediately preceding rewards produce demonstrable reinforcer effects.

The effects of reinforcer efficacy on persistence were not as clear. Whereas reward history generally produced greater persistence relative to no-reward history, persistence was moderate to very strong in all test components within the reward-history condition (with few exceptions: three tests for Laila and one test for Ace), regardless of the reinforcing efficacy demonstrated during the previous reward-history phase.

Rate of reinforcement is regularly implicated as the variable responsible for differences in response persistence as tested under multiple schedule arrangements (Grimes & Shull, 2001; Mace et al., 2010; Nevin, Tota, Torquato, & Shull, 1990; Shahan & Burke, 2004; for exceptions, see Nevin, Grace, Holland, & McLean, 2001). Interestingly, the rate of reward in component 2 (prior to the test components) was equal across conditions. If rate of reward were the sole variable contributing to response persistence, equal (or nearly equal) persistence would be observed across conditions, similar to what was observed for Lester. However, here *dissimilar* levels of persistence were often observed across conditions (i.e., Ace and Elliot), indicating that reward history may strengthen stimulus-reward associations in a manner similar to rate of reward, and thus may similarly affect response persistence. Additional studies should examine this as a variable possibly affecting persistence (and overjustification) on a more widespread scale.

Chapter 3: Experiment 2

Research on behavioral persistence indicates that baseline rate of reward has a central importance in governing response persistence during disruption (such as extinction, as applied in the overjustification effect). Similarly, baseline rate of reward may affect responding during tests of overjustification under conditions amenable to momentum. The purpose of Experiment 2 was to examine the extent to which rate of reward affects responding as it relates to these phenomena.

Aims and Hypotheses: Experiment 2

The aim of Experiment 2 was to examine the effects of rate of reward on overjustification and behavioral persistence. Behavioral research suggests the reinforcer rate, and not the rate of responding, is the crucial factor central to BMT. Accordingly, it was hypothesized that behavioral persistence would be relatively greater in the conditions associated with a higher rate of reward, and lower in the condition associated with the relatively lower rate of reward. Table 7 displays expected response levels, reward rates, and predictions of behavioral persistence and overjustification for each condition. Columns 1 and 2 indicate relative rate of reward (column 1: VI high and VT high relative to VI low) and relative rate of responding (column 2: VT high relative to VI high and VI low) across conditions. Column 3 indicates predicted outcomes for tests of behavioral persistence (strong or weak) and overjustification effects (relative frequency of obtained effects) across conditions. Differences in persistence and overjustification effects observed between Condition 1 and Condition 2 may be attributed to differences in response rates, as the rate of reward is constant across these conditions. On the other hand, differences in outcomes across Condition 1 and Condition 3 may be attributed to differences in the rate of reward, as response rates should be similar across these conditions (one would also expect different outcomes across Condition 2 and Condition 3 in this case).

Table 7

Experiment 2 Reward Rates, Expected Relative Response Rates, Predicted Outcomes

Condition	Relative reward rate	Relative response rate	Behavioral persistence/ relative frequency of OJ Effects
(C1) (VI high)	High	High	Strong/Infrequent (relative to C3)
(C2) (VT high)	High	Low	Strong/Infrequent (relative to C3)
(C3) (VI low)	Low	High	Weak/Frequent (relative to C1 & C2)

The importance of the rate of reinforcement in increasing behavioral persistence may likewise extend to the strengthening of responding more generally, resulting in not only more persistent behavior as it is examined in behavioral persistence studies, but also more robust responding in the face of extinction as it may be applied in tests of overjustification (thus making overjustification effects less likely under relatively higher rates of discriminated reinforcement). Past research provides some evidence of this, given that behavioral studies commonly employ relatively higher rates of reinforcement and often do not find overjustification effects, whereas cognitive studies generally employ relatively lower rates of reinforcement and more often observe the phenomenon. In light of this and the shared similarities between persistence and overjustification, it was hypothesized that given an equal number of tests for overjustification effects across conditions, the frequency of obtained overjustification effects would be relatively *lower* in the conditions with *higher* rates of reward, and relatively *higher* in the condition with the *lower* rate of reward.

The non-contingent (“free”) reinforcement within the VT High Condition should produce relatively lower levels of responding compared to that of the VI High Condition while maintaining a high rate of reinforcement equal to that of the VI High Condition. Thus, observing overjustification effects (or observing relatively greater overjustification effects) in both conditions, and not in the VI Low Condition, may provide further evidence of the importance of stimulus-reward relations over response levels in obtaining increases in behavioral persistence and decreases in overjustification effects.

Method

Participants and Setting

Participants included four children ages 3-5 attending a local preschool in Nashua, New Hampshire. Participant and parent demographic data were collected during parental consent procedures and are summarized in Table 8. Columns 1 and 2 refer to the participant, whereas the remaining columns reflect information about the parents and family. Race, gender, ethnicity, sexual orientation, religion, or family or socio-economic status did not determine participation. One participant did not complete the study because he exhibited an excessive amount of out-of-seat behavior.

All sessions took place in quiet rooms with a table, chairs, and session materials present. As mentioned above, behavioral persistence depends upon stimulus – reinforcer relations, to the extent that resistance to disruption is positively related to the rate of reinforcement in the environment in which the behavior occurs. Thus, different contexts were presented for each condition, and each context was associated with a different theme (i.e., barnyard, jungle, or ocean). These contexts were illustrated using presentation boards covered with theme-specific posters depicting context-specific environment and animals living in the environment. For example, the "ocean" presentation board depicted a blue ocean with fish, an octopus, and a whale, and the "jungle" presentation board depicted a green jungle with trees and vegetation, monkeys, and a giraffe. The experimenter wore different baseball caps (a green cap for the jungle, a blue cap for the ocean, and a red cap for the barnyard) affixed with miniature animals (an octopus and dolphin for the ocean context; a giraffe and elephant for the jungle context; a cow and a horse for the barnyard context) to further distinguish the three areas.

Table 8

Experiment 2: Summary of Participant Demographic Information

Participant Gender	Participant Race/Ethnicity	Employment Status	Total Family Income	Marital Status
Male (50%)	Caucasian (75%)	Employed (100%)	\$0-\$39,999 (0%)	Single (0%)
	African American (0%)	Student (0%)	\$40,000-\$79,999 (0%)	Married (100%)
Female (50%)	Hispanic (0%)	Unemployed- (0%)	\$80,000-\$110,999 (50%)	Separated or Divorced (0%)
	Other (25%)		>\$110,999 (50%)	Widowed (0%)

Materials

Materials included the presentation boards, hats, and miniatures specific to each context, one high-preferred academic or skills-based activity (the significance of activity preference is described in further detail below), and one high-preferred edible reward (e.g., jelly beans or M&Ms). Activities and edible rewards were identified through Stimulus Preference Assessments conducted during pre-experimental procedures.

Dependent Measures

Experiment 2 aimed to examine the effects of rate of reward and rate of responding (the independent variables) on later overjustification and behavioral persistence the dependent variables). Overjustification effects are exemplified by a decrease in responding following the withdrawal of reward relative to the level of responding that occurred before the reward was introduced. Within-session tests of the overjustification effect and behavioral persistence involved the sequential presentation of five components: no reward (baseline), reward, no reward (test), no reward (test), and no reward (test). The intervening reward periods involved the manipulation of the independent variables, differing the rate of reward delivery and levels of expected responding across conditions. Overjustification effects were examined as in Experiment 1: for each condition the frequency of responding during no-reward test components *following* reward delivery was compared to the mean frequency of unrewarded responding *prior to* reward delivery (i.e., during baseline). Difference scores were calculated as in Experiment 1.

Behavioral persistence is exemplified by continued responding in the face of a challenge (here, the withdrawal of reward). Persistence was determined by calculating disrupted responding (e.g., responding exposed to extinction) as a proportion of previously undisrupted "baseline" responding (e.g., responding exposed to reward or reinforcement). Thus, for the persistence measure, responding during each test component of each condition was compared to responding during the previous reward period (Component 2) within the same test series.

Interobserver Agreement (IOA)

IOA was assessed by trained independent observers using DataPal. IOA was assessed for participant behavior (frequency of responding) as well as experimenter behavior (reward delivery). IOA was assessed for 20% of sessions for Ace, 30% of sessions for Elliot, 30% of sessions for Laila, and 33% of sessions for Annie. Partial-interval agreement was calculated by dividing each session into 10-s intervals and dividing the lower number of recorded responses (or duration) by the larger number of recorded responses (or duration). Agreement for the frequency of responding was 80% for Lester (range, 78% to 98%), 94% for Elliot (range, 89% to 100%), 87% for Ace (range, 83% to 93%), and 90% for Lulu (range, 88% to 97%). Agreement for reward delivery was 98% for Lester (range, 90% to 100%), 93% for Elliot (range, 90% to 100%), 93% for Ace (range, 90% to 98%), and 85% for Lulu (range, 80% to 92%).

Pre-Experimental Design and Procedures

Activity Stimulus Preference Assessment (SPA)

A six-item activity SPA was conducted two times in the manner described in Experiment 1. Moderate to high-preferred tasks were selected for inclusion in the subsequent experimental procedures (those associated with a mean selection percentage of at least 60%).

Edible Stimulus Preference Assessment (SPA)

A six-item edible SPA was conducted two times in the manner described in Experiment 1. High-preferred edibles were selected for inclusion in the subsequent experimental procedures and were associated with a mean selection percentage of at least 80% (Fisher et al., 1992).

Experimental Design and Procedures

Data Collection. Data were collected using DataPal, a computer-based data-collection program that allows real-time data collection of duration and frequency data. Data were collected by the primary experimenter or by a trained assistant. Duration data were collected on target task engagement, and frequency data were collected on target responding and reward delivery.

Sessions were conducted using an A-B-A-B reversal design where A = Baseline (no reward) and B = Test. Three conditions (described below) were alternated in a multielement design. (Table 9 provides a visual description of the sessions/components within each phase for each condition). Sessions were 1 minute in Baseline and 5 minutes in the Test Phase (described below) and were conducted 3 to 5 days per week over several weeks.

Table 9

Experiment 2: Description of sessions/components for each phase and condition.

Phase	Condition 1 (e.g., Ocean Context)	Condition 2 (e.g., Jungle Context)	Condition 3 (e.g., Barnyard Context)
A - Baseline	No Reward	No Reward	No Reward
B - Test Series (by component)	No Reward	No Reward	No Reward
	↓	↓	↓
	Reward – *High Rate (Contingent)*	Reward – *High Rate (Non-contingent)*	Reward – *Low Rate (Contingent)*
	↓	↓	↓
	No Reward (Test 1)	No Reward (Test 1)	No Reward (Test 1)
	↓	↓	↓
	No Reward (Test 2)	No Reward (Test 2)	No Reward (Test 2)
	↓	↓	↓
	No Reward (Test 3)	No Reward (Test 3)	No Reward (Test 3)

Phase A: Baseline

As stated, overjustification effects have been determined to be most likely for responses that are initially associated with a high level of intrinsic motivation. Level of activity engagement during a baseline period may be considered a behavioral measure of intrinsic motivation to the extent that it reflects responding in the absence of any programmed extrinsic rewards. Accordingly, the purpose of Phase A -

Baseline was to determine an initial level of responding within each environment in the absence of any reward deliveries.

During Baseline, three conditions (Condition 1, Condition 2, and Condition 3) were randomly presented. Conditions were represented following an equal number of presentations across all other conditions (e.g., Condition 1, Condition 2, Condition 3; Condition 2, Condition 1, Condition 3; Condition 3, Condition 2, Condition 1). Each condition was presented three to five times, or until stability. Sessions were conducted identically across conditions, with the exception that each condition was presented in a separate context (i.e., a separate context board, as described for Experiment 1), associated with different themes (i.e., ocean, jungle, or barnyard). The context and theme associated with each condition remained constant throughout the initial phases of the experiment.

Prior to the start of each session, the experimenter asked the child to indicate the area they were in using the procedures described for Experiment 1. A high-preferred activity (e.g., sorting colors) was presented to the participant and the experimenter told the participant, "Here is an activity for you." Data were collected on the duration of task engagement and the frequency of target responses.

Phase B: Test

The purpose of Phase B was to test the effects of relatively high and low rates of reward on overjustification and behavioral persistence. During this phase, three conditions (VI high, VT high, and VI low) were quasi-randomly presented, with the stipulation that VI high always preceded VT high (so that the reward schedule of the VT could be yoked, or based on, the previous VI-high condition, this is explained in greater detail below). Sessions were conducted identically across conditions, with the exceptions that (a) different reward schedules were delivered across conditions, and (b) each condition was presented in a separate context, as described for baseline.

No-reward components. No reward components were conducted as described for no-reward components of Phase C in Experiment 1.

Reward components. Reward components were conducted as described for reward components of Phase C, Experiment 1, with the exception that the preferred edible was delivered on a pre-determined schedule, depending upon the condition. During the VI-high condition, rewards were delivered at a relatively high rate (i.e., VI 3 s or every 3 s, on average, contingent on a target response). During the VT-yoked high condition, the number of rewards equaled that of the previous VI-high session, but they were now delivered "freely" (not contingent upon responding). Though producing a rate of reward equal to the previous VI high condition, the VT condition was expected to produce a relatively lower rate of responding. During the VI-low condition, rewards were delivered on a relatively lower rate (i.e., VI 15 s, or every 15 s, on average, contingent upon a target response). Data were collected on duration of task engagement, response frequency, and reward delivery.

Stimulus Reassignment (Reversal)

The conditions associated with each context were reassigned during the AB reversal to replicate any effects of the independent variables using a different context. Reversals for each phase were otherwise conducted as described. In an effort to minimize potential carry over effects, baseline reversals were extended until response levels were similar to those obtained during the initial baseline, or until 30 sessions were conducted without producing response levels approximating those of the initial baseline.

Results: Pre-Experimental Procedures

Activity and Edible SPAs

Table 10 illustrates the items selected for inclusion in subsequent experimental procedures. Parenthetical percentages indicate the mean selection percentages associated with these items across both SPA presentations.

Table 10.

Experiment 2: Activities and Edible Items Selected for Experimental Procedures

Participant	Activity	Edible
Ace	Perler Beads (100%)	Cookie (60%)
Elliot	Perler Beads (80%)	Gushers (70%)
Laila	Sticker Mosaic (80%)	Veggie Sticks (80%)
Annie	Sticker Mosaic (90%)	Jelly Beans (80%)

Results: Experimental Procedures

Session-by-Session Baseline Results

Session-by-session data are illustrated in Appendix B. Baseline data indicated similar responding across all baseline contexts for all participants. General response patterns during Phase B indicated that reinforcer effects during the VI High and VI Low condition were inconsistent within and across participants. To examine this relation more explicitly, we determined the mean reinforcing efficacy of the individual rewards employed for each participant across VI low and VI high conditions. To do this, the mean rate of responding from the previous baseline was subtracted from the rate of responding observed during each reward component of those conditions. This reflected how much responding increased during each reward period relative to baseline. All of the individual scores were then averaged to determine the mean reinforcer efficacy of the stimulus employed for each participant. On average, rewards increased responding by 1.27 responses for Elliot, by 1.9

responses for Ace, by 2.3 responses for Annie, and by 2.4 responses for Laila (see Figure 64, p. 146 for an illustration of these results).

Overjustification Effects

The overjustification and behavioral persistence analyses were measured within each test component in the manner described for Experiment 1. To illustrate, the following depicts how difference scores were calculated for Ace, for the first test series within the VI high condition (jungle context). Ace's mean responding during baseline was $M = 3.33$; $SD = 1.24$. This mean was compared to response frequencies during each test component (Components 3, 4, and 5). Those frequencies were 5 (Test 1), 3 (Test 2), and 2 (Test 3). To calculate difference scores, the mean response level in Baseline was subtracted from each of these frequencies resulting in the following difference scores: 5-3.33 = 1.67 for Test 1 (Figure 31, black bar outlined in red); 3 - 3.33 = - 0.33 for Test 2 (Figure 32, dark grey bar outlined in red), and 2-3.33 = -1.33 for Test 3 (Figure 32, light grey bar outlined in red). Given the standard deviation during baseline ($SD = 1.24$), two of these difference scores resulted in absolute values outside of what might be expected from general variability in responding (Test 1, improvement effect; Test 3, overjustification effect). "No effect" is considered to have occurred for test scores falling within the range of the standard deviation to the mean.

Figures 31 through 33 illustrate the results of the overjustification analysis by test component for Ace. Figure 31 illustrates results from the VI-high condition, Figure 32 illustrates results from the VT-high condition, and Figure 33 illustrates results from the VI-low condition. Test series is listed across each *x*-axis, with data illustrating (from left to right) data from the first three test series (from the initial test phase), followed by the second three-test series (from the reversal).

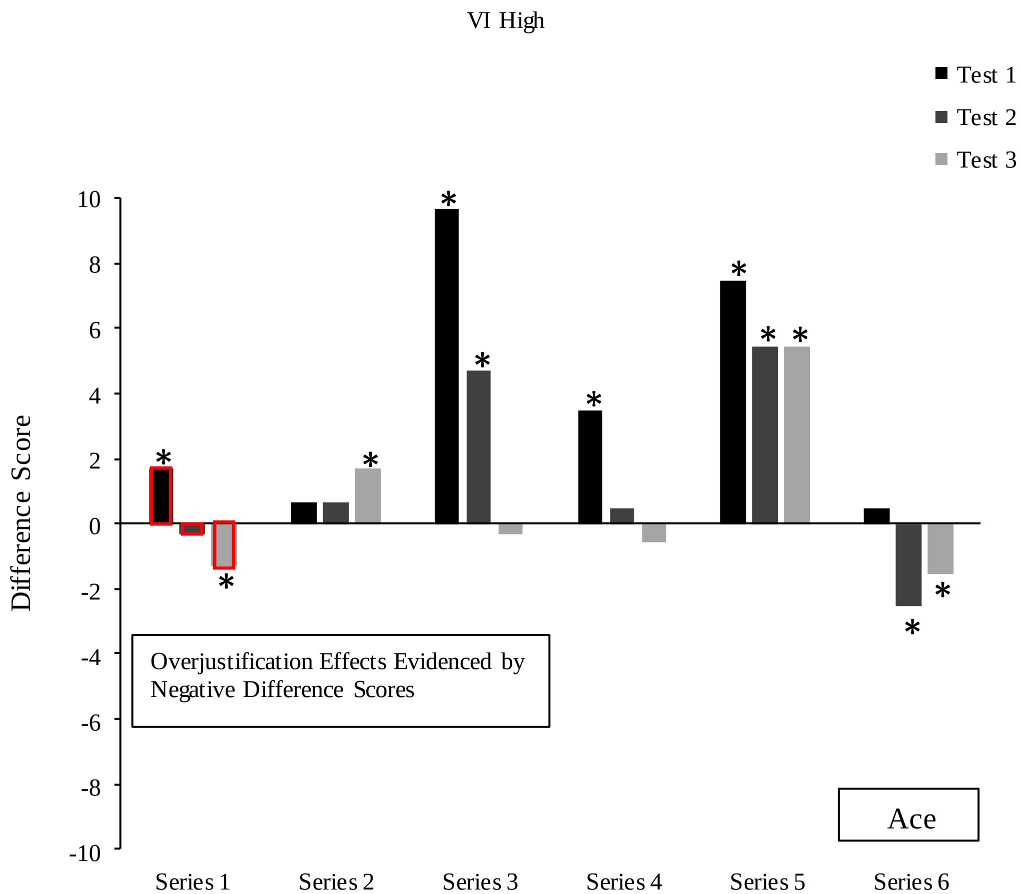

Figure 31. Component-by-component difference scores during the VI high condition for Ace. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

