THE EFFECT OF SCHEDULES OF REINFORCEMENT ON THE FORCE AND RATE OF RESPONSES DURING EXTINCTION

by

Ofelia Margarit Flores

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in

The Faculty of Graduate and Postdoctoral Studies

(Special Education)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

August 2015

Abstract

Approximately 30 to 40% of individuals diagnosed with autism display problem behaviour (i.e., aggressive behaviour, SIB, property destruction). Problem behaviour is socially stigmatizing and generally a predictor of a poor quality of life. Although force is a defining aspect of problem behaviour, rate is the most frequent measure during behavioural assessment and treatment. With the purpose of examining the influence of schedules of reinforcement on the force and rate of the response during extinction, I conducted two experiments in three individuals diagnosed with autism. Using a reversal design, one participant was exposed to VR5 followed by EXT (Experiment 1); and two participants were exposed to a sequence of VR5+CRF followed by EXT (Experiment 2). Findings of Experiment 1 in Participant 2 showed no clear functional relations between VR5 and the level, trend and variability of force of response during EXT. However, a functional was demonstrated between VR5 and the level, trend and variability of rate of response during EXT. Findings of Experiment 2 in Participant 3 evidenced functional relations between a VR5 + CRF schedule of reinforcement and the level, trend and variability of force and rate of the response during EXT. Participant 4 evidenced a functional relations between VR5 + CRF a decrease in trend, and an increase in variability of force during EXT. In summary, Results across the three participants demonstrated a systematic variance between schedules of reinforcement operating prior to extinction and changes in level, trend, and/or variability in force and rate of the response. Results suggest that force and rate, as a result of the introduction of one or two schedules of reinforcement, varied systematically but differently for each individual. I suggest that clinicians should include a measure of force in addition to rate during the assessment and treatment of problem behaviour. Further research is needed to increase the generality of these results.

Preface

The Behavioural Research Ethics Board (BREB) from the University of British Columbia approved this project and associated method on March 10, 2015. The certificate number is H14-03396.

I was the lead investigator for the two experiments that this thesis contains. I was responsible for the data collection, analysis of data and the majority of manuscript composition.

The experimental apparatus was developed and provided by Dr. Rooker W. Griffin from John Hopkins University.

Table of Contents

List of Tables

List of Figures

Acknowledgements

I would like to express my deepest gratitude to the research school that unconditionally collaborated in this study. The students, parents, teachers and staff, provided the environment, and work which made possible the completion of this research.

I offer my most sincere gratitude to my supervisor, Dr. Joseph Lucyshyn, who has supported me throughout my thesis with his patience, knowledge, experience and gave perhaps the most valued aspect, time. Without his support and contribution this thesis would not have been possible. Thank you.

I would also like to thank sincerely Dr. Griffin Rooker, who from a distance provided such valuable advice, support and encouragement. His experience in this field of study was invaluable and he shared it willingly.

My gratitude and respect goes also to Dr. Sterett Mercer, whose encouragement, insightful comments and thoughtful questions incented me to widen my perspective of this study.

I would also like to thank Dr. Laura Grow, who helped me with the conceptualization and design of this project.

A special thanks goes to my fellow colleagues and friends for generously volunteering their time to code Interobserver agreement and Treatment Integrity data.

I am also grateful to my children, and loved ones for their patience and love and for having them in my life.

Dedication

To the parents and caregivers of children with Autism

1 Introduction

Autism Spectrum Disorder (ASD) is characterized by deficits in social and communication skills and the presence of restrictive and repetitive behaviour (American Psychiatric Association, 2013). Although not part of diagnostic criteria, prevalence estimates indicate that individuals diagnosed with ASD often engage in aggression, self-injurious behaviour (SIB), and property destruction (Matson & LoVullo, 2008). For example, Kanne and Mazureck (2011) examined the occurrence of aggression in 1380 children with a diagnosis of ASD between the ages of 4 to 17 years old (mean = 9.1 years old, SD = 3.5 years) and found that approximately 35% of these individuals displayed moderate to severe aggressive behaviour. Similarly, a meta-analysis of studies conducted on the incidence of aggression, SIB and property destruction among individuals with developmental disabilities showed that ASD was more frequently associated with the occurrence of problem behaviour (McClintock, Hall, & Oliver, 2003). These behaviours vary in severity from relatively minor and short-lived to severe, chronic, and potentially life threatening (Emerson, 1992). There is clear evidence that the presence of these behaviours is a significant health issue (Kats, Payne, Parlier & Piven, 2013).