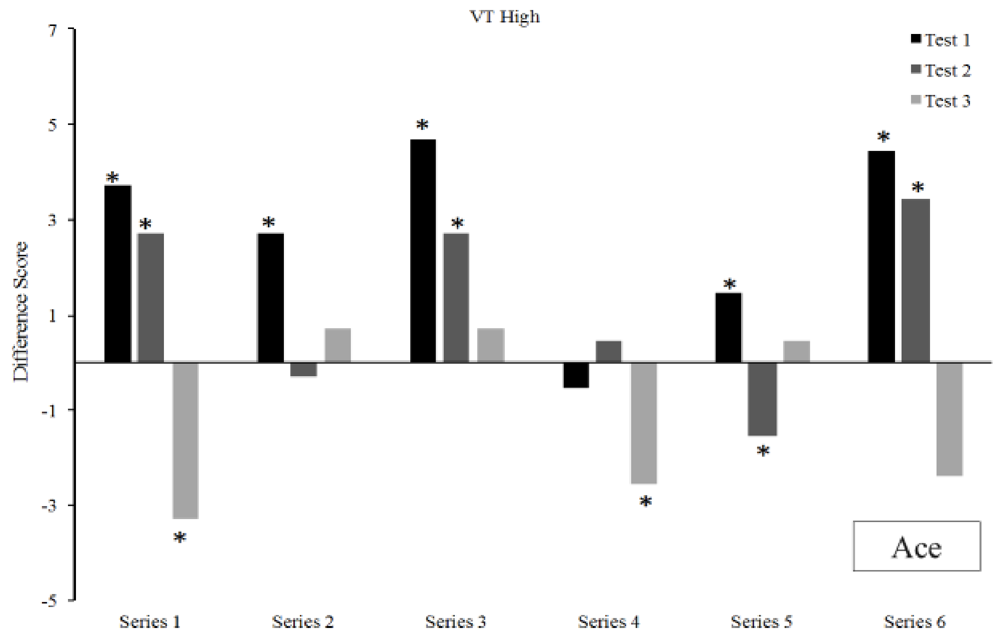

Figure 32. Component-by-component difference scores during the VT high condition for Ace. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

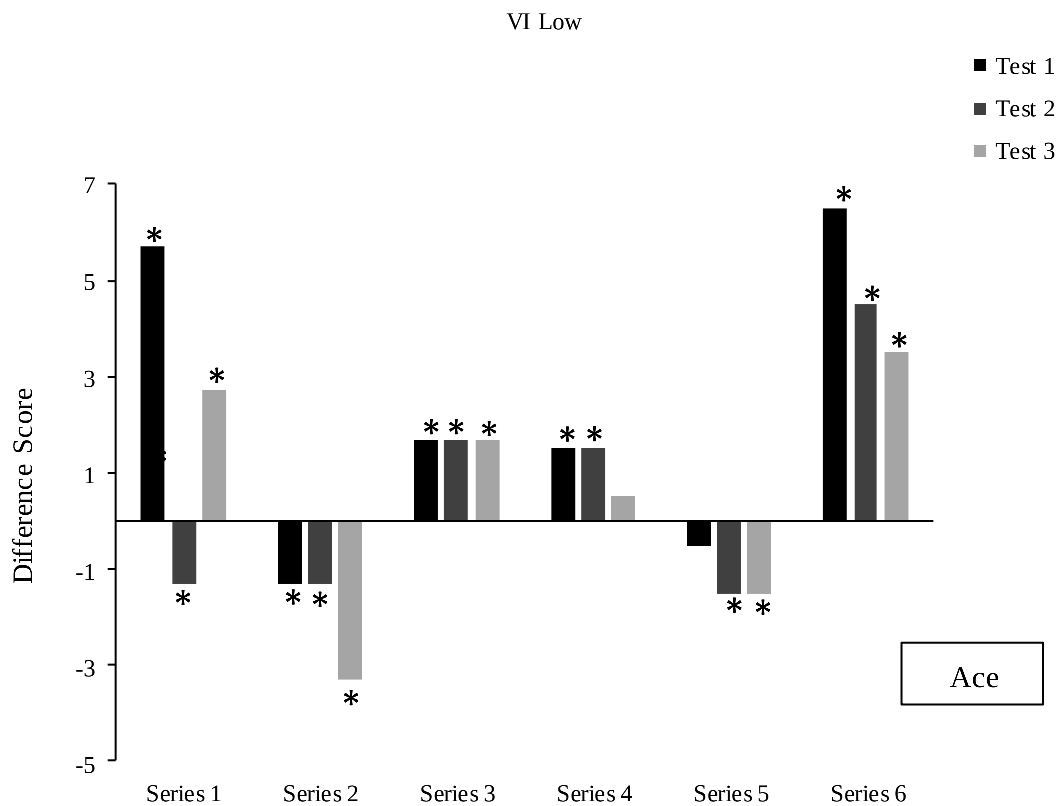

Figure 33. Component-by-component difference scores during the VI low condition for Ace. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

During the VI high condition, improvement effects were observed for 8 of 18 test components and overjustification effects were observed during 3 of 18 components. No effects were observed in 7 test components. During the VT high condition, improvement effects were observed during 8 of 18 test components, overjustification effects were observed in 4 of 18 components, and no effects were observed during 6 components. During the VI low condition, improvement effects were observed during 10 of 18 test components, overjustification effects were observed in 6 of 18 components, and no effects were observed during 2 components.

Figure 34 illustrates mean difference scores across all components and phases within the VI high condition (black bar, *M* = 1.92), the VI low condition (dark grey bar, *M* = 1.15), and the VT high condition (light grey bar, *M* = 0.92) for Ace. Mean difference scores were compared to the standard deviation across both baseline phases (*SD* = 1.29) and indicated mean improvement effects within the VI high condition.

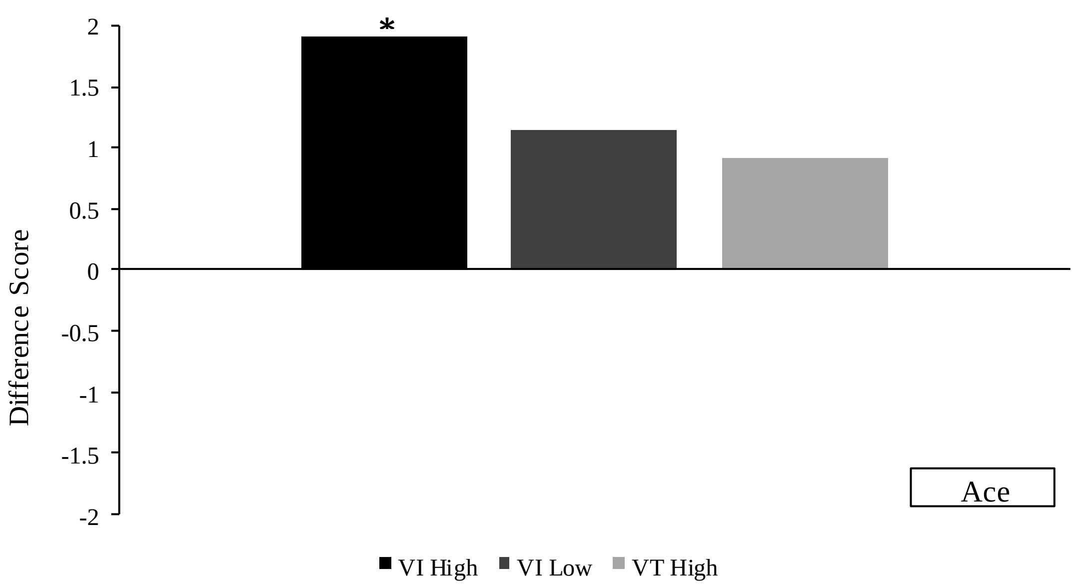

Figure 34. Mean difference scores during the VI high condition (black bar), VI low condition (dark grey bar), and VT (yoked) high condition (light grey bar) for Ace. The asterisk denotes mean difference scores with absolute values greater than the standard deviation across both baseline phases (indicative of overjustification effects or improvement effects).

Figures 35 through 37 depict the results of the overjustification analysis by test component for Elliot. Figure 35 illustrates results from the VI-high condition, Figure 36 illustrates results from the VT-high condition, and Figure 37 illustrates results from the VI-low condition. During the VI high condition, improvement effects were observed for 5 of 18 test components and overjustification effects were observed during 4 of 18 components and no effects were observed during 9 of 18 components. During the VT high condition, improvement effects were observed during 8 of 18 test components and overjustification effects were observed in 8 of 18 components and no effects were observed during 2 of 18 components. During the VI low condition, improvement effects were observed during 8 of 18 test components, overjustification effects were observed in 6 of 18 components, and no effects were observed in 4 components.

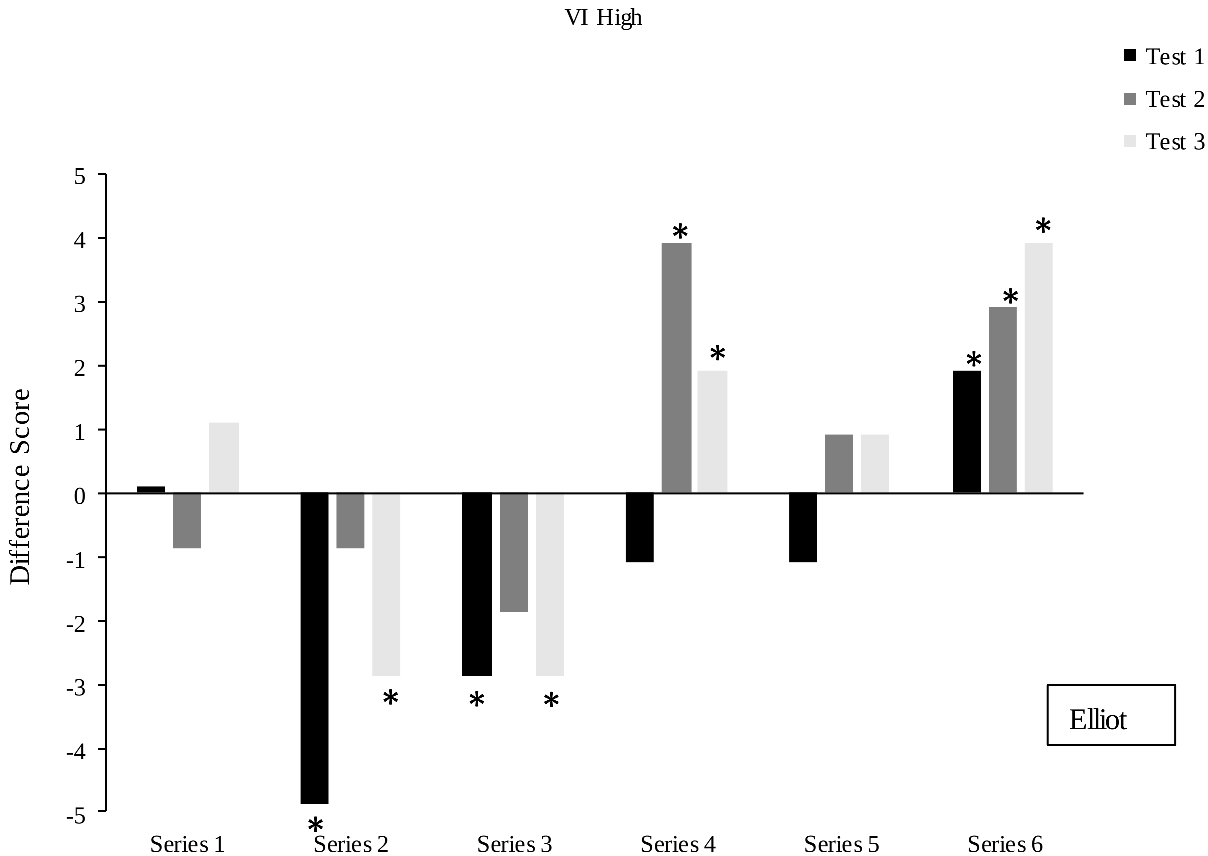

Figure 35. Component-by-component difference scores during the VI high condition for Elliot. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

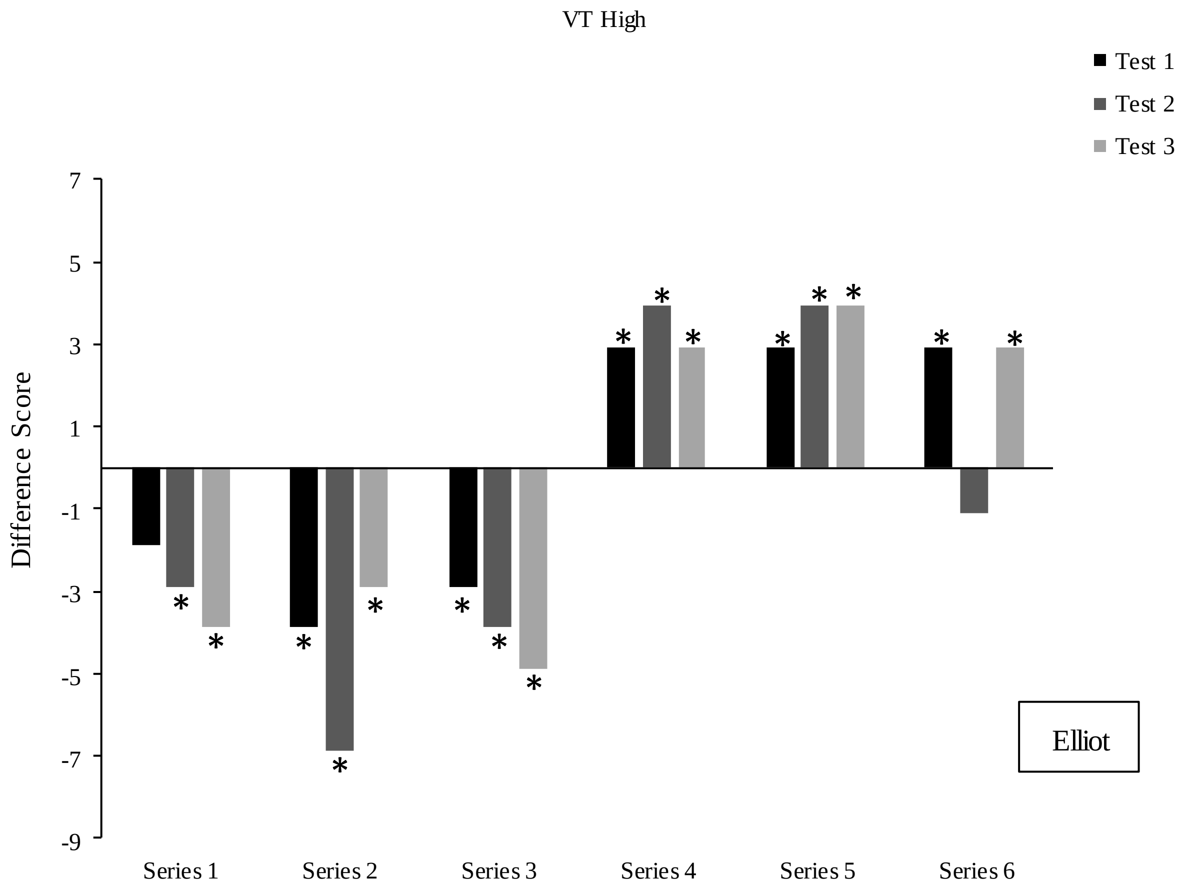

Figure 36. Component-by-component difference scores during the VT high condition for Elliot. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

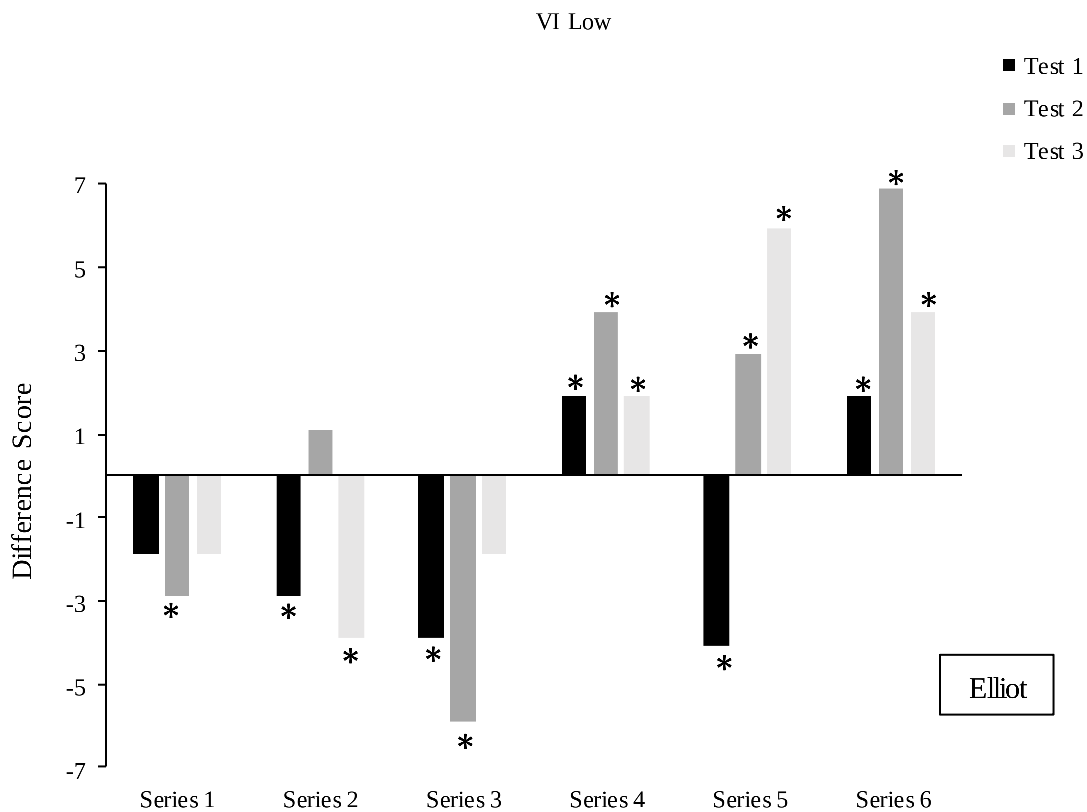

Figure 37. Component-by-component difference scores during the VI low condition for Elliot. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

Figure 35 illustrates mean difference scores across all components and phases within the VI high condition (black bar, $M = 0.09$), the VI low condition (dark grey bar, $M = 0.08$), and the VT high condition (light grey bar, $M = - 0.48$) for Elliot. Mean difference scores were compared to the standard deviation across both baseline phases (SD = 1.25). Mean results indicated no overjustification effects or improvement effects for any condition.

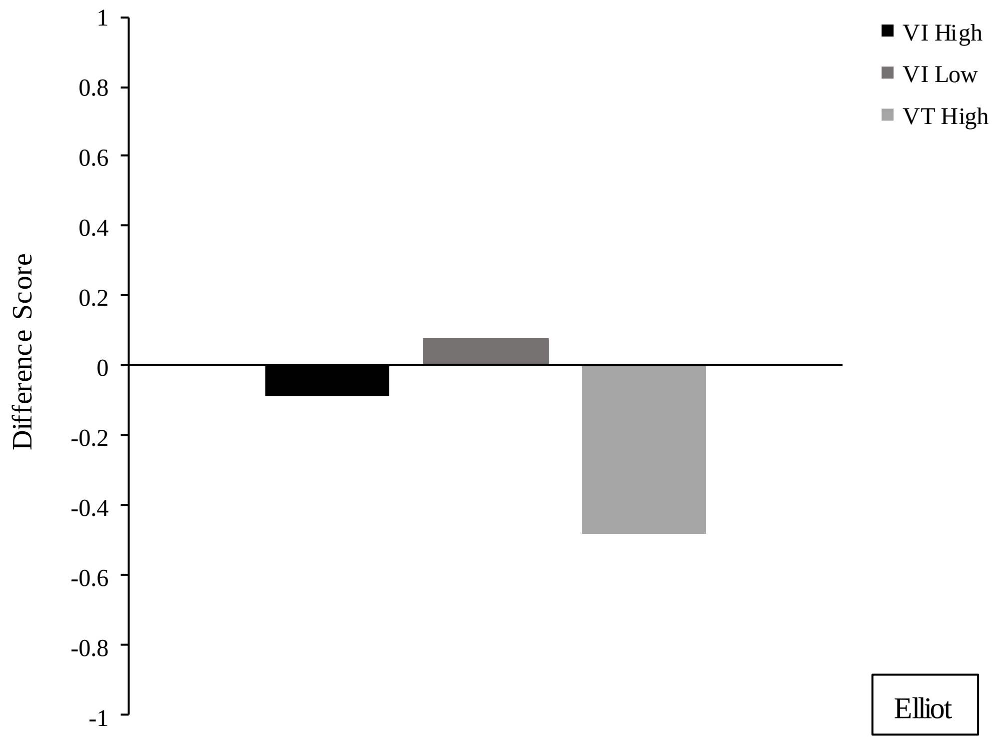

Figure 38. Mean difference scores during the VI high condition (black bar), VI low condition (dark grey bar), and VT high condition (light grey bar) for Elliot. When present, asterisks denote mean difference scores with absolute values greater than the standard deviation across both baseline phases.