Without systematic support, individuals with problem behaviour may have fewer educational, recreational, and occupational opportunities than their same-aged typically developing peers (Horner, 2000). Even moderate but chronic problem behaviour is socially stigmatizing and frequently a rationale for more restrictive educational and residential settings, and limited employment opportunities (Farmer & Aman, 2011). Moderate to severe problem behaviour can have a significant impact on the individual's wellbeing and be one predictor of a poor quality of life (Horner, Carr, Strain, Todd, & Reed, 2002; Lucyshyn, et al., 2009).

Caregivers of individuals with problem behaviour frequently experience stress and a reduced sense of self-efficacy. For example, Ingersoll and Hambrick (2011) conducted a survey of 149 parents of children with ASD and found higher levels of stress and depression among parents rearing children with ASD compared to caregivers raising typically developing children (Hastings & Johnson, 2001). Other studies have shown that the intensity of SIB, aggressive, and disruptive behaviour is directly correlated with higher levels of parental stress and depression (Baker, Blacher, Crnic, & Edelbroock, 2002; Hastings, 2002).

Behavioural intervention for severe problem behaviour is considered to be highly effective for treating these behaviours (Matson & LoVullo, 2008; Pelios, Morren, Tesch, & Axelrod, 1999). The recommended course of clinical care for these behaviours is to conduct a functional behavioural assessment (FBA) to identify the maintaining consequences of severe problem behaviour (i.e., the functional reinforcers) and use the results of this assessment to develop a treatment package that includes the elimination of reinforcement for problem behaviour, the delivery of the reinforcement contingent upon alternative behaviour, and the management of the antecedent stimuli that occasion or increase the likelihood of problem behaviour (O'Neill, Albin, Storey, Horner, & Sprague, 2015). To assess the effectiveness of treatment, clinicians typically measure how often problem behaviour occurs (i.e., frequency) in a baseline (i.e., pre-treatment) phase compared to the frequency of behaviour in a treatment phase. This measure is used to evaluate treatment effectiveness based on the reasonable assumption that reducing the rate at which severe problem behaviour occurs reduces the risk of injury to the individual or others. However, in this typical arrangement, the severity of problem behaviour is often supposed to be constant and thus is not typically measured. This is despite the fact that force of severe problem behaviour is a defining feature of these behaviours. Furthermore, previous research suggests that frequency and force are separable dimensions of behaviour

(Notterman & Mintz, 1965; Skinner, 1938).

Response force is a fundamental characteristic of any response (including problem behaviour) and rate is sensitive to force only at a given threshold. That is, if a response does not reach a defining threshold for problem behaviour, it is not considered severe problem behaviour. For example, scratching ones arm would not be considered SIB; however, when scratching occurs so forcefully as to break the skin, the behaviour would be considered SIB.

In addition, measuring only the frequency of a response makes data collection insensitive to changes in its force. In clinical care, response force is often assumed to be static (i.e., neither increasing nor decreasing); therefore, treatment procedures applied towards reducing frequency of SIB are assumed to have no influence on the force of SIB. However, basic and applied research has demonstrated that changes in contingencies of reinforcement that affect frequency can have unintended effects on the force of the response (Notterman & Mintz, 1965; Rooker, 2010).

In spite of the importance of force in the context of problem behaviour, force has been largely overlooked in research studies. Force, magnitude, or intensity of the behavior can have devastating consequences for individuals with ASD and for the people involved in their care. The force of aggression and SIB that causes injuries may increase the value of escape from the perspective of caregivers; that is, caregivers are more likely to avoid or terminate caregiving behaviours that occasion severe aggression or SIB (Hastings, 2002). Frequent referrals for behavioural services are preceded by episodes of increased aggressive behaviour, SIB or destructive behaviour (McClintock et al., 2003). Thus, how response force changes in the course of the treatment of problem behaviour is a question that requires investigation. The outcomes of such studies may provide interventionists and families with a technology to prevent or reduce episodes of excessive force in the course of assessment and intervention. A better understanding of force in the behavioural repertoire of persons with ASD is likely to offer significant implications in the selection of treatment and arrangement of contingencies recommended for individuals who display severe problem behaviour.