Figures 39 through 41 illustrate the results of the overjustification analysis by test component for Laila. Figure 39 illustrates results from the VI-high condition, Figure 40 illustrates results from the VT-high condition, and Figure 41 illustrates results from the VI-low condition. During the VI high condition, improvement effects were observed for 11 of 18 test components, overjustification effects were observed during 1 of 18 test components, and no effects were observed during 6 of 18 components. During the VT high condition, improvement effects were observed during 17 of 18 test components and no effects were observed during 1 of 18 components. No overjustification effects were observed. During the VI low condition, improvement effects were observed during 15 of 18 test components, no effects were observed during 2 of 18 test components, and overjustification effects were observed in 1 of 18 components.

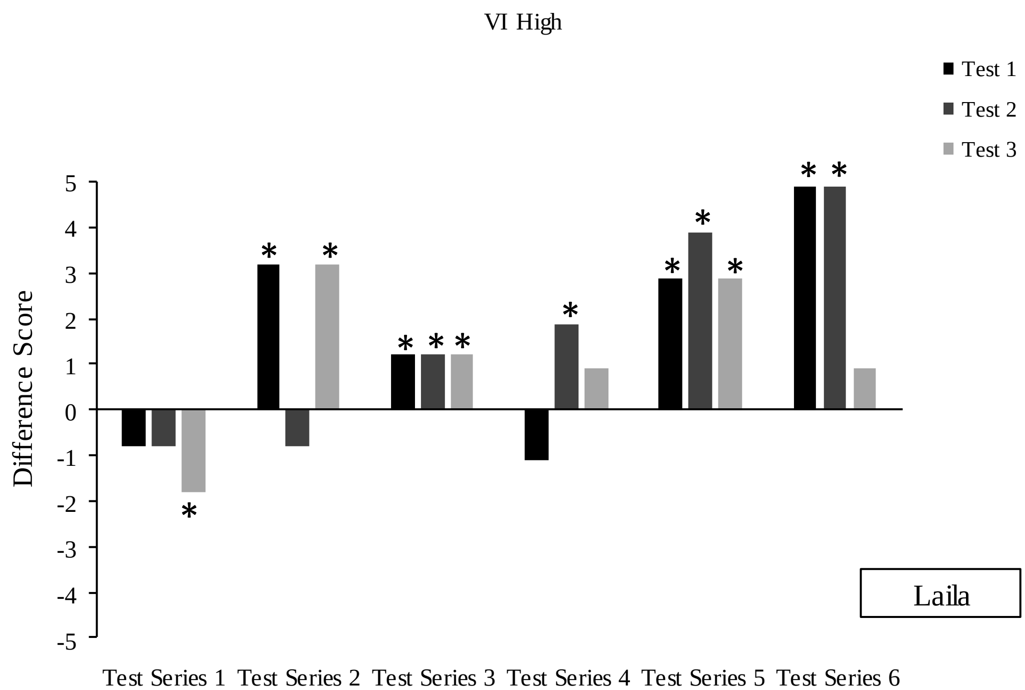

Figure 39. Component-by-component difference scores during the VI high condition for Laila. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks

denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

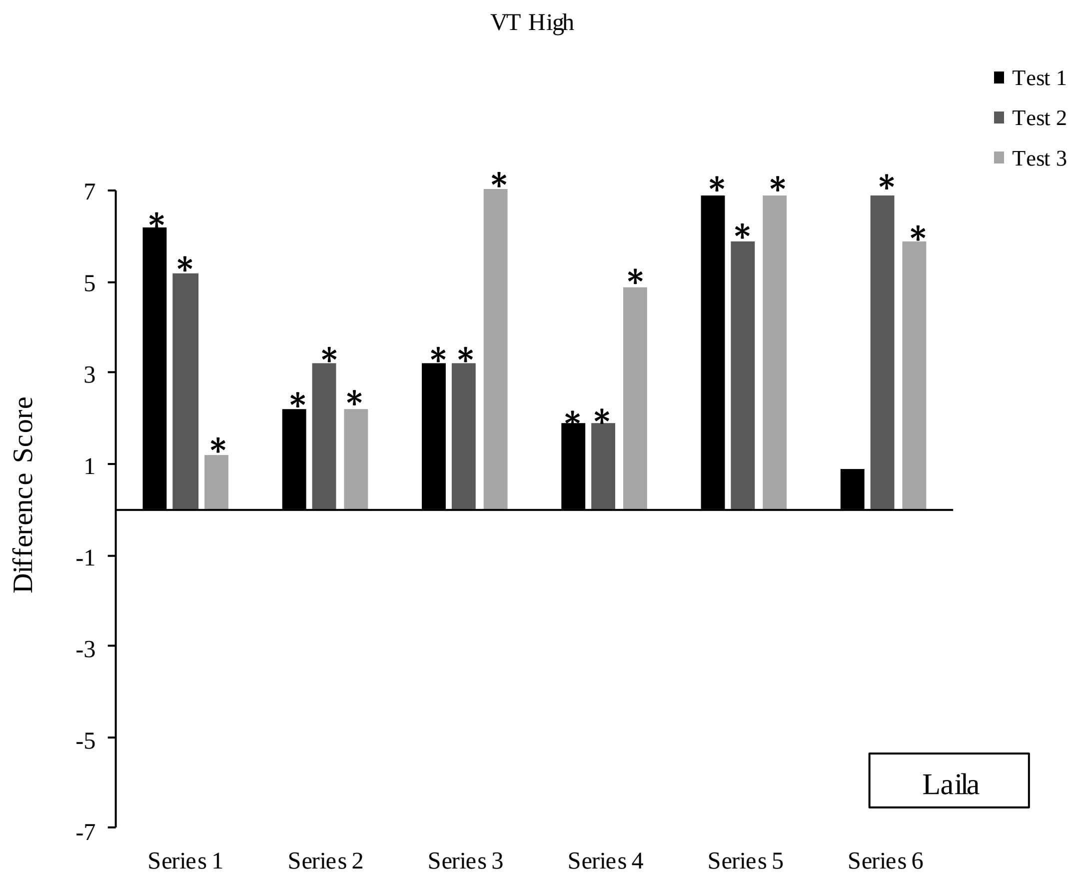

Figure 40. Component-by-component difference scores during the VT high condition for Laila. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

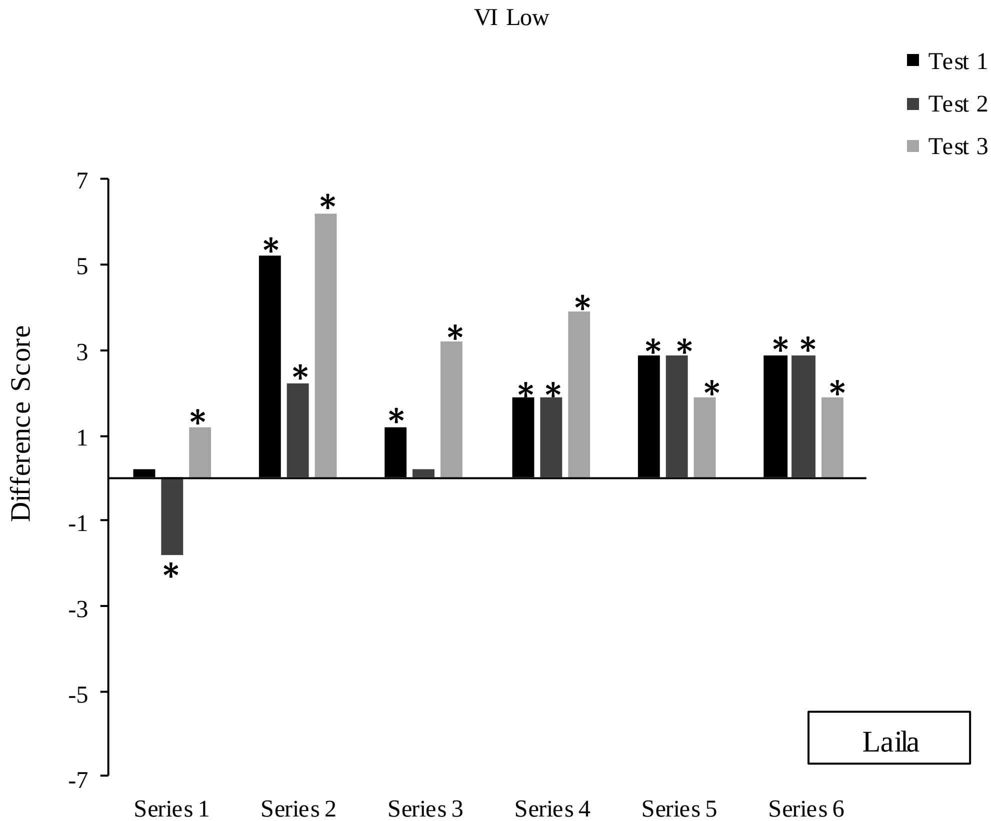

Figure 41. Component-by-component difference scores during the VT high condition for Laila. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

Figure 42 illustrates mean difference scores across all components and phases within the VI high condition (black bar, *M* = 1.55), the VI low condition (dark grey bar, *M* = 2.27 and the VT high condition (light grey bar, *M* = 4.21) for Laila. Mean difference scores were compared to the standard deviation across both baseline phases (SD = 1.94) and indicated mean improvement within the VI low and VT high conditions.

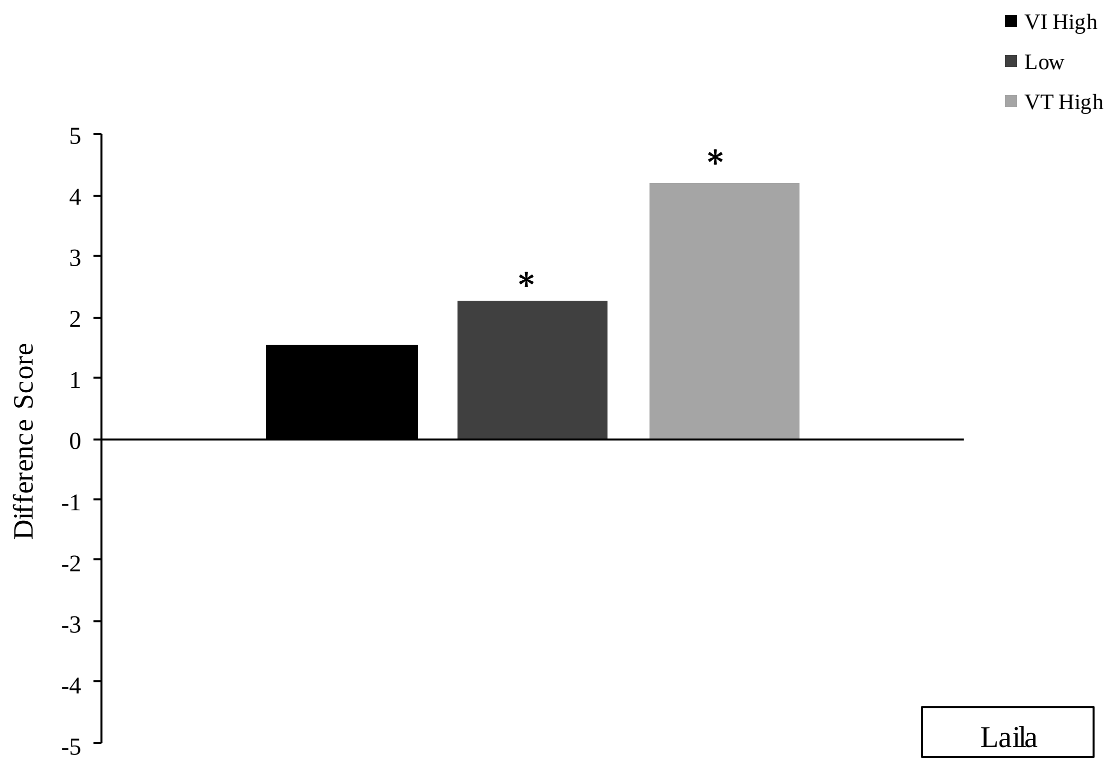

Figure 42. Mean difference scores during the VI high condition (black bar), VI low condition (dark grey bar), and VT (yoked) high condition (light grey bar) for Laila. Asterisks denote mean difference scores with absolute values greater than the standard deviation across both baseline phases.

Figures 43 through 45 illustrate the results of the overjustification analysis by test component for Annie. Figure 43 illustrates results from the VI-high condition, Figure 44 illustrates results from the VT-high condition, and Figure 45 illustrates results from the VI-low condition. During the VI high condition, improvement effects were observed for 6 of 18 test components and no effects were observed in 12 of 18 components. No overjustification effects were observed. During the VT high condition, improvement effects were observed during 10 of 18 test components and no effects were observed in 8 of 18 components. No overjustification effects were observed. During the VI low condition, improvement effects were observed during 11 of 18 test components, no effects were observed in 6 of 18 components, and overjustification effects were observed in 1 of 18 components.

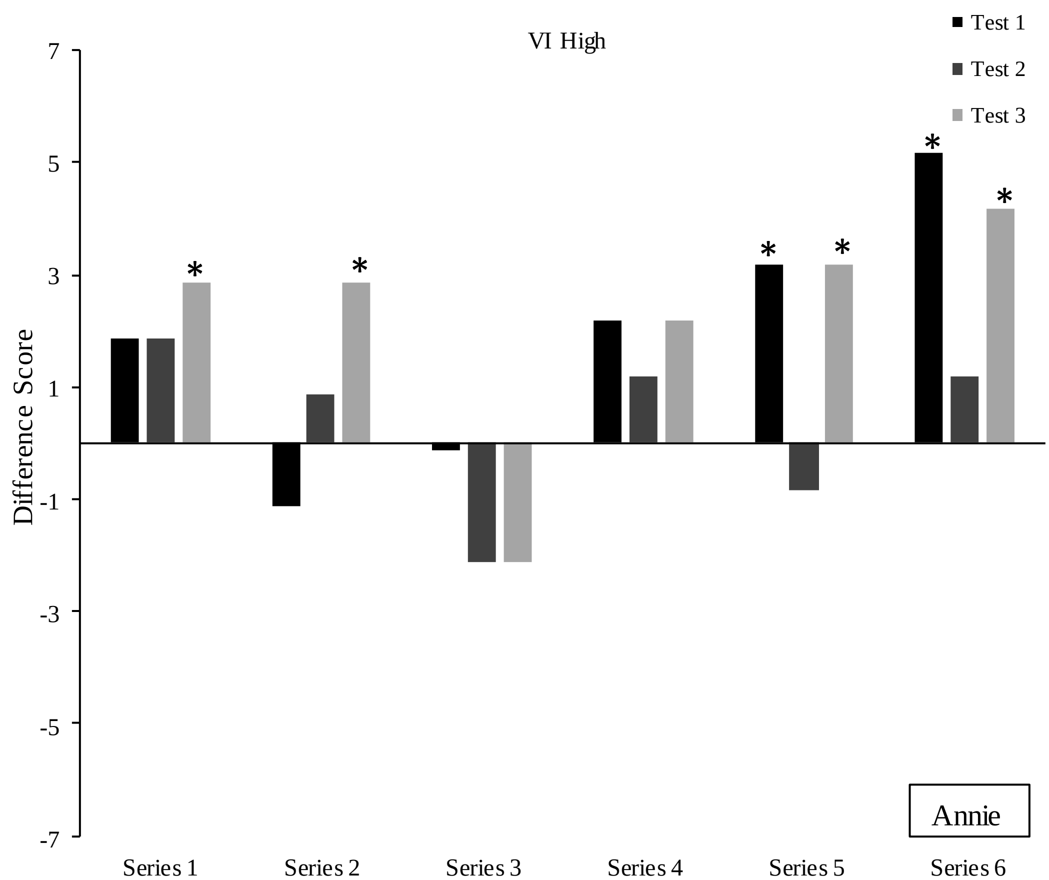

Figure 43. Component-by-component difference scores during the VI high condition for Annie. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

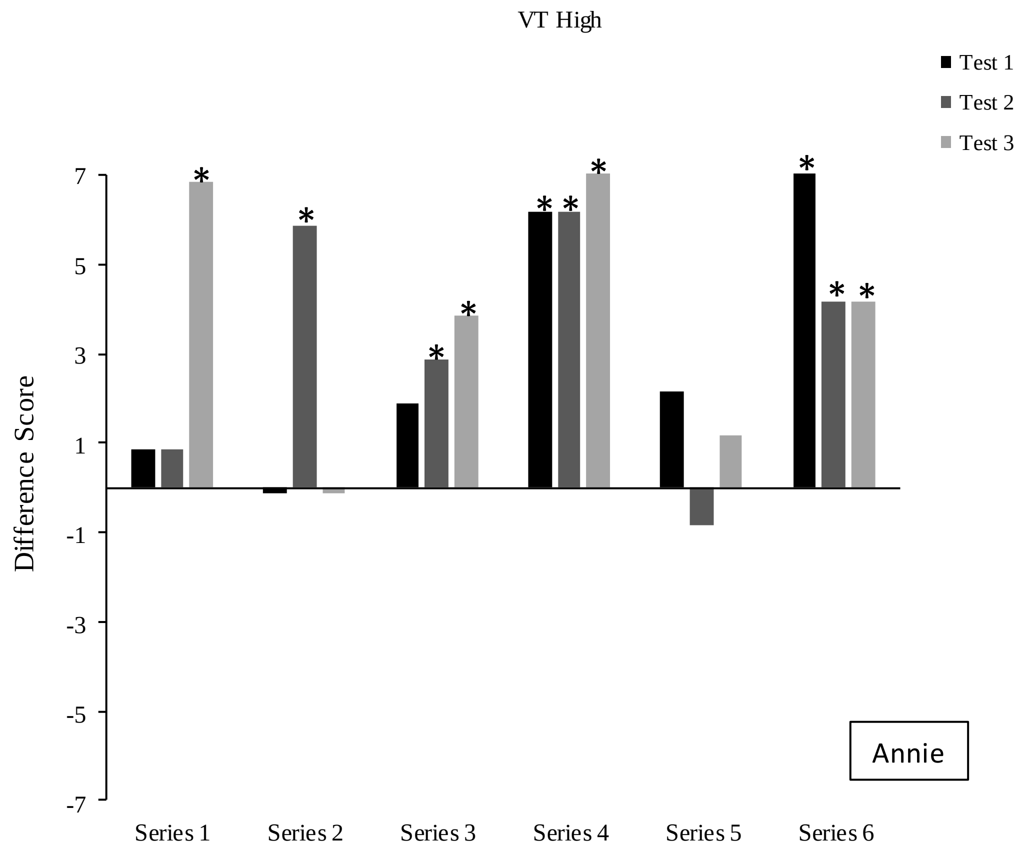

Figure 44. Component-by-component difference scores during the VT high condition for Annie. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

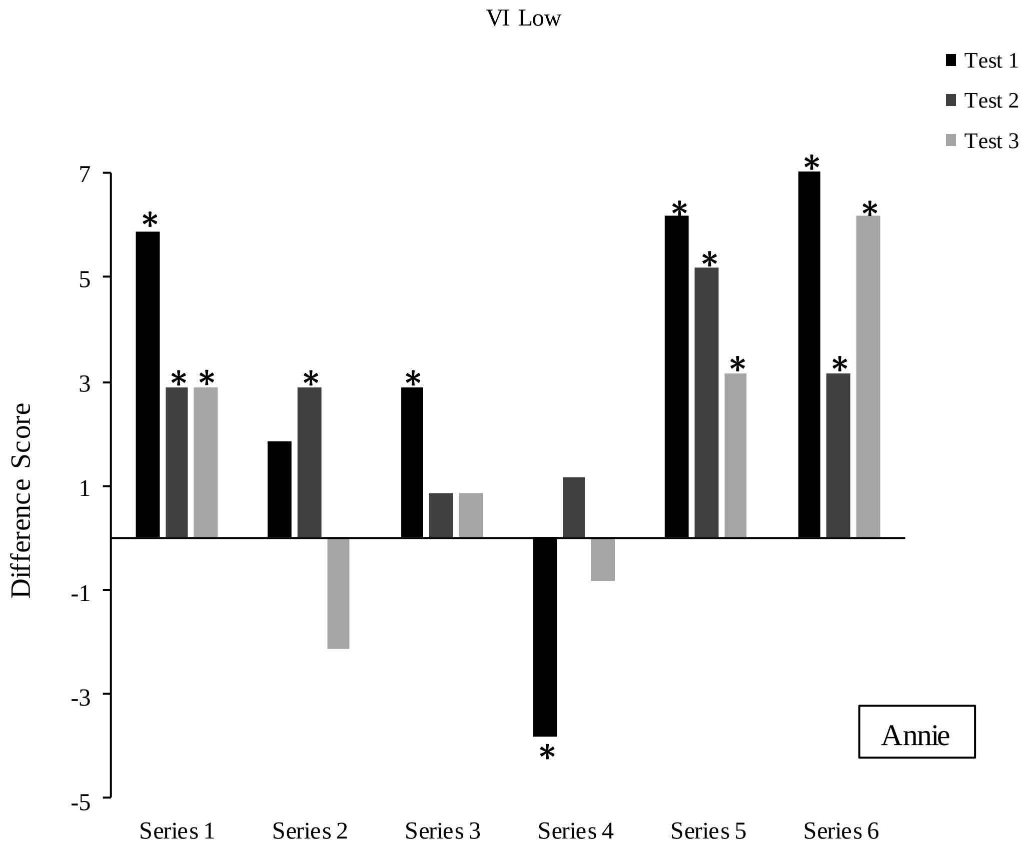

Figure 45. Component-by-component difference scores during the VI low condition for Annie. Black bars denote difference scores from the first test component of each series, dark grey bars from the second, and light grey bars from the third. Asterisks denote difference scores with absolute values greater than the standard deviation from baseline (indicative of overjustification or improvement effects).

Figure 46 illustrates mean difference scores across all components and phases within the VI high condition (black bar, M = 2.59), the VI low condition (dark grey bar, M = 3.82 and the VT high condition (light grey bar, M = 4.59) for Annie. Mean difference scores were compared to the standard deviation across both baseline phases (*SD* = 2.65) and indicated mean improvement effects within the VI low and VT high conditions.

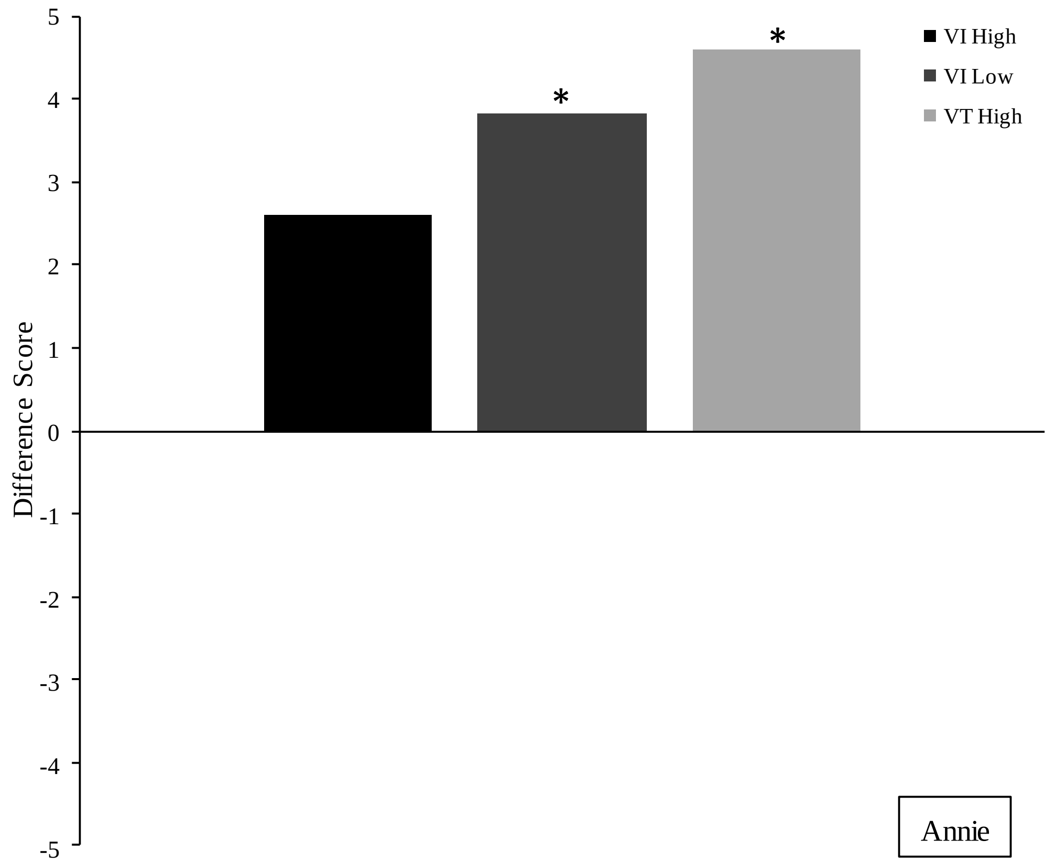

Figure 46. Mean difference scores during the VI high condition (black bar), VI low condition (dark grey bar), and VT high condition (light grey bar) for Annie. When present, asterisks denote mean difference scores with absolute values greater than the standard deviation across both baseline phases.

Additional Overjustification Analysis

The overjustification evaluations above involve calculations of differences scores to compare pre- and post-reward responding for each participant (i.e., post-reward responding minus pre-reward responding). Proportional measures may control for individual differences in pre-reward responding, allowing for a comparison of overjustification effects and improvement effects across participants. Figure 47 illustrates the results of individual differences scores for each participant, converted to proportions to allow for this comparison.

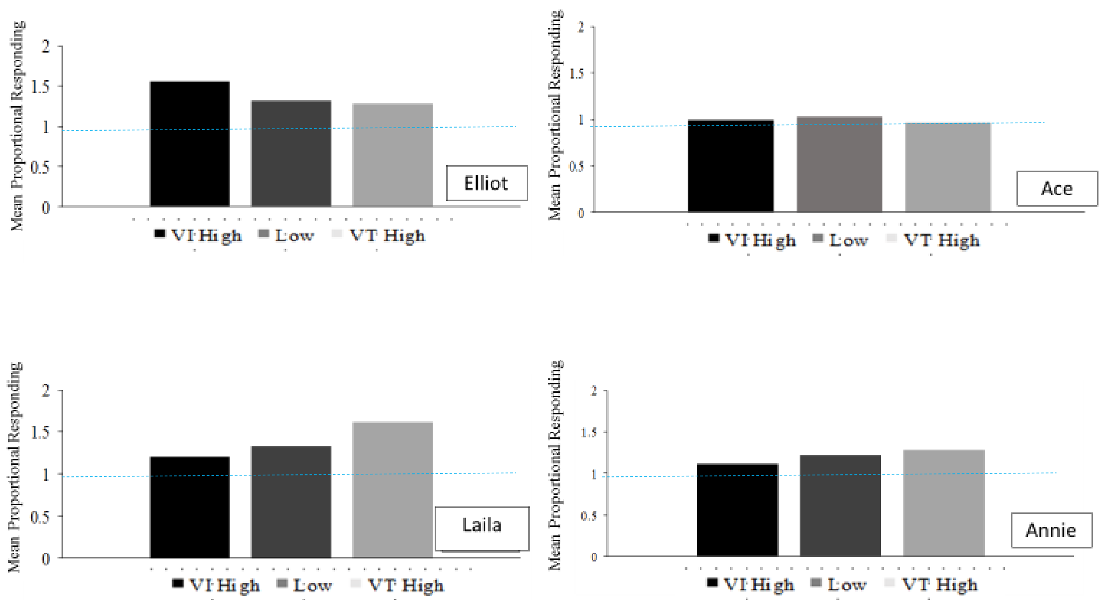

Figure 47. Mean proportional responding (post reward frequency divided by pre-reward frequency) during the VI High Condition (black bars) VI Low Condition (dark grey bars) and the VT High Condition (light gery bars). Scores above the dotted lines designate a mean increase from pre- to post- reward, whereas scores below the line denote mean a decrease.

Results indicate that during the VI High Condition, mean proportional improvement effects were similar for Ace, Laila, and Annie, whereas a relatively higher mean proportional improvement effect was observed for Elliot. During the VI

Low Condition, mean proportional improvement effects were similar across all participants. During the VT High Condition, mean proportional improvement effects were similar for Elliot, Ace, and Annie, whereas a relatively higher mean proportional improvement effect was observed for Laila.

Behavioral Persistence

Behavioral persistence was measured as in Experiment 1, comparing the frequency of responding during the no-reward test components within Phase B (Components 3, 4, and 5) to responding during the previous reward component (Component 2) of the same series. Likewise, the same categories of persistence strength were used here to facilitate discussion of the data. These categories are listed for reference in Table 11.

Table 11.

Experiment 2: Categories of Persistence Strength

Value	Strength
= / > 0.90	Very Strong
0.80 – 0.89	Strong
0.70 – 0.79	Moderately Strong
0.60 – 0.69	Moderately Weak
0.50 – 0.59	Weak
< 0.50	Very Weak

Figures 48 through 50 illustrate the results of the persistence analysis by test component for Ace. During the VI high condition (Figure 48), persistence during the first test component of any series was very strong to strong, often preceded by progressively weaker responding in subsequent test components within that series (with a notable exception within the second test series in which all test components produced very strong persistence). Strength varied across test components (range, 0.2 to 2.5).

During the VT high condition (Figure 49), persistence was strong to very strong across components during the first three test series. During the second three test series, persistence was relatively much weaker, but varied in strength from very weak to very strong (range, 0.11 to 4.0). During the VI low condition (Figure 50), persistence varied considerably across test series from very weak to very strong (range, 0.29 to 2.5).

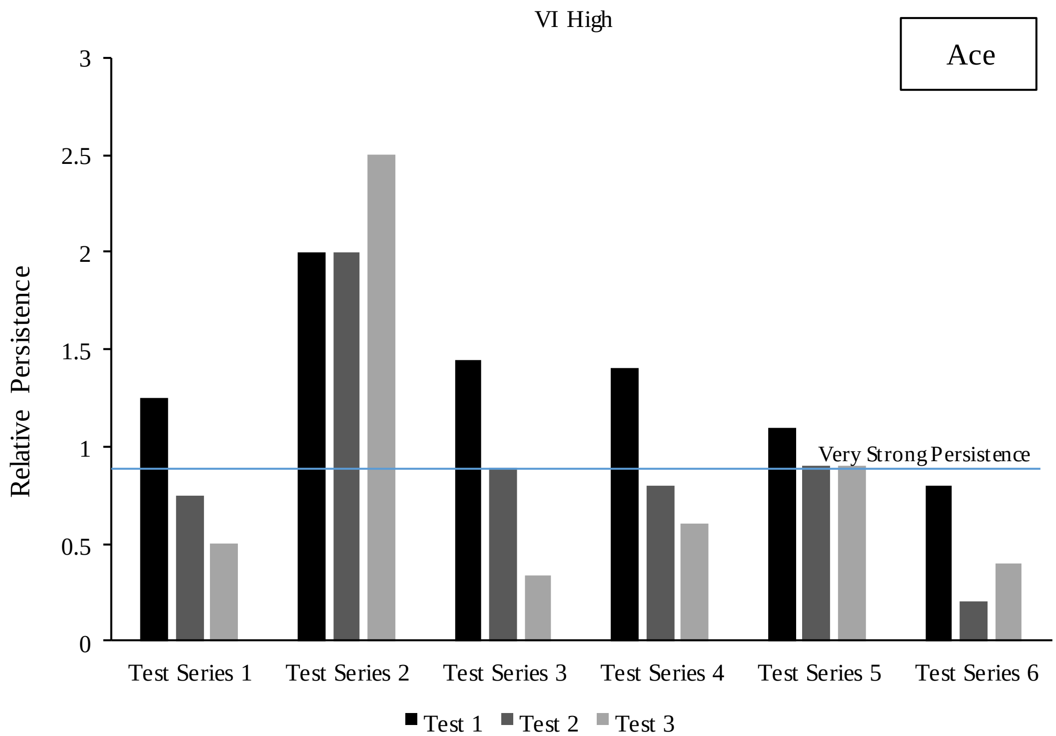

Figure 48. Persistence results for Ace across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

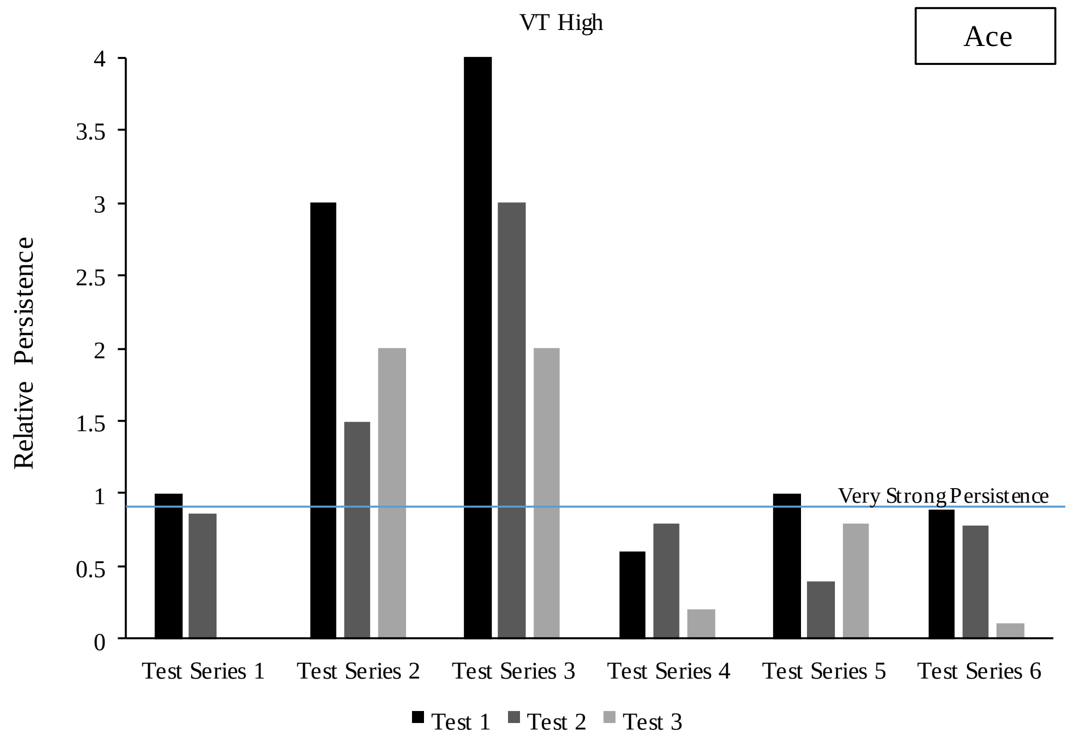

Figure 49. Persistence results for Ace across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VT high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

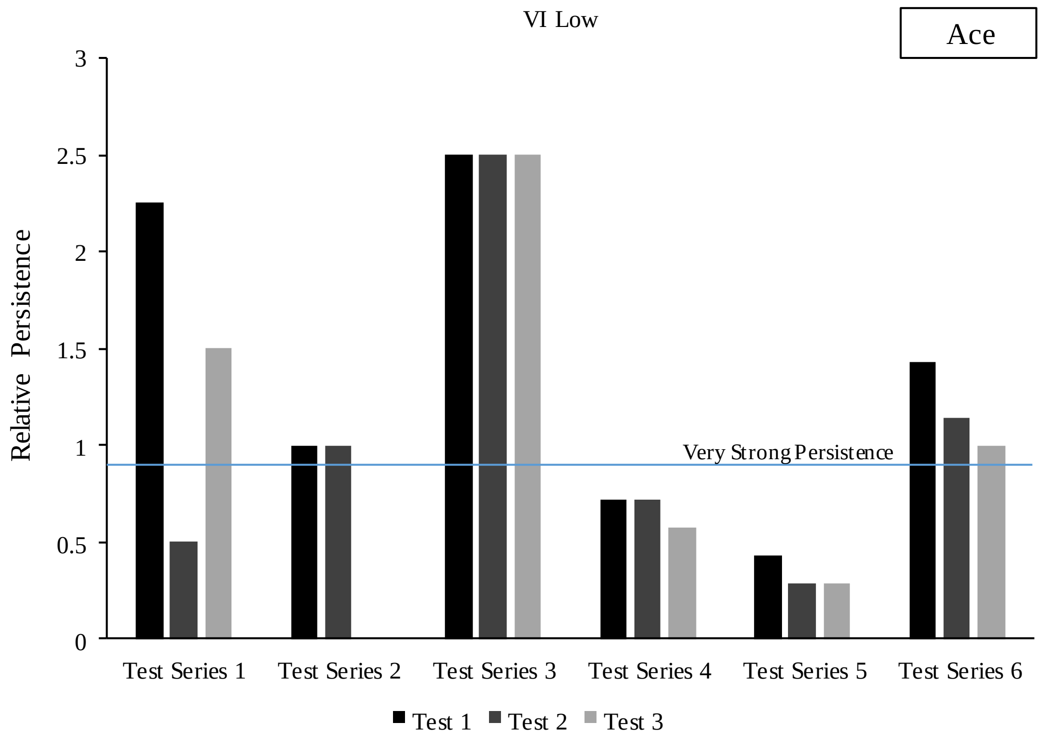

Figure 50. Persistence results for Ace across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI low condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Figure 51 illustrates mean persistence strength (*y*-axis) for Ace across all components within the VI high condition (black bar), VI low condition (dark grey bar) and VT high condition (light grey bar). Results indicate mean persistence was very strong across conditions (M = 1.04 [VI high] M = 1.13 [VI low]; M = 1.27 [VT high]).

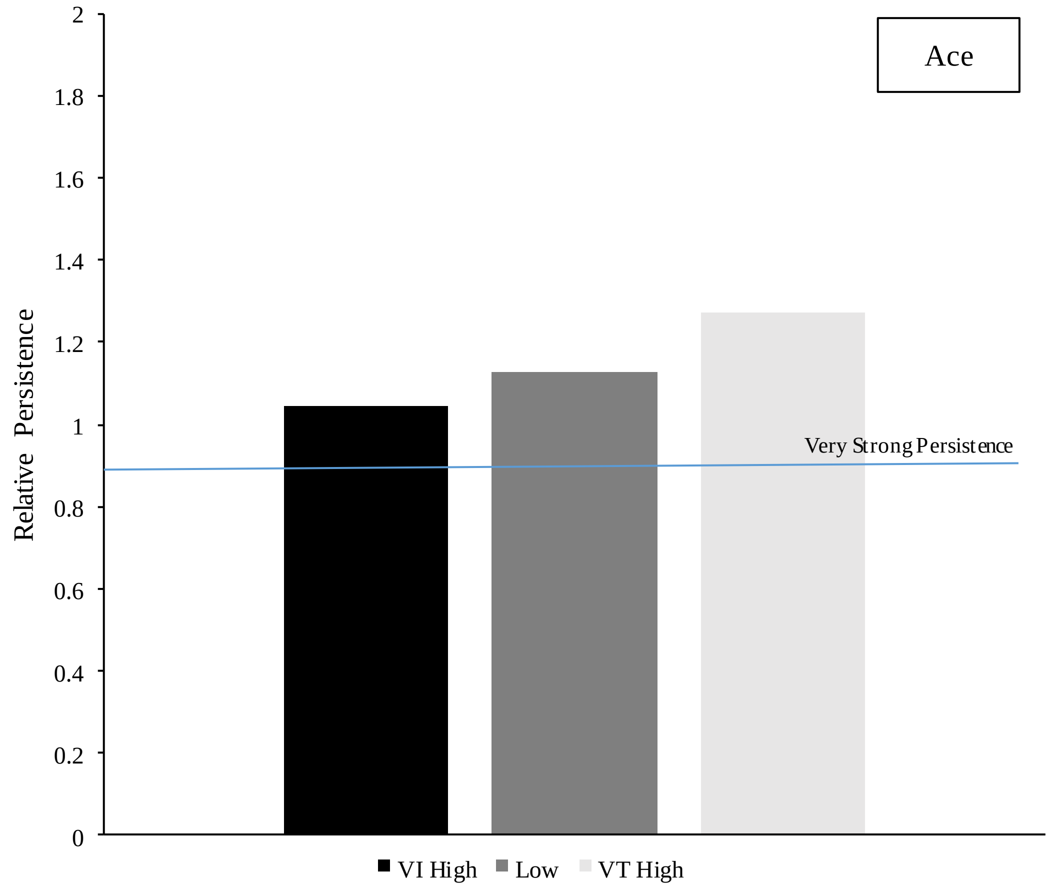

Figure 51. Mean persistence across conditions for Ace (VI high, black bar; VI low, dark grey bar; VT high, light grey bar).

Figures 52 through 54 illustrate results of each test component from Elliot's persistence analysis. During the VI high condition (Figure 52), persistence strength varied from very weak to very strong (range, 0.3 to 1.1), with persistence strength consistently strong or greater with one exception. During the VT high condition (Figure 53), persistence again varied from weak to strong (range, 0.2 to 1.66), though a general (but inconsistent) strengthening effect was obtained over successive test presentations. During the VI low condition (Figure 54), persistence strength varied within and across test series, ranging from very weak to very strong (range, 0.38 to 2.0).