1.1 Identifying the Function of Problem Behaviour

As previously noted, the first step in the process of treatment involves functional behavioural assessment and identification of the environmental variables that influence the occurrence of problem behaviour. Results of the assessment form the basis of the selection of behavioural treatment. The selection of treatment components based on the functional behavioural assessment has a profound impact on the effectiveness of intervention. Treatments that match the function of the behaviour are more likely to succeed than treatments based on assumptions about the function of behaviour (Newcomer & Lewis, 2004). For example, Iwata, Pace, Cowdery and Miltenberger (1994) identified the function of SIB of three individuals with developmental disabilities. In this study, the same topography of behaviour served a different function for each participant. The authors then conducted a parametric analysis that exposed each behaviour to each treatment and demonstrated that treatment was effective for reducing SIB only when the consequence that was withheld was the one that had been maintaining the behaviour.

There are three categories of functional behavioural assessment: indirect assessment, direct assessment, and experimental functional analysis. These are defined below.

1.2 Indirect and Direct Assessments

Indirect assessments involve the use of rating scales, questionnaires and interviews with people who are associated with the person who engages in problem behaviour. An example of an indirect assessment is the Questions About Behavioral Function (Matson & Vollmer, 1995). The QABF is a questionnaire containing 25 questions to assess the following: (a) attention (e.g., "Engages in the behavior to get attention"), (b) escape (e.g., "Engages in the behavior to escape work or learning situations"), and/or (c) automatic functions of behaviour.

Direct assessments involve the conduct of observations to identify potential relationships between behaviour and environmental events. Observations are conducted in situations in which problem behaviour is most and least likely to occur. Examples of direct assessments include antecedent-behaviour-consequence recording, narratives, and scatter-plot analysis (Touchette, MacDonald, & Langer, 1985).

Both indirect and direct assessments are convenient and require relatively little training to conduct. However, an indirect assessment alone or a direct assessment alone have been shown to be insufficient procedures to accurately identify functions of problem behaviour, and thus may result in false identification of maintaining consequences (Thompson & Iwata, 2007). Although an indirect assessment *combined with* a direct assessment have been shown to lead to valid hypotheses about the function of problem behaviour (McIntosh et al., 2008; Loman & Horner, 2014), when hypotheses about the functions of problem behaviour cannot be confirmed by observations conducted after an indirect assessment, then an experimental functional analysis may become necessary.

1.3 Experimental Functional Analysis

Experimental functional analysis (FA) involves the direct manipulation of antecedent and consequent events that might maintain problem behaviour (Hanley, Iwata, & McCord, 2003; Hanley, 2012; Iwata & Dozier, 2008). Functional analysis methodology was first described by B. F. Skinner (1953), and later developed for use with people by Iwata, Dorsey, Slifer, Bauman, and

Richman (1982/1994). The FA described by Iwata et al. (1982/1994) uses an ABC operant model (Beavers, Iwata & Lerman, 2013; Hagopian, Rooker, Jessel & De Leon, 2013). Carr and Durand (1985) described an alternative AB experimental model for identifying the function of problem behaviour. This model is based on arranging antecedents and observing behaviour. Both approaches proposed the use of experimental techniques for behavioural assessment and subsequent treatment. Beavers et al. (2013) found that over the past 30 years, the ABC model has been used more frequently than the AB model.

Initially, Iwata and his colleagues developed an experimental protocol to understand, assess, and treat SIB. The authors compared the rate of SIB during three test conditions (i.e., demand, attention, and alone) to a control condition. The FA methodology provided a protocol for identifying positive, negative, and automatic variables functionally related to problem behaviour. Since its original publication, the FA protocol outlined by Iwata et al. (1982/1994) has been employed to assess other behavioural problems such as feeding disorders, sleeping disturbances, and elopement (Beavers et al., 2013; Hanley et al., 2003; Mace, 1994). Subsequently it has been expanded for assessment of problem behaviour maintained by access to positive reinforcement in the form of tangibles (Day, Rea, Schussler, Larsen, & Johnson, 1988) and to escape from social situations (Harper, Iwata, & Camp, 2013). Additionally, functional analysis has proven effective in assessing the function of behaviour among typically developing students in educational settings (Greer et al., 2013) and children with Attention Deficit Hyperactivity Disorder (Northup et al., 1995).

The common measure reported during functional analysis is the frequency of responding over a unit of time, or the percentage of intervals during which problem behaviour occurs (Thomason-Sassi, Iwata, Neidert & Roscoe, 2011). Beavers et al. (2013) examined 158 studies that used FA to determine the function of problem behaviour. In their study, the rate of response was the most commonly reported data (i.e., 90.7% of the studies). Duration and latency were only reported in 9.3% of the studies. Surprisingly, even though force is a defining and salient feature of problem behaviour, none of the studies reviewed by these authors reported data on it. However, research on force has been conducted in the context of a functional analysis of problem behaviour (Rooker, 2010), or a functional analysis of stereotyped movements and motor tics (Crosland, Zarcone, Schroeder, Zarcone, & Stephen 2005). These studies are reviewed later in the introduction when I discuss research on force of responding.

1.4 Function-Based Interventions

Successful identification of maintaining consequences and functional relations should be the initial step in the development of individualized function-based interventions. Although successful treatment can be derived without an FBA in some cases, best clinical practice is to first identify the variables maintaining problem behavior and incorporate these variables into treatment. However, applied research has a significant number of examples of interventions that have not documented the sources of control of problem behaviour (Ducharme & Van Houten, 1994). For example, enriching the environment with arbitrary but powerful reinforcers, and implementing punishing consequences might result in reduction of problem behaviour (Hanley, 2012; Iwata & Dozier, 2008). However, research has shown that knowledge of maintaining consequences lead practitioners to choose reinforcement-based procedures instead of restrictive treatments (Pelios et al., 1999). Kahng, Iwata, and Lewin (2000) found a decrease in the use of punishment procedures and an increase in reinforcement-based procedures for addressing problem behaviour among practitioners using a function-based treatment approach. Examples of function-based interventions include: (a) manipulating antecedent variables (e.g., establishing operations and discriminative stimuli); (b) reinforcing the occurrence of competing or alternative responses; and (c) implementing extinction for problem behaviour (Iwata & Wordsdell, 2005).

The study of behavioural antecedents led to the analysis of motivational or establishing operations. Iwata, Smith, and Michael (2000) emphasized the influence of establishing operations (EO) on behaviour. The effects of EOs are observed on the rate of response and on the effectiveness of relevant reinforcer. That is, the effectiveness of the reinforcer depends on the level of satiation or deprivation of the specific reinforcer (McGill, 1999). For instance, in behaviour maintained by attention, limited social contact has been correlated with the occurrence of SIB (Hall & Oliver, 1992). Likewise, a dense schedule of non-contingent attention has been shown to reduce the occurrence of SIB (Hagopian, Fisher, & Legacy, 1994; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). Problem behaviour has often been associated with negative reinforcement. Iwata, Pace, Kalsher, Cowdery, and Cataldo (1990) found that exposing individuals to escape extinction was related to a significant reduction in the rates of SIB.

Several studies have shown that reinforcement-based procedures are most effective when problem behaviour is placed on extinction (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Lerman, Iwata, & Wallace, 1999; Mazaleski, Iwata, Vollmer, Zarcone, & Smith, 1993). Differential reinforcement is a behavioural procedure that combines reinforcement and extinction for increasing appropriate behaviour and decreasing problem behaviour. There are three types of differential reinforcement procedures: (a) reinforcement of incompatible behaviour (DRI); (b) reinforcement of alternative behaviour (DRA); and (c) reinforcement of other behaviour (DRO). A common form of DRA is functional communication training (FCT).

1.4.1 Functional Communication Training. Research has shown that the development of problem behaviour in individuals with ASD is related to deficits in receptive and expressive language skills (Dominick, Davis, Lainhart, Tager-Flusberg, and Folstein, 2007; McClintock et al., 2003). Carr and Durand (1985) found that individuals with severe language impairments engaged in aggressive behaviour and SIB to communicate basic wants and needs. They advanced an intervention approach based on teaching a communicative response known as functional communication training (FCT; Carr & Durand, 1985). FCT requires the identification of the function of behaviour and the selection of a verbal operant that mediates the maintaining consequence. As a differential reinforcement procedure, FCT is most effective when used in combination with extinction (Hagopian et al., 1998). Across more than four decades of research, FCT has been shown to be an evidence-based practice for reducing severe problem behaviour and increasing appropriate communication skills (Durand & Merges, 2001).

Kahng et al. (2002) examined interventions that were selected for 396 cases involving severe SIB. Differential reinforcement was used more frequently than any other behavioural treatment (i.e., 42% of the cases). On 75% of these cases the incidence of SIB was eliminated or reduced to near zero levels.

For a differential reinforcement procedure to be effective, it must include the accurate identification of the reinforcer. Mazaleski et al. (1993) found that including an extinction component to a DRO procedure in the treatment of SIB of three individuals with disabilities resulted in a significant reduction in the rate of problem behaviour. Hagopian et al. (1998) compared the effects of FCT with and without extinction and punishment for 21 individuals with intellectual disabilities. Functional communication training without extinction was ineffective in reducing problem behaviour in all eleven applications of the procedure. However, FCT combined with extinction or punishment resulted in a 90% reduction of problem behaviour.