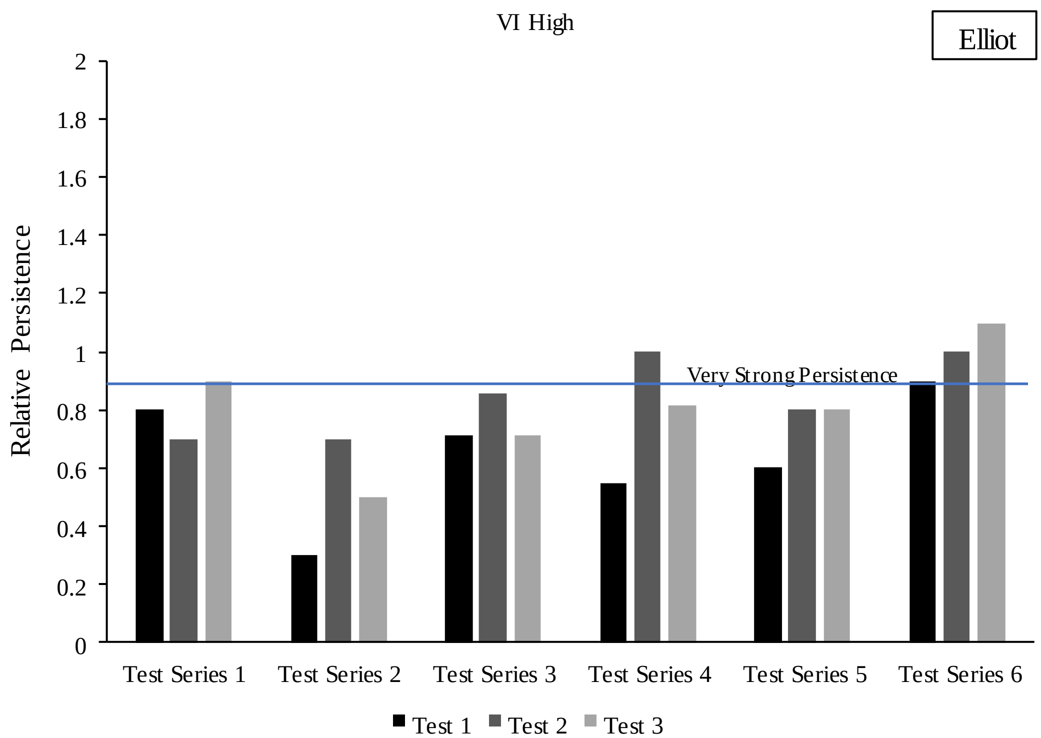

Figure 52. Persistence results for Elliot across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

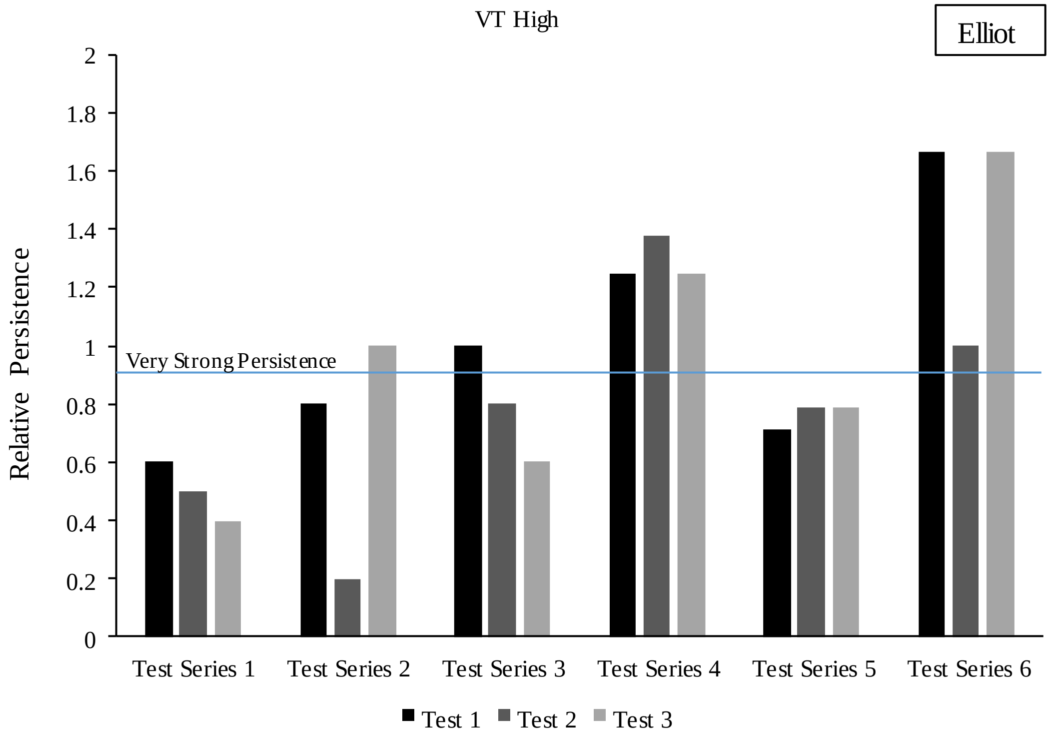

Figure 53. Persistence results for Elliot across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VT high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

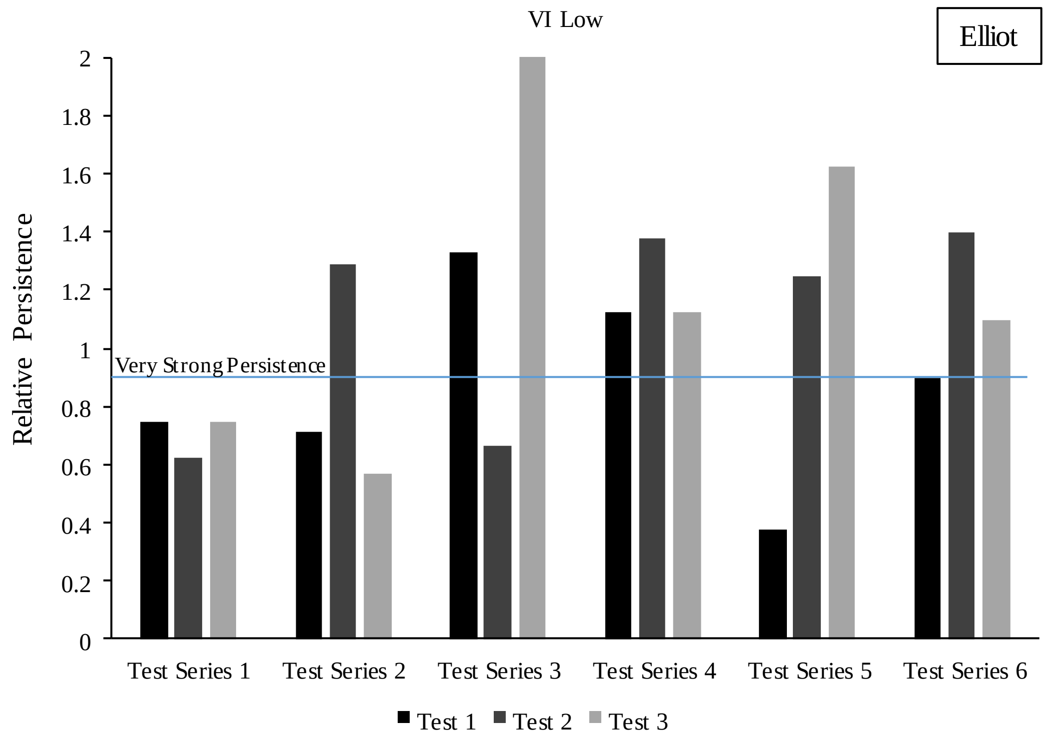

Figure 54. Persistence results for Elliot across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI low condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Figure 55 illustrates mean persistence strength for Elliot across all components within the VI high condition (black bar), VI low condition (dark grey bar) and VT high condition (light grey bar). Results indicate mean persistence was moderately strong to very strong across conditions (M = 0.76 [VI high] M = 1.05 [VI low]; M = 0.91 [VT high]).

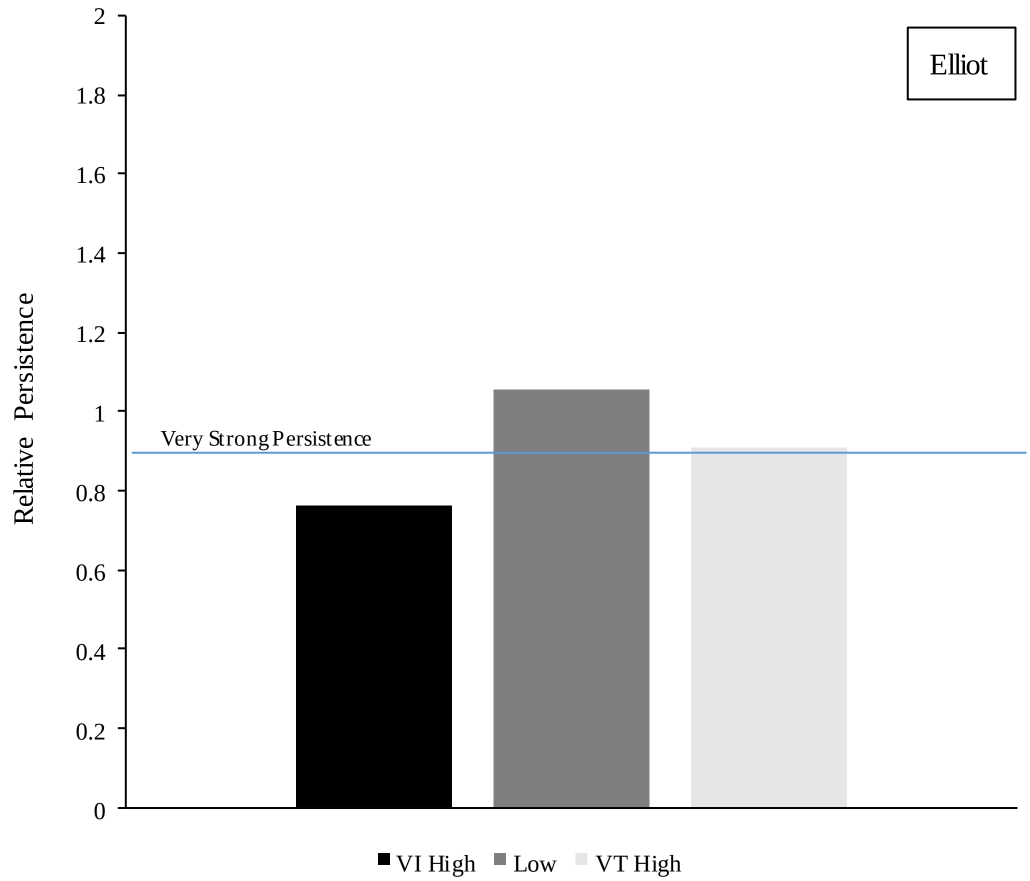

Figure 55. Mean persistence across conditions for Elliot (VI high, black bar; VI low, dark grey bar; VT high, light grey bar).

Figures 56 through 58 illustrate results of each test component of Laila's persistence analysis. During the VI high condition (Figure 56), persistence strength varied from moderately strong to very strong (range, 0.7 to 1.4). During the VT high condition (Figure 57), persistence again varied from moderately strong to very strong (range, 0.7 to 1.4). During the VI low condition (Figure 58), persistence strength varied from very weak to very strong (range, 0.5 to 1.7).

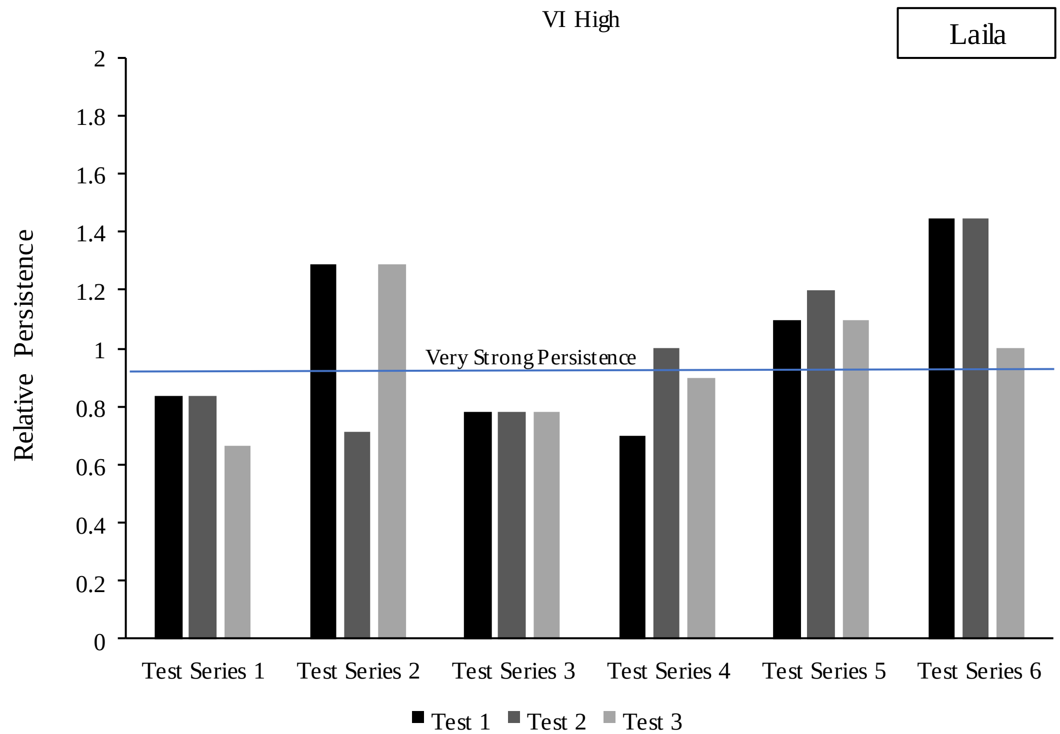

Figure 56. Persistence results for Laila across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

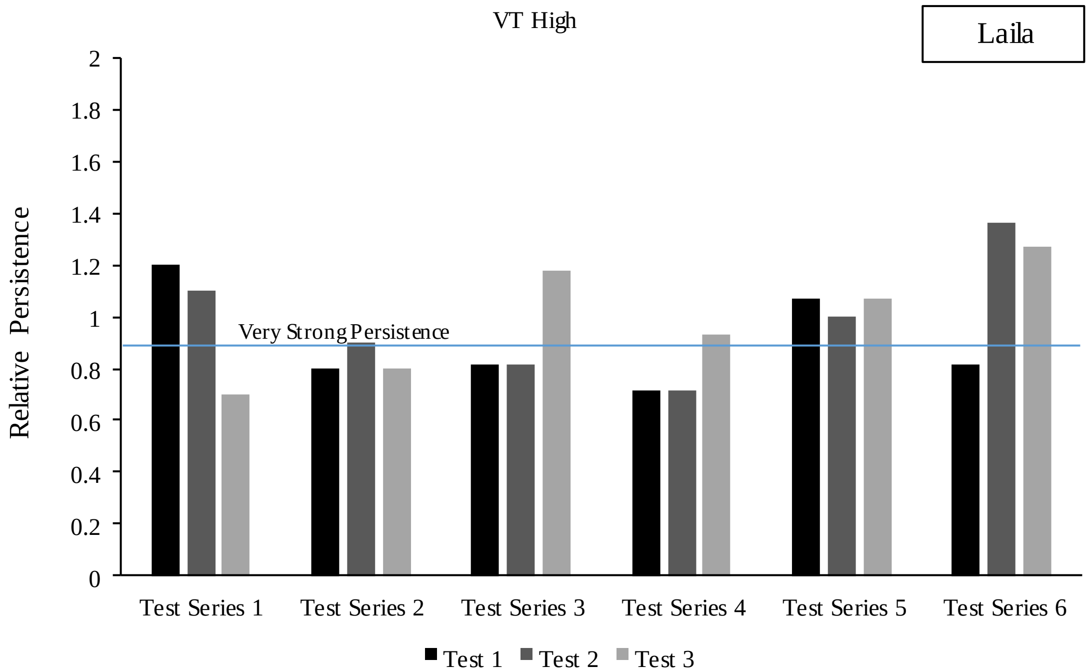

Figure 57. Persistence results for Laila across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VT high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

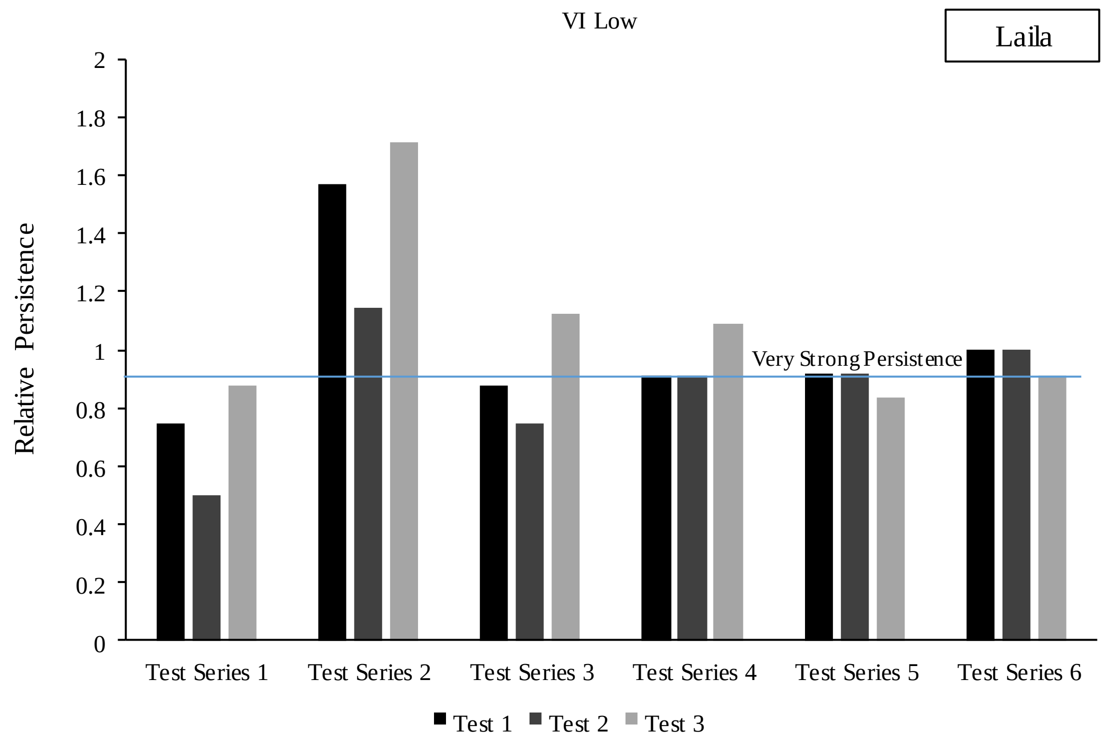

Figure 58. Persistence results for Laila across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI low condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Figure 59 illustrates mean persistence strength for Laila across components in the VI high condition (black bar), VI low condition (dark grey bar), and VT high condition (light grey bar). Results indicate mean persistence was very strong across conditions (M = 0.99 [VI high] M = 0.98 [VI low]; M = 0.96 [VT high]).