1.4.2 Extinction. Extinction occurs when the relationship between response and consequence is terminated (Lerman & Iwata, 1996). That is, following each instance of the behaviour, the specific reinforcer responsible for maintaining the response is withheld. The correct application of extinction reliably decreases the frequency of the behaviour (Ducharme & Van Houten, 1994; Iwata et al., 1994). There are three basic variations of extinction that are relevant for treatment: (a) extinction of positively reinforced behaviour (e.g. attention, tangibles): (b) extinction of negatively reinforced behaviour (e.g., escape from demands, escape from social interaction); and (c) extinction of automatically reinforced behaviour (Iwata et al., 1994). It is essential that the reinforcer withheld is not determined by a procedural decision but by the functional assessment of the problematic behaviour.

Extinction is a critical component of function-based interventions for reducing severe problem behaviour to socially acceptable levels (Lerman & Iwata, 1996). The immediacy of intervention effects during extinction may be affected by the prior history of reinforcement. Persistent problem behaviour is frequently maintained by intermittent reinforcement and associated with increased resistance to extinction (Lerman, Iwata, Shore, & Kahng, 1996). Lerman and Iwata (1996) demonstrated that problem behaviour with a history of intermittent reinforcement showed more resistance to extinction than behaviour maintained on a continuous schedule of reinforcement (CRF). However, results from a recent study revealed greater resistance to extinction after exposing problem behaviour to continuous reinforcement rather than to intermittent reinforcement (MacDonald, Ahearn, Parry-Cruwys, Bancroft, & Dube, 2013). Given these mixed findings, additional research is needed to better understand the impact of the history of reinforcement on the length and rate of responding during extinction.

There are several potential side effects that may occur during extinction, including but not limited to (a) an extinction burst, (b) behavioural variability, and (c) spontaneous recovery

(Ducharme & Van Houten, 1994; Lerman & Iwata, 1996; Lerman et al., 1999). The side effects of extinction have been demonstrated in humans and non-human organisms. For the purpose of this study, I will discuss extinction burst and behavioural variability. Additionally, I will review studies that have examined the fluctuation of force during extinction.

Extinction burst. An extinction burst is characterized by a temporary increase in responses after behaviour is exposed to extinction. Skinner (1938) reported data from studies with non-human species that manifested temporary increases in the rate of responding during extinction. Numerous studies have provided extensive evidence of this phenomenon (Ducharme & Van Houten, 1994; Lerman et al., 1999).

Lerman et al. (1999) examined the prevalence of an extinction burst in 30 individuals with intellectual disabilities. A temporary increase in behaviour occurred in 39% of the cases. Results of a previous study by Lerman and Iwata (1995) involving 113 individuals with disabilities showed a lower incidence of extinction burst. For individuals exposed to extinction plus reinforcement-treatment, the incidence of extinction burst was 24%. Conversely, 36% of individuals exposed to extinction-alone-treatment demonstrated an extinction burst. Interestingly, the extinction burst is one of the most common reasons for excluding extinction as a component of function-based interventions for severe problem behaviour (Lerman et al., 1999).

Behavioural variability. Another potential side effect of extinction is the occurrence of varied topographies of responses during extinction. Regardless of whether the behaviour that emerges throughout extinction is considered appropriate or inappropriate, the responses that arise during extinction are likely part of the same response class. These responses may include problem behaviour (e.g., SIB, aggression) and appropriate behaviour (e.g., mands, compliance). Goh and Iwata (1994) examined the aggressive behaviour displayed by an individual exposed to extinction of SIB. Aggressive responses observed during treatment with extinction were never observed during baseline. The authors concluded that the aggressive responses and SIB belonged in the same response class.

Grow, Kelley, Roane and Shillingsburg (2008) induced variability by exposing problem behaviour to extinction. During the first extinction session, participants displayed appropriate behaviour and received the identified reinforcer. Other studies have increased the emission of specific verbal responses by employing extinction. Betz, Higbee, Kelley, Sellers and Pollard (2011) increased the number of novel mand frames used by children diagnosed with ASD by inducing variability through extinction of previously reinforced mands. Thus, depending upon the goal of the intervention, an increase of variability might be desired and planned or prevented and minimized.

Force. Skinner (1938) observed temporary increases in the force of responses when extinction was implemented. Throughout extinction, the responses reported were as forceful as the organism was physically able to produce (i.e., 50% of its weight). This fact is of particular interest in regard to problem behaviour, where force is a defining characteristic of the severity of the response. Skinner developed several conclusions about the force of response. First, organisms engaged in the least effortful response during continuous reinforcement. Second, when the response was placed on extinction, a sudden increase in force was observed. Third, intermittent schedules of reinforcement produced higher levels of force than continuous reinforcement schedules. The research results presented by Skinner (1938) produced the first account of the influence of reinforcement and extinction on the force of behaviour.

1.5 The Impact of Schedules of Reinforcement on the Force of Responses

Schedules of reinforcement might be among the most critical controlling variables of problem behaviour, hence the importance of identifying, prior to treatment, not only the maintaining consequence but also the operating schedule of reinforcement on the behaviour of interest (Zeiler, 1977). In particular, for clinical purposes, it is crucial to consider how behaviour targeted for intervention has a unique history of reinforcement that influences the outcomes of treatment. For example, previous research has demonstrated that a history of intermittent reinforcement produces greater resistance to extinction, causes higher variability, and produces higher rates of response during extinction (Lerman & Iwata, 1996; Skinner, 1938). However, only a limited number of basic and applied studies have examined the influence of reinforcement on the force of responding during extinction.

1.5.1 Basic research studies with non-human species. Basic research studies have attempted to answer empirical questions on the impact of independent variables, such as schedules of reinforcement, and the level, variability, and distribution of force of responding (Blixt & Ley, 1969; Morris, 1968; Mintz, 1962; Notterman, 1959; Notterman & Mintz, 1965; Trotter, 1956).

Researchers have consistently replicated a stable low level of force during continuous reinforcement and an increase in force during initial implementation of extinction. For example, Trotter (1956) evaluated the impact of different response effort on the force of response during continuous reinforcement and extinction. In his experiment, Trotter conditioned 12 rats to depress a knob to gain access to reinforcers. The response effort was manipulated using different knob weights (i.e., 10 g, 30 g and 50 g). Trotter found that during continuous reinforcement, responses met but rarely exceeded the effort required for reinforcement. During extinction, the rats displayed responses with peak forces above 100 g regardless of the initial work requirement during continuous reinforcement (i.e., 10, 30, or 50 g). The force of responses produced by the rats during extinction was greater than the force observed during the reinforcement phase. As Skinner (1938) noted, the intensity of the responses during extinction reached the physical capability of the animal.

Expanding on the study conducted by Trotter (1956), Notterman (1959) investigated the bar pressing response of rats during acquisition, continuous reinforcement, and extinction. During acquisition, the rats emitted responses with a variety of forces initially followed by a sharp decrease to a relatively low and stable force of response. Throughout continuous reinforcement, the variability of force decreased and the animal displayed a stereotypical pattern of response. In contrast, there was a marked increase in the force exhibited during extinction. In light of this data, Notterman concluded that as the conditioning advanced, responses decreased in force and force variability. However, an inverse effect was observed when the reinforcer was withheld. As extinction was introduced, the force and variability of the force of the response increased.

In the 1960s, the first systematic analyses were conducted on the impact of schedules of reinforcement on the force of response during conditioning and extinction (Mintz 1962, Notterman & Mintz, 1965). Notterman and Mintz compiled data from a series of experimental studies in a book titled *Dynamics of Response.* The data published is the most comprehensive collection of basic studies on the force of response in living organisms. One set of studies addressed the effects of different response efforts on the force during extinction. Notterman and Mintz (1965) reinforced two groups of rats for pressing levers with different weights (e.g., 2.5 and 8 g). Subsequently, the response effort was increased to 16 g for the two groups. Regardless of the criteria for reinforcement, the subjects demonstrated a sharp increase in the level of force and force variability during extinction. The results were consistent with previous studies

(Notterman, 1959; Trotter, 1956).

Pinkston and McBee (2014) exposed rats to intermittent fixed ratio schedules (FR) and tandem schedules. They found that the force of response increased after the delivery of reinforcement and decreased as responses within the ratio requirement advanced. These results did not replicate the findings reported by Notterman and Mintz (1965) who recorded a drop in the level of force after the delivery of reinforcement. Pinkston and McBee (2014) concluded that the force of response within ratio schedules varied as a function of the ordinal position of the response and not as a function of an extinction effect as suggested by Notterman and Mintz (1965). The results of the aforementioned basic investigations suggest that the force of the response is determined by multiple environmental variables such as temporal timing interacting with the work requirement, the work requirement itself (i.e., the ratio to complete) and the schedules of reinforcement (Pinkston & McBee, 2014).