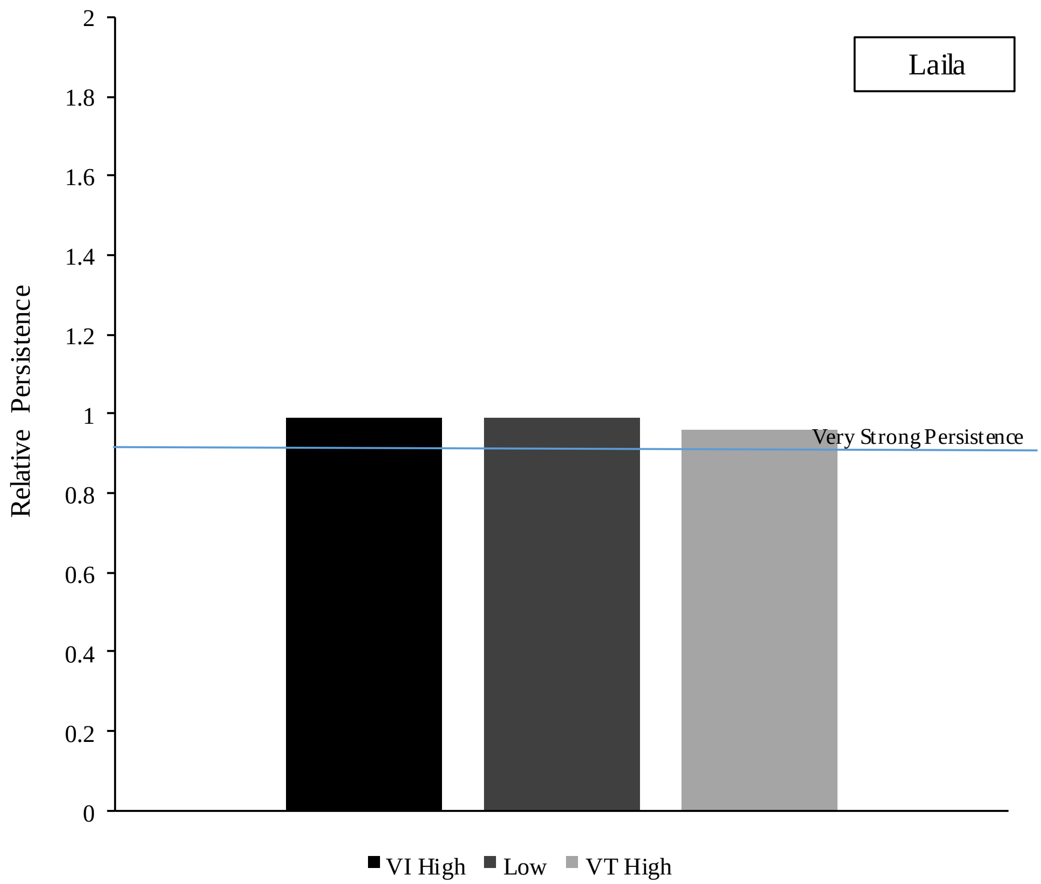

Figure 59. Mean persistence across conditions for Laila (VI high, black bar; VI low, dark grey bar; VT high, light grey bar).

Figures 60 through 62 illustrate results of each test component of Annie's persistence analysis. Data indicate relatively stable persistence across test components in the VI high (Figure 60) and VI low conditions (Figure 61), with persistence strength ranging from moderately strong to very strong in the VI low condition and from moderately weak to very strong in the VI high condition (VI low range, 0.75 to 1.6; VI high range, 0.67 to 1.4). Relatively greater variability was observed across test components within the VT high condition (Figure 62), with persistence strength ranging from moderately weak to very strong (range, 0.61 to 2.14).

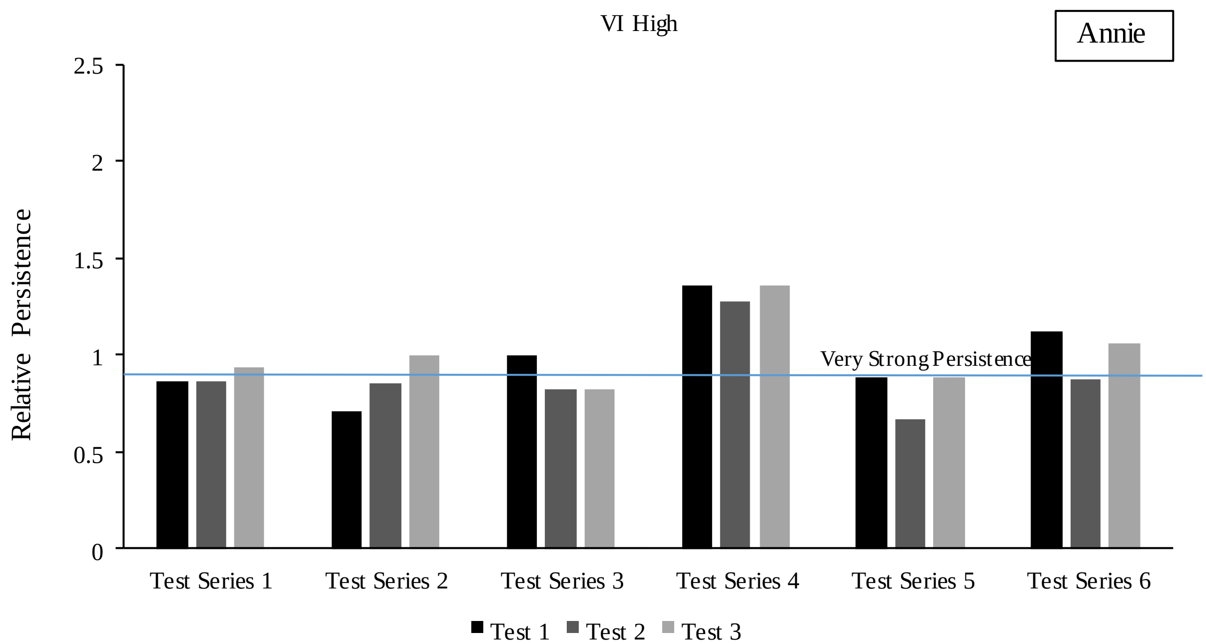

Figure 60. Persistence results for Annie across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

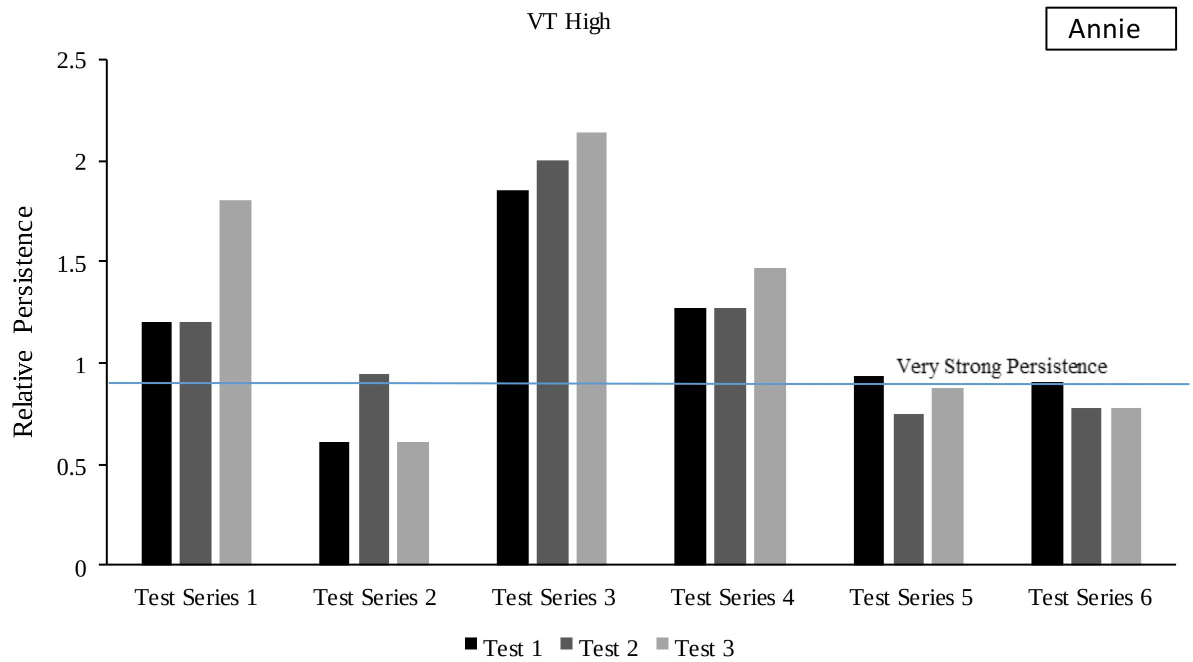

Figure 61. Persistence results for Annie across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VT high condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

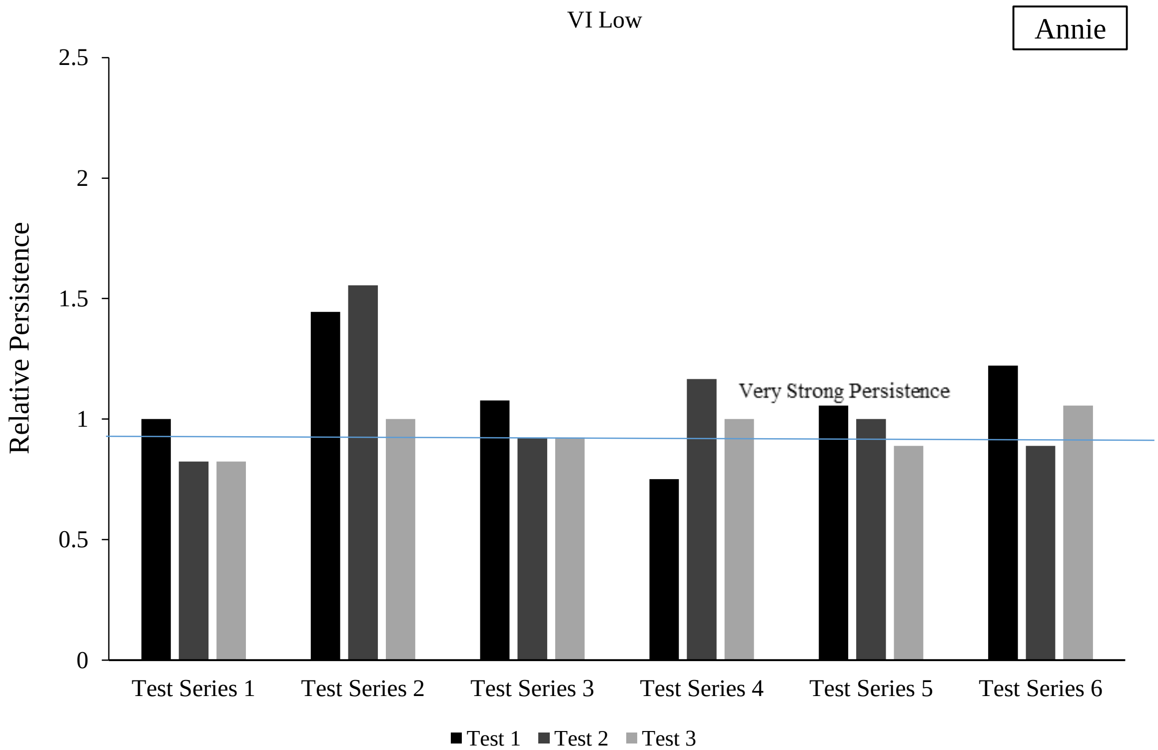

Figure 62. Persistence results for Annie across test components (Test 1, black bar; Test 2 dark grey bar; Test 3, light grey bar) during the VI low condition. Increases in persistence strength (indicated on the *y*-axis) are indicated as values approach 1.0 (indicating 100% response persistence moving from rewarded to unrewarded responding).

Figure 63 illustrates mean persistence strength for Annie across all components within the VI high condition (black bar), VI low condition (dark grey bar) and VT high condition (light grey bar). Results indicate mean persistence was very strong across conditions (M = 0.97 [VI high] M = 1.0 [VI low]; M = 1.2 [VT high]).

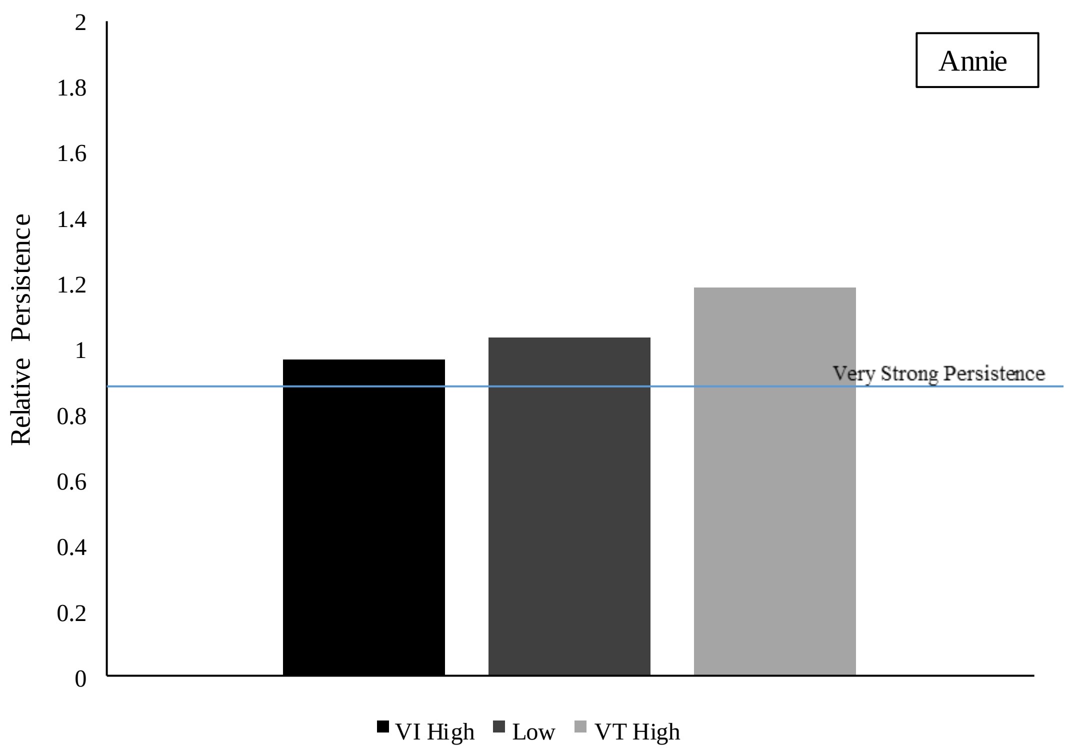

Figure 63. Mean persistence across conditions for Annie (VI high, black bar; VI low, dark grey bar; VT high, light grey bar).

Additional Analyses

Results from Experiment 1 indicated that overjustification effects were generally obtained given relatively weaker or an absence of reinforcement effects (indicating rewards were not functional reinforcers when overjustification effects were obtained). Additional analyses were conducted to determine if a similar finding might be obtained from the data in Experiment 2. To examine this relation, the mean reinforcing efficacy of the individual rewards used for each participant across VI low and VI high conditions was first determined. To do this, the mean rate of responding from the previous baseline was subtracted from the rate of responding observed during each reward component of those conditions. This reflected how much responding increased during each reward period relative to baseline. For example, the mean baseline frequency for Ace was 3.3 during the initial baseline, and he responded 4 times during the first reward component. The reinforcing efficacy of the reward for that component would be 4.0-3.3 = 0.7, indicating a 0.7 increase in responding from the baseline mean to reward. All of the individual scores were then averaged to determine the mean reinforcer efficacy of the stimulus employed for each participant. This was compared to the proportion of tests resulting in overjustification effects across participants.

Figure 64 illustrates the results of this analysis, indicating the mean reinforcing efficacy of rewards used and the total proportion of tests (out of all 54 tests) resulting in overjustification effects for each participant. A general pattern can be observed across participants: stronger mean reinforcer effects (Laila/Annie/Ace) are associated with a relatively smaller proportion of tests resulting in overjustification effects, whereas relatively weaker mean reinforcer effects (Elliot) are associated with a relatively higher proportion of tests resulting in overjustification.

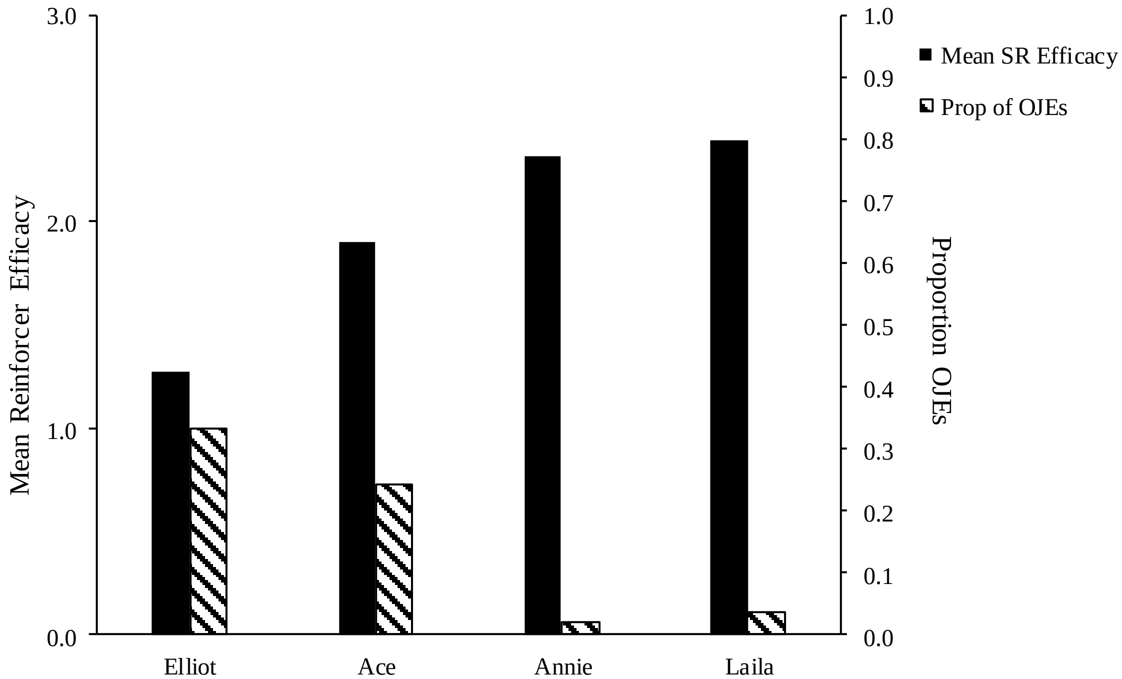

Figure 64. Mean reinforcer efficacy (black bars, primary axis) and proportion of tests resulting in overjustification effects (out of all 54 tests) (striped bars, secondary axis) across participants.

An additional analysis was conducted to examine possible relations between reinforcer efficacy (as determined above) and persistence strength. Figure 65 illustrates the mean reinforcer efficacy across VI low and VI high conditions and the proportion of strong or very strong persistence strength across test components and participants. Lower mean reinforcer effects (Elliot/Ace) are associated with a relatively lower proportion of strong to very strong persistence values, whereas relatively higher mean reinforcer effects (Annie/Laila) are associated with a relatively higher proportion of strong to very strong persistence.

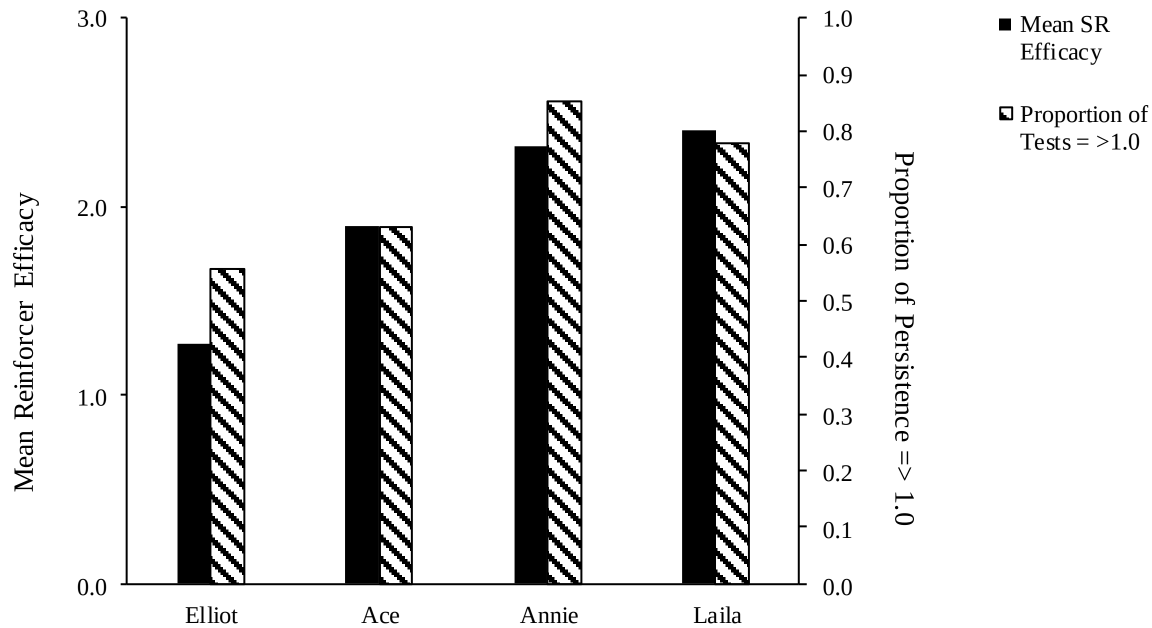

Figure 65. Mean reinforcer efficacy (black bars, primary axis) and the frequency of persistence tests resulting in strong to very strong persistence (=>1.0) (out of all 54 tests) (striped bars, secondary axis) across participants.