1.5.2 Basic and translational studies with humans. To some extent, the generality of the results on response force have been established in humans. Morris (1968) included three teenagers with developmental and intellectual disabilities in a study that examined the distribution of the force of response across different experimental conditions. Morris observed low levels of force during periods of reinforcement and increased levels of force during extinction. Following the same line of research, Blixt and Ley (1969) recruited a group of 80 typically developing individuals between 9- to 11-years of age. The experimenters reinforced and subsequently extinguished the lever pressing response. An overwhelming majority of responses during extinction (i.e., 90%) were more forceful than the mean force of responses during reinforcement.

More recently, Rooker (2010) conducted a series of three translational studies on force with humans. In Study 1, the force and rate of a button-pressing response was measured during continuous reinforcement and extinction. The rate and force of response during continuous reinforcement was relatively stable across participants. During extinction, two participants displayed an extinction burst while the rate of response in two other participants dropped to near zero almost immediately. Three participants exhibited more forceful responses during the initial implementation of extinction. The author also observed that rate and force of responses were inversely related. That is, as rate increased, force decreased and vice versa. Additionally, the mean peak force during extinction was higher than during continuous reinforcement. The results of the first Study by Rooker (2010) replicated those of Blixt and Ley (1969), Morris (1968), and Notterman (1959) and have clinical implication for the assessment and treatment of problem behaviour.

In Study 2, Rooker compared the force of response during continuous (FR1 or CRF) and during fixed ratio (FR10) schedules of reinforcement. The rate of response observed during FR1 was consistent with the results of Study 1 described above (i.e., stable rate). By comparison, the rate of responses during FR10 increased either immediately or eventually. In terms of force in Study 2, the participants exhibited stable levels with slight increases in force as well as minimal increases in the variability of force. The results of the Study 2 replicated the results of Notterman (1959) during FR 1; however, the increased levels of force observed in periods of extinction during intermittent schedules were not replicated in humans exposed to FR 10 (Mintz, 1962; Notterman & Mintz, 1965; Rooker, 2010).

1.5.3 Applied research studies. It is critical to conduct research on the environmental variables (e.g., schedules of reinforcement) that may influence the force of response in natural settings. It is somewhat surprising that few studies have investigated the impact schedules of reinforcement or other independent variables on the intensity (force) of problem behaviour.

Behavioural interventions. Research on selective mutism is an example of the impact of behavioural interventions on the force of an operant response. In selective mutism, an individual vocally communicates but fails to produce audible speech in specific settings (e.g., social or public situations). A number of studies have evaluated behavioural treatments for increasing the volume of vocal output and transfer stimulus control to natural settings. Wulbert, Nyman, Snow, and Owen (1973) conducted a study with a young individual with no known developmental or intellectual disability. The participant of the study, who previously exhibited a conspicuous selective mutism, produced audible vocalizations after exposure to a behavioural intervention consisting of stimulus fading, reinforcement, and time out. In another study, the vocal communication of an individual diagnosed with a severe cognitive delay increased after the implementation of a token economy and the extinction for inaudible communication (Jackson & Wallace, 1974). After a systematic intervention, the volume of the participant's speech increased and reached the established audible criteria in a controlled setting. More recently, other behavioural procedures such as shaping the level of loudness and graduated exposure to natural settings has been successfully employed to treat a young individual with a long history of selective mutism (Facon, Sahiri, & Riviere, 2008).

Assessment of problem behaviour. As previously stated, rate of behaviour is the most widely reported measure, even though force may better represent the serious effects of problem behaviour (Iwata, Pace, Kissel, Nau, & Farber,1990; Newell, Challis, Boros, & Bodfish, 2002). Rate-based assessments of SIB or aggressive behaviour may inadequately inform clinicians about the severity and risks for the individual who engages in severe SIB or aggression. With the purpose of assessing the severity of the injuries produced by SIB, Iwata et al. (1990) developed the Self-Injury Trauma Scale (SIT). The SIT is an observational tool that allows clinicians and researchers to classify and measure the amount of external injury caused by SIB. Additionally, it provides a baseline for current physical damage on the area to which SIB is directed. Frequent monitoring after treatment could identify the effectiveness of an intervention. Measuring the severity by physical examination represents the entry into evaluation of the effect of force of SIB.