Discussion

Experiment 2 aimed to examine the effects of rate of reward on overjustification and behavioral persistence. It was predicted that behavioral persistence would be greater in the conditions employing relatively higher rates of reward (VI and VT high) and lower in the condition with relatively lower rates of reward (VI low). Relatedly, it was predicted that overjustification effects would be less likely in conditions with higher rates of reward, relative to those with lower rates. Results did not conform to these hypotheses. Collectively, test results indicated improvement effects or no effects occurred much more frequently than overjustification effects across all conditions and participants. An exception can be noted for Elliot, for whom overjustification and improvement effects occurred with nearly equal frequencies.

There were no consistent patterns across participants in relation to the effects of rate of reward on response persistence, which did not indicate any strong effects or patterns of responding associated with any one condition. Generally, persistence was moderate to high across participants and conditions. This runs counter to what is typically reported in basic research, which generally indicates components with relatively higher rates of reward are associated with relatively stronger persistence. Notably, most basic research on momentum has examined responding that is not already occurring at high rates in the absence of reward. These responses are generally highly sensitive to reinforcement; because rates are generally low during baseline, they have more room to "move" during reinforcement (i.e., they are functional reinforcers). In addition, animal behavior is often examined under conditions that are likely to promote the value of the reward (i.e., deprivation). These variables contribute to an increased value of reward and may also contribute to the reward's value in increasing persistence strength. Thus, higher value rewards may produce differences in persistence across components involving different rates of reward (again, regardless of the absolute rates of responding) to a greater extent than rewards of lesser value. By contrast, the conditions of the current studies generally worked against improved value (reinforcer efficacy) of the rewards employed. First, responses within the current study were already occurring at high levels in the absence of reward. Accordingly, they had relatively less room to "move" during periods of reinforcement. Second, there were no procedures analogous to deprivation, often used in basic research to increase reward value (and responding to access those rewards, see Nevin & Grace, 2000). These variables collectively indicate the stimuli here were likely of relatively lesser value. Data support this supposition, indicating that the highest mean value of reinforcer efficacy only produced an increase from baseline of about 2 responses. It is possible that different rates of reward have more effect on persistence when the reward is valuable (as in basic research) and these differences are not as distinct when the rewards are not as valuable (as indicated here). This indicates the possibility that persistence is affected by rate of reward as a function of its reinforcing value in moving from no-reward to reward (to be distinguished from its observed reinforcing efficacy within the reward phase alone). Evidence of this possibility may be exemplified through the results of the additional analyses examining mean reinforcer efficacy across participants, indicating that relatively stronger reinforcers were associated with stronger persistence values.

Results from the reinforcer analysis indicated that greater reinforcer value was associated with fewer occurrences of weak to very weak persistence, and more occurrences of strong to very strong persistence. An opposite effect was observed in relation to reinforcer efficacy and overjustification effects: stronger mean reinforcer effects (Laila/Annie) were associated with a small proportion of tests resulting in overjustification, whereas relatively weaker mean reinforcer effects (Elliot/Ace) were associated with a relatively higher proportion of tests resulting in overjustification effects. This points to the possibility that (a) the reinforcing efficacy of rewards used in studies of overjustification matters and (b) protective effects of reinforcers on overjustification effects may work in part through produced increases in persistence strength.

Chapter 4: General Discussion

Results of Experiment 1 indicated that overjustification effects were more likely in the No-Reward History Condition relative to the Reward-History Condition, but overall were just as likely not to occur as to occur. Results from Experiment 2 generally indicated improvement effects were more frequent than overjustification effects across participants and conditions, apart from Elliot for whom nearly equal frequencies of overjustification effects and improvement effects were obtained. Findings across studies are in line with results from a recent meta-analysis examining 65 data sets involving baseline-reinforcement-baseline designs amenable to examining overjustification effects. Results indicated the mean differences between pre- and post- reward responding did not differ from zero; improvement effects occurred just as frequently as overjustification effects (Levy et al., 2016).

Prior research has shown that stimulus-reward relations govern response persistence in the face of a challenge or disruption, with higher rates of reward associated with stronger persistence values. Results from Experiment 1 suggest that the stimulus-reward associations governing persistence through rate of reward may extend to reward history. With few exceptions, relatively stronger persistence values were associated with the Reward-History Condition relative to the No-Reward History Condition. Accordingly, aggregate reinforcement history may have a similar relation to behavioral persistence as does rate of reinforcement: The current data suggest that longer reinforcement histories, or longer durations of exposure to reinforcement, may produce heightened stimulus-reinforcer associations resulting in stronger persistence values. Further, although results from Experiment 1 indicated overjustification effects occurred just as frequently as improvement effects (across conditions and participants), overjustification effects were more frequent in the No-Reward History Condition relative to the Reward-History Condition indicating the increased persistence strength due to aggregate reward history may have had some protective effects against overjustification effects.

Whereas differences in persistence were often observed across conditions in Experiment 1, differences in persistence were not often observed across conditions in Experiment 2. Importantly, both studies involved the same variables potentially limiting the value of reward (i.e., the use of responses that already occurred at relatively high-levels in the absence of reward and an absence of manipulations to increase the reinforcing value of rewards). It is possible that even under conditions of relatively low reinforcer value, longer exposures to a reinforcement schedule within extended reward histories (as in Experiment 1) may have additive effects. Here, even reinforcers of relatively small value may "add up" over repeated presentations to produce heightened stimulus-reinforcer associations, thus producing strengthened persistence values relative to the No-Reward History Condition. Accordingly, when moderate to high baseline levels of engagement and low reward value preclude substantial differences in persistence through varying rates of reinforcement delivered in a single session, extended reward histories may provide an alternative means to demonstrate differences in persistence.

Results from these studies also provide evidence of another variable that may affect persistence: results indicate that the reinforcing efficacy of rewards may affect response persistence. It is important to note that here we are not referring to the effects of the reward on the *absolute* rate of responding observed during the reward period – past research has repeatedly demonstrated that the rate of reward, not responding, determines persistence. Instead, current data may indicate that the proportional increase in responding from baseline to reward may partly establish the value of the reward in producing strengthening effects in relation to persistence. As Figures 60 and 61 illustrate, larger mean reinforcer values more frequently resulted in strong to very strong persistence values, whereas smaller reinforcer values more frequently resulted in weak to very weak persistence values. Consider two separate, identical multiple schedules with separate reinforcers associated with each arrangement (e.g., Arrangement A: Component 1- VI 3 s [jellybean], Component 2- VI 15 s [jellybean]; Arrangement B: Component 1-VI 3 s [cracker], Component 2- VI 15 s [cracker]). Now consider "jellybean" is much more valuable (preferred) as a reinforcer relative to "cracker" (as identified through separate, independent reinforcer assessments comparing proportional increases in responding from no-reward to reward using these two items under identical reinforcement schedules). In that case, Component 2 of Arrangement A may be associated with stronger persistence values in the face of a challenge to responding relative to Component 2 in Arrangement B.

In Nevin's model of behavioral persistence, the rate or total reinforcement prior to disruption plays a central role in determining response persistence in the face of disruption, regardless of the rate of responding prior to disruption (Nevin, Tota, Torquato, & Shull, 1990). Research has provided extensive evidence of this (for a review see Nevin & Grace, 2000). However, the value or reinforcing efficacy of the stimulus may still matter (again, not in the absolute value of behavior it produces under reinforcement conditions [prior to disruption], but in the proportional change it produces moving from unreinforced responding to reinforced responding). In this way, rate of reward may affect persistence in conjunction with its value as a reinforcer. Further, results from Experiment 1 indicate that persistence may be strengthened by accumulated reinforcement independent of rate of reinforcement. When one of these variables does not strengthen persistence independently on its own, (as when responses already occur at high-levels in the absence of reward, as in the current studies, negating the possibility of robust reinforcer value) it may be that other variables work in conjunction (or in isolation) to increase persistence. Accordingly, persistence may be affected by the interactions of multiple variables: (a) the current value of the activity (as indicated by response levels in the absence of reinforcement), (b) the value, or reinforcing efficacy of the reward (the proportion of change it produces indicated from reinforcement effects using that stimulus) and (c) the rate or total reinforcement provided prior to disruption.

It is also notable that the participants with the most valuable reinforcers (Laila and Annie) not only had the highest frequencies of strong to very strong persistence (Figure 69) but also had the highest frequencies of improvement effects across conditions (Figure 72). Notably, this extended to the VT high condition. This may well illustrate the proposition that the higher value rewards produced the greatest persistence values (perhaps minimizing overjustification effects) even when they were delivered non-contingently (or for “free”), thus highlighting that “value” here does not refer to nor depend upon absolute rates of responding produced by the reward during the reward component. These results are limited; however, they are in contrast to past evidence indicating that overjustification effects are more likely when rewards are delivered regardless of performance (Cameron & Pierce, 2002; Deci, 1971; Lepper, Greene, & Nisbett, 1973). This is feasibly in line with the idea Carton (1996) proposed to account for findings that tangible rewards have been found to produce overjustification effects to a greater extent relative to verbal rewards. He speculated that this may be because tangible rewards are often only delivered one time in a session, whereas verbal rewards are delivered more frequently. The repeated presentations of the verbal rewards may have produced stronger reinforcer effects relative to the single presentation of the tangible reward, perhaps attributing to the discrepancy in overjustification effects across studies using tangible or verbal rewards. The current results point to an additional possibility – repeated presentations of the verbal rewards may have produced stronger persistence strength relative to the single presentation of the tangible reward, potentially mitigating overjustification effects. It follows that rewards that are delivered even for free, but with sufficiently high rates or extended histories, may similarly diminish overjustification effects through added persistence strength as they may have for Laila and Annie. Future studies may examine these variables to better understand the circumstances under which even "free" rewards may (or may not) produce overjustification effects.

Results from Experiment 1 indicate overjustification effects within the Reward-History Condition were relatively more frequent when reinforcement effects were weak or absent during the preceding reward history phase. This result was consistent across participants. Results from Experiment 2 indicated stronger mean reinforcer effects were associated with very few occurrences of overjustification and high frequencies of improvement effects. By contrast, relatively weaker reinforcer effects were associated with relatively more occurrences of overjustification. Results across studies indicate that the reinforcing efficacy of rewards used in studies of overjustification effects matters. This is especially important in light of historic discrepancies in results across cognitive and behavioral research on this phenomenon. Cognitive researchers often find evidence of the phenomenon (Deci & Ryan, 1985; Hagger, & Chatzisarantis, 2011; Ma, Jin, Meng, & Shen, 2014; Rummel & Feinberg, 1988; Wiechman & Gurland, 2009) whereas behavioral researchers do not (Bright & Penrod, 2009; Fisher, 1979; Levy et al., 2016; Peters & Vollmer, 2014). The current results indicate that these differences may stem in part from consistent differences in the reinforcing value of the rewards used across disciplines. Cognitive studies often employ rewards, socially defined to be of value (Deci & Ryan, 1985; Hagger, & Chatzisarantis, 2011), whereas behavioral researchers generally include reinforcers, defined by their strengthening effects on behavior (Bright & Penrod, 2009; Peters & Vollmer, 2014). The reinforcing efficacy of rewards in prior cognitive studies on the overjustification effect is often unknown (or unreported); however, we do know that these studies generally involved activities that were highly preferred, as these are the most susceptible to overjustification effects. This is important to the extent that these are the very activities for which rewards are most likely not to function as reinforcers (due to potential ceiling effects). Without knowing the immediate effects of reward on target behavior we cannot accurately determine whether it is a functional reinforcer. The current data across Experiments 1 and 2 indicate that the reinforcing efficacy of rewards may have different effects on responding following their withdrawal (i.e., that rewards that function as reinforcers may be less likely to produce overjustification effects), indicating that the reinforcing efficacy of reward used in overjustification investigation may be important to the outcomes.

An additional, consistent difference across psychological perspectives in examining overjustification is in the type of design used. Behavioral researchers generally examine overjustification effects using single-subject designs in a manner analogous to that of the reward-history condition of Experiment 1: using repeated reward deliveries over time prior to tests of overjustification. On the other hand, developmental researchers have commonly used between-group designs, often providing rewards during a single session prior to the test period (without an aggregate reward history). This may be analogous to the No-Reward History Condition within Experiment 1. Results of Experiment 1 consistently indicated that the reward-history condition was associated with relatively fewer occurrences of overjustification. Accordingly, this suggests the historic discrepancies across fields of research may be due in part to consistent differences in research design and the reward histories commonly embedded within them.

A summary of data from Experiments 1 and 2 conservatively indicate the following:

1. Reward history was associated with fewer overjustification effects relative to no-reward history.
2. Overjustification effects were less frequent during the Reward History Condition following reward histories that produced reinforcer effects.

3. Improvement effects and no effects were much more common relative to overjustification effects across conditions within Experiment 2.
4. Within Experiment 2, reinforcer effects of greater magnitude were associated with fewer overjustification effects and more frequent persistence values categorized as strong to very strong across participants.

Collectively, these findings indicate that persistence may provide some protection against overjustification effects and may be strengthened by extended reward histories (as indicated by Experiment 1), and by using established, high-value reinforcers (as indicated by Experiment 1 and Experiment 2). These data likewise provide additional evidence negating the harmful effects of reinforcers, in general, and provide support for the continued use of programmed reinforcement contingencies. This is especially pertinent for behavior analysts who often program reinforcement contingencies across a variety of environments. Further, behavior therapists often arrange reinforcement programs with repeated reward deliveries (not as isolated events) using established reinforcers (as opposed to rewards). The current data would suggest these arrangements are particularly likely to strengthen, not weaken, later responding in the absence of reward.

Limitations and Future Directions.

Through a review of the meta analyses, some determinants of overjustification are consistent across studies: overjustification effects seem to be more likely when expected, tangible rewards are delivered contingent on task completion, and regardless of performance, for a high-interest activity. Measures were taken to meet these requirements (i.e., participants were told ahead of session that they were earning rewards, tangible rewards were included in lieu of praise, and rewards were delivered contingent upon task completion but without a performance criteria). However, the rewards in Experiment 1 and Experiment 2 were not delivered directly to the participant immediately following task completion but were instead placed in a bowl (within the participants view) for consumption following each session. This procedural modification decreased the temporal proximity between task completion and the experience of the reward (i.e., consumption of the edible), limiting the extent to which these reward parameters “match” those most likely to produce overjustification effects.

The children who participated in this study were all of a similar background (i.e., Caucasian, mid to high SES, living in two-parent households) and were all within the ages of 3-5. The extent to which these results may apply to a more ethnically and socio-economically diverse population, or to individuals outside of this age range, is unknown.

High-value activities (i.e., those associated with high level of intrinsic motivation) have been established in past research as most susceptible to overjustification-like effects. Accordingly, activities that produced responding at moderate to high frequencies in the absence of reward were used in Experiments 1 and 2. This presented some challenges. For example, it may be difficult to demonstrate increases in responding during reward periods due to ceiling effects. This may partly account for why relative increases in responding during the reward period were not consistently observed for some participants. Moreover, programmed rewards may function to punish responses that are already occurring at high rates if the activity is more valuable relative to the programmed reward. Roane et al. (2003) demonstrated this effect in their examination of the overjustification effect. Their results indicated that the removal of the reward (during tests of overjustification) produced an increase in responding. Subsequent analyses indicated that rewards functioned as punishment. It is difficult to examine similar effects for the current studies, as rewards were not delivered immediately during sessions, but were delivered in a bowl for consumption immediately following session. However, it is interesting to note that this procedural modification was made due to preliminary data from pilot participants that indicated that the immediate delivery of the rewards (within session) seemed to compete with activity engagement, resulting in lower levels of engagement during reward periods. Frank-Crawford et al. (2012) reported a similar effect.

In Experiment 1 we did not see differentially higher persistence values in the Reward-History Condition relative to the No Reward-History Condition for 2 of 4 participants. In Experiment 2, we did not observe the differentially stronger persistence values under higher rates of reinforcement generally observed in basic research. These findings may have been due to design limitations. Basic momentum research generally tests persistence following stable responding in a multiple schedule arrangement. In Experiment 1, there was a relatively small window for stable responding, as the reward period was only presented one time prior to the tests. As well, in Experiment 2, alternating schedules of reinforcement were broken up by the test components, limiting the stability of rewarded responding prior to tests of persistence. Future research may consider alternative designs aimed to better promote the response stability more common to tests of persistence.

Appendix A: Session-by-Session Results, Experiment 1

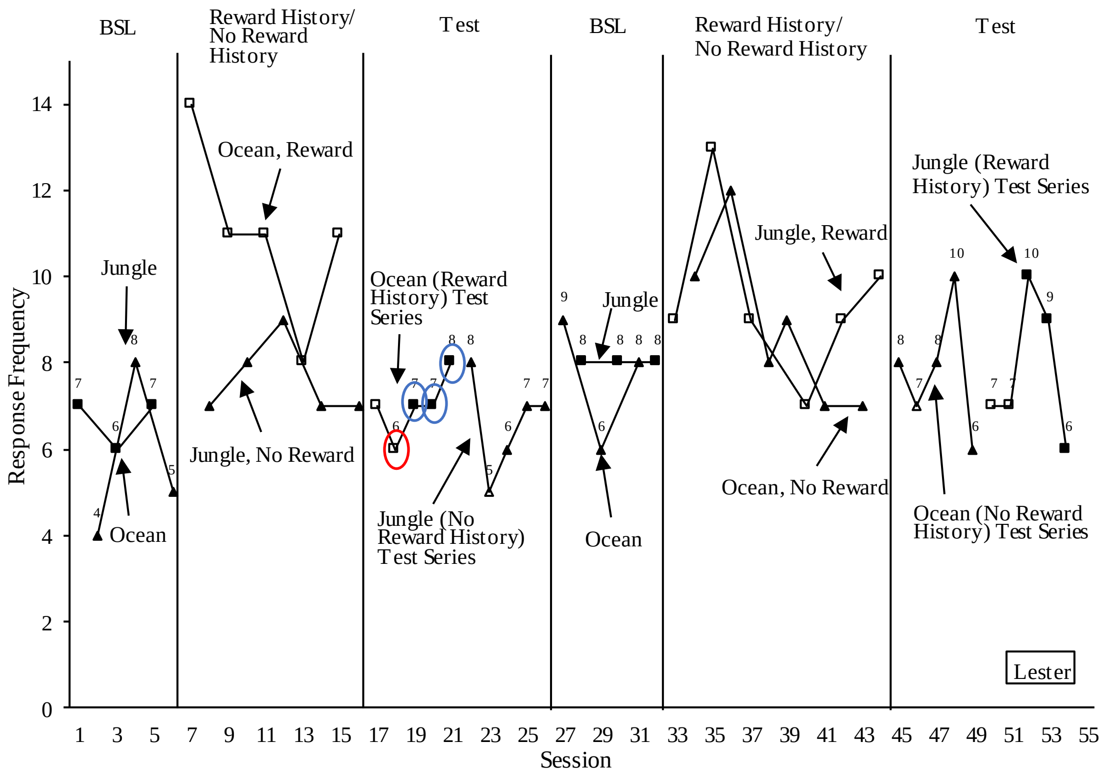

Figure A1. Session-by-session data across phases for Lester. Filled data paths indicate no-reward sessions or components, open data paths indicate reward sessions or reward components, squares illustrate responding associated with the reward history condition, and triangles illustrate responding associated with the no-reward history condition. Labels indicate the context of these conditions. Test components circled in red or blue are highlighted for reference in a later section of the text.