Several studies have examined the force and limb trajectories of SIB in individuals diagnosed with developmental or intellectual disabilities (Newell, Sprague, Pain, Deutsch, & Meinhold, 1999; Newell et al., 2002). Using videotapes of episodes of individuals with SIB, experimenters analyzed the limb movements to provide an estimate of the force incurred. In addition, from the analysis of these videotapes, the authors developed a non-intrusive, but time-intensive approach for assessing the force of problem behaviour.

Instead of assuming the force of the response from the analysis of rate, Rooker conducted a study that systematically measured force with individuals with a history of problem behaviour (Rooker, 2010). Rooker employed a methodology that was similar to Newell et al. (1999) and Newell et al. (2002) to measure the force of aggressive responses and property destruction during a behavioural assessment. Rooker (2010) initially conducted a functional analysis to identify the function of problem behaviour in four participants. Functional analysis sessions were videotaped for subsequent analysis. Each session was uploaded to kinetic movement software (i.e., HuMAN motion system) that generated computerized models and calculated the angular velocities of joint motions. That is, the force of each instance of problem behaviour was derived from the speed of rotation of the joint.

Results obtained for two participants showed that the force of aggressive responses decreased as the assessment progressed despite an increase in the rate of responses. However, a third participant showed only a slight decrease in force. The last participant did not exhibit any decrease in force during the assessment. Regardless of the mixed results between participants, there was no evidence of an increase in the force of response. Although the experiment expanded the use of an experimental methodology for the assessment of force, the results were not conclusive. Additional research is needed to assess the force of problem behaviour during functional analysis and function-based intervention.

Data from the Rooker study also provided evidence contrary to the notion that functional analysis "makes behaviour worse." On the contrary, results across these studies showed a decrease and stabilization of force and rate of response during continuous reinforcement, suggesting a preventative strategy for treating severe problem behaviour. However, the impact of intermittent schedules of reinforcement on force of responding during extinction remains unclear and warrants further investigation.

In conclusion, based on the evidence presented, problem behavior maintained under an intermittent schedule of reinforcement may result in an upsurge of force during extinction. Depending on the topography of the behaviour, this effect might have overwhelming consequences for the individual, the family and potentially the community at large. Uncovering the dynamics of the force of response during intermittent schedules of reinforcement and extinction is likely to offer more precise knowledge related to behavioural assessment that can contribute to improvements in the efficiency and effectiveness of treatment for severe problem behaviour. Thus, further study of force of response in the context of different schedules of reinforcement and of extinction is a socially important goal.

In clinical settings it is important to develop interventions that minimize the unwanted side effects of extinction (e.g., increases in force, increases in rate) but remain effective for reducing problem behaviour. Due to the absence of evidence on the dynamics of force during extinction, and the potential risks associated with increases in the force of severe aggression, SIB and property destruction, two translational studies were conducted in a school setting. The purpose of the first study was to evaluate the effects of a history of intermittent reinforcement on the force and rate of response during extinction. The purpose of the second study was to assess the effects of prior exposure to an intermittent schedule followed by continuous reinforcement on the force and rate of response during extinction.

2 CHAPTER Research Methodology

This section describes the general procedures for Experiment 1 and Experiment 2.

2.1 Participants and Setting

Six participants were initially recruited at a local school that offers special education for children diagnosed with autism. From the original six participants, three remained to complete the study. Of the three who did not continue, one participant unexpectedly went on vacation at the beginning of the study. A second participant underwent target training but after two weeks of training, did not acquire the target response A third participant underwent preference assessment but did not demonstrate any preference for edibles, thus limiting the implementation of reinforcement procedures. The remaining three participants were assigned to Experiment 1 and Experiment 2. Participant 2 was assigned to Experiment 1 and Participants 3 and 4 were assigned to Experiment 2. All the participants were selected based on teacher evaluation of their level of communication, their ability to remain at a table for a period of 5 min, and the lack of past or current history of aggression, self-injurious behaviour, or property destruction. Demographic information of each participant can be found in Table 2.1.

Table 2.1. Demographic Characteristics of Participants.

Code	Age	Sex	Diagnosis	Study
P002	14	Female	Autism	One
P003	16	Male	Autism	Two
P004	11	Male	Autism	Two

The study was conducted in a 5 m by 3 m room at the participants' school. The room used was in actual fact a storage room but for the purpose of this study was equipped with one table, two chairs, a video camera, a computer