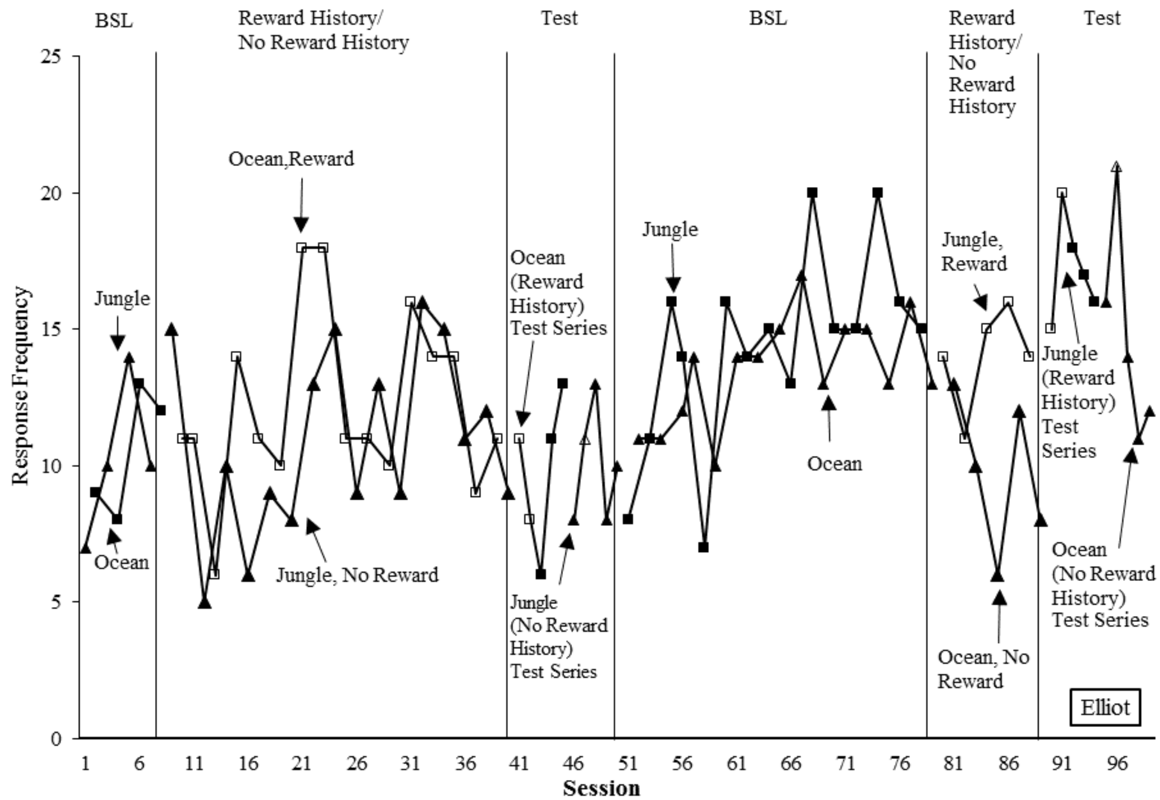

Figure A2. Session-by-session data across phases for Elliot. Filled data paths indicate no-reward sessions or components, open data paths indicate reward sessions or reward components, squares illustrate responding associated with the reward history condition, and triangles illustrate responding associated with the no-reward history condition. Labels indicate the context of these conditions.

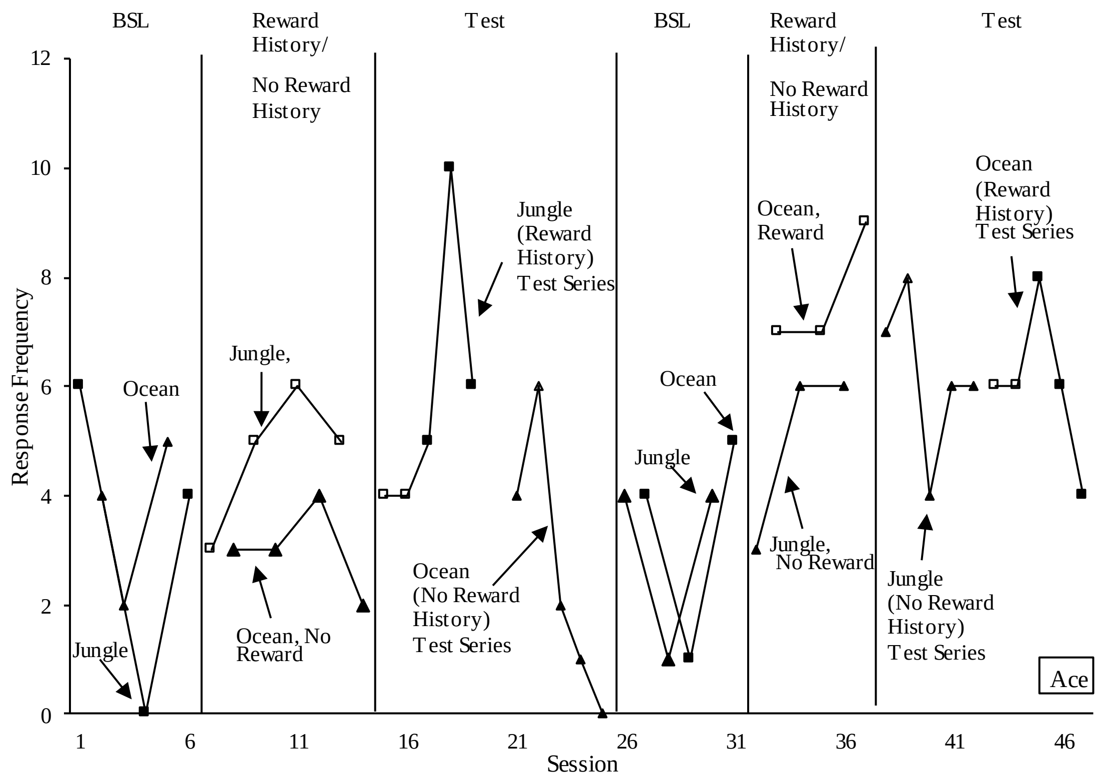

Figure A3. Session-by-session data across phases for Ace. Filled data paths indicate no-reward sessions or components, open data paths indicate reward sessions or reward components, squares illustrate responding associated with the reward history condition, and triangles illustrate responding associated with the no-reward history condition. Labels indicate the context of these conditions.

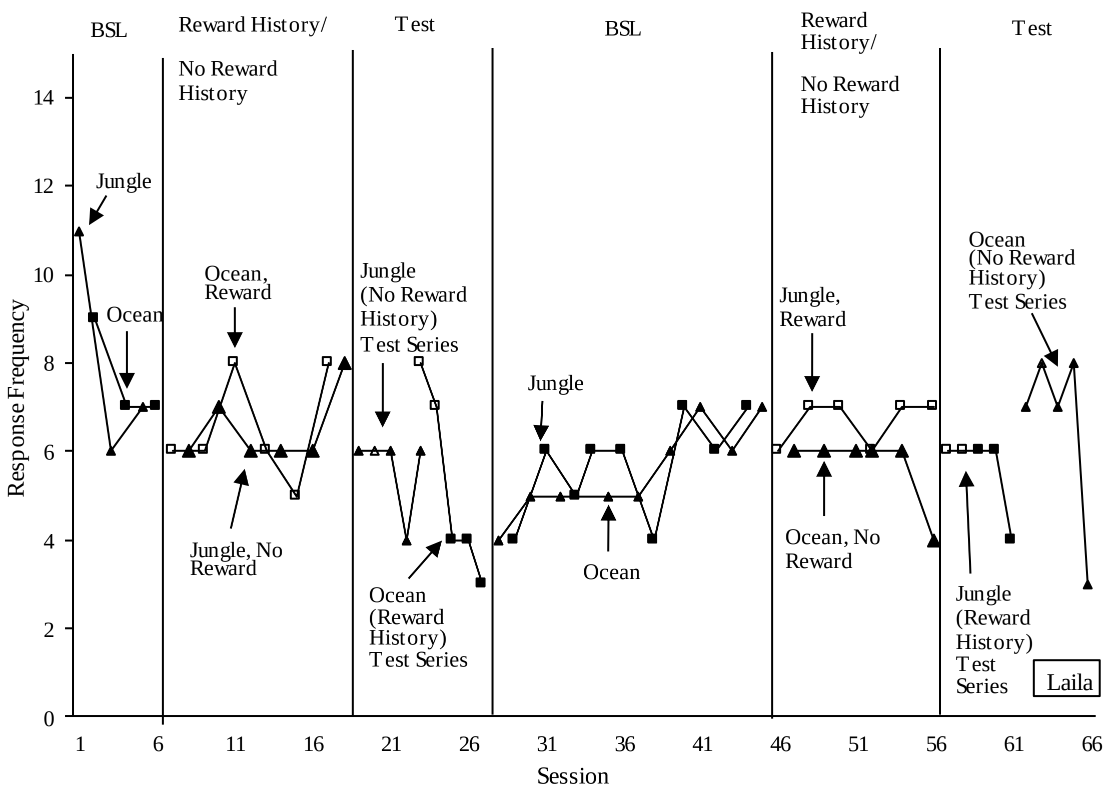

Figure A4. Session-by-session data across phases for Laila. Filled data paths indicate no-reward sessions or components, open data paths indicate reward sessions or reward components, squares illustrate responding associated with the reward history condition, and triangles illustrate responding associated with the no-reward history condition. Labels indicate the context of these conditions.

Appendix B: Session-by-Session Results, Experiment 2

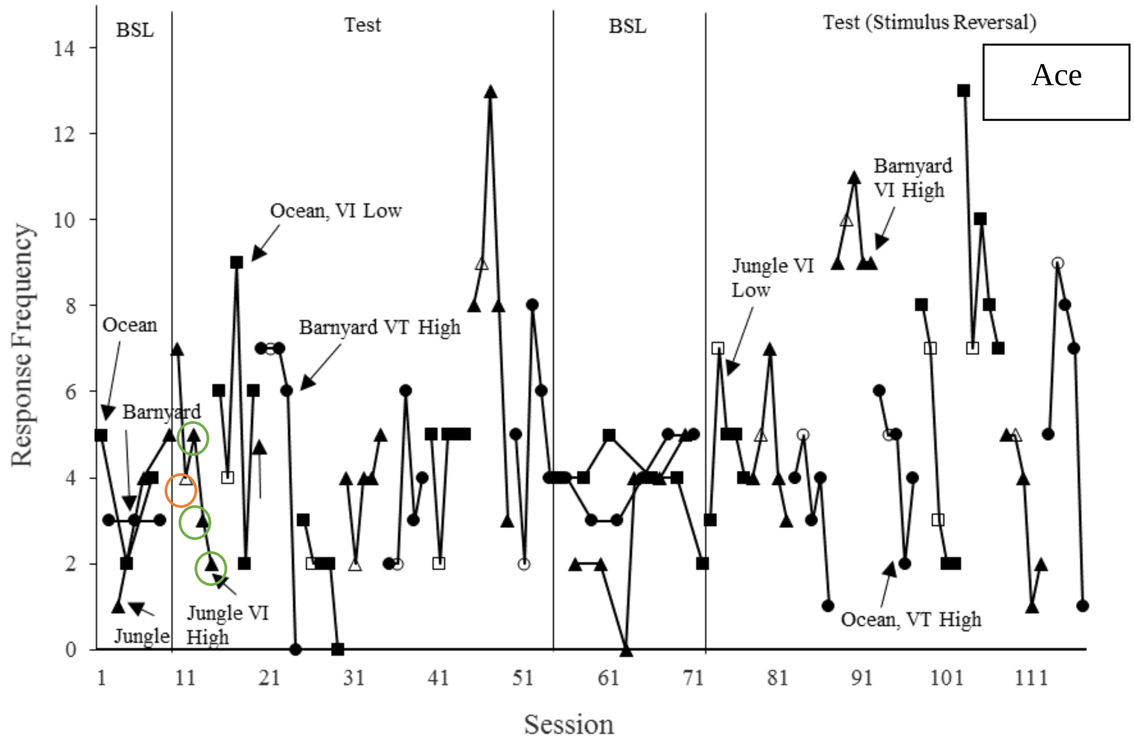

Figure B1. Session-by-session data across phases for Ace. Filled data paths indicate no-reward sessions (BSL phases) or components (test phases). Open data paths indicate reward sessions (BSL phases) or reward components (test phases). Squares illustrate responding associated with the VI low condition, triangles illustrate responding associated with the VI high condition, and circles illustrate responding associated with the VT high condition. Labels indicate the context of these conditions.

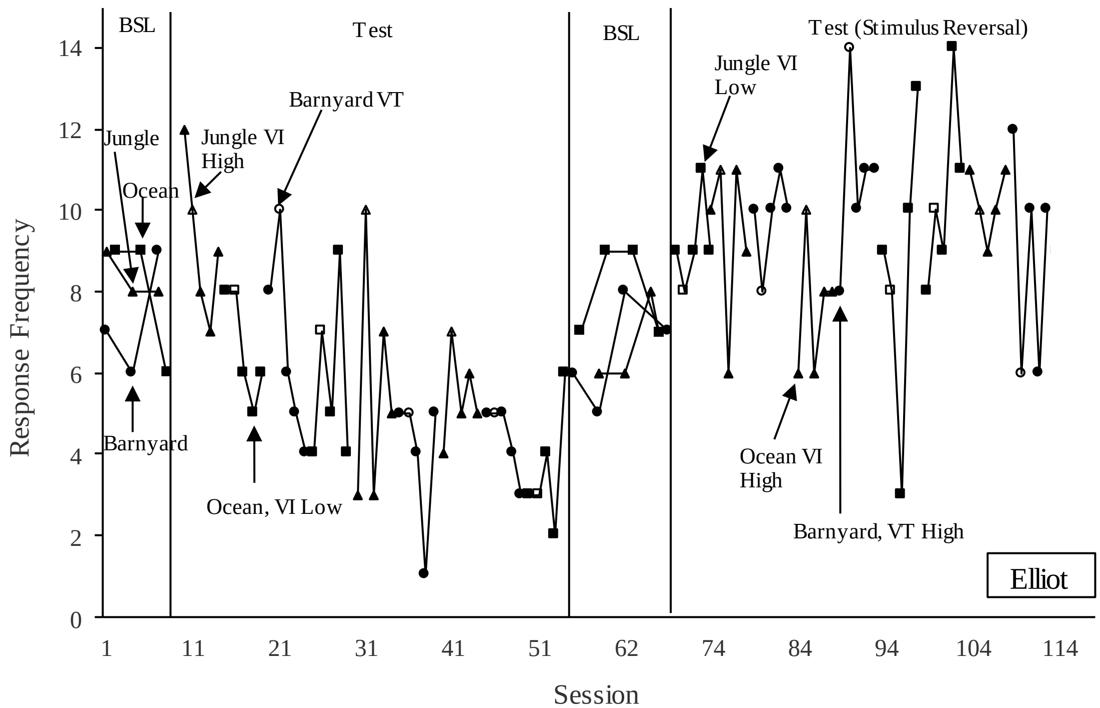

Figure B2. Session-by-session data across phases for Elliot. Filled data paths indicate no-reward sessions (BSL phases) or components (test phases). Open data paths indicate reward sessions (BSL phases) or reward components (test phases). Squares illustrate responding associated with the VI low condition, triangles illustrate responding associated with the VI high condition, and circles illustrate responding associated with the VT high condition. Labels indicate the context of these conditions.

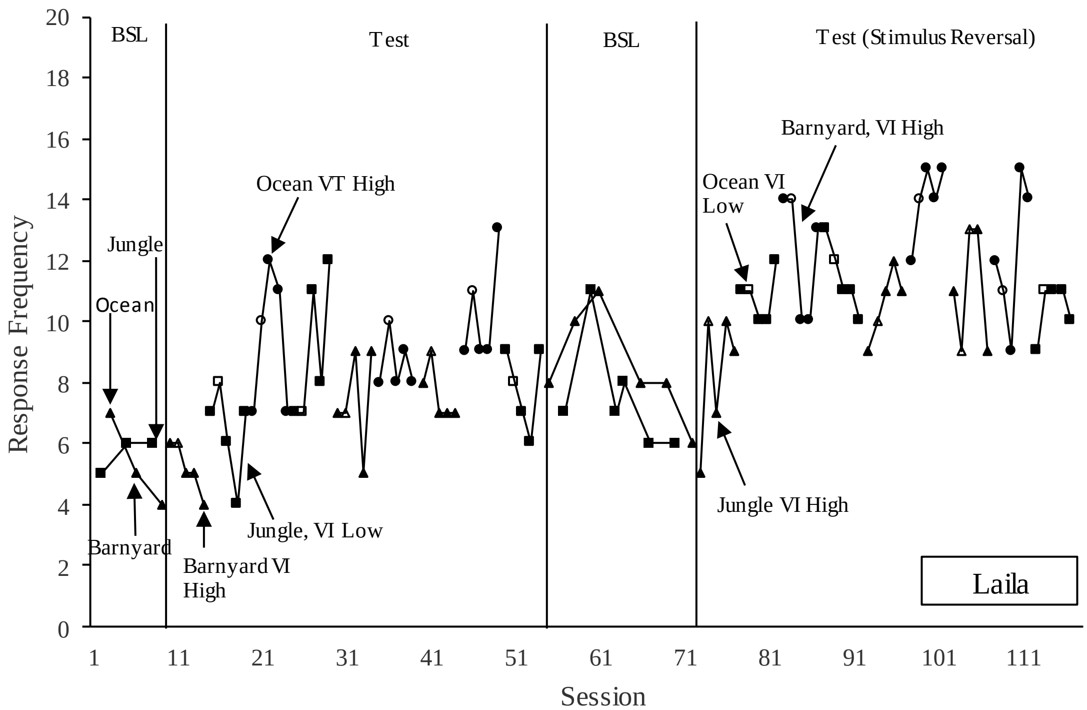

Figure B3. Session-by-session data across phases for Laila. Filled data paths indicate no-reward sessions (BSL phases) or components (test phases). Open data paths indicate reward sessions (BSL phases) or reward components (test phases). Squares illustrate responding associated with the VI low condition, triangles illustrate responding associated with the VI high condition, and circles illustrate responding associated with the VT high condition. Labels indicate the context of these conditions.

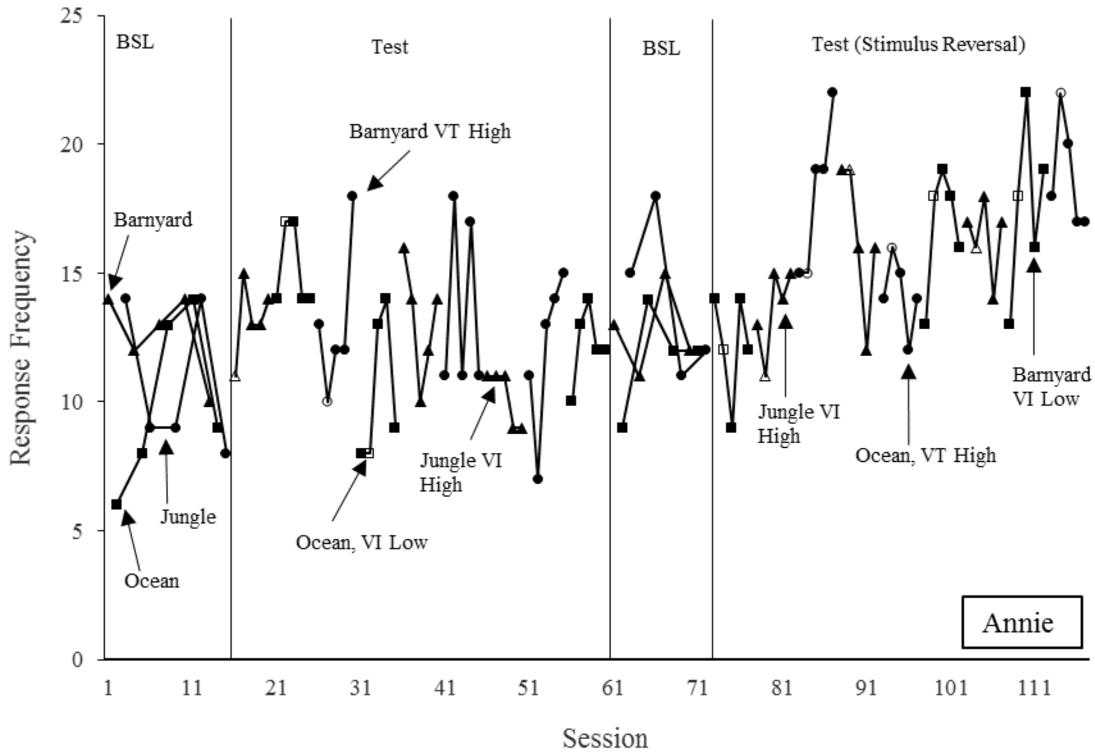

Figure B4. Session-by-session data across phases for Annie. Filled data paths indicate no-reward sessions (BSL phases) or components (test phases). Open data paths indicate reward sessions (BSL phases) or reward components (test phases). Squares illustrate responding associated with the VI low condition, triangles illustrate responding associated with the VI high condition, and circles illustrate responding associated with the VT high condition. Labels indicate the context of these conditions.

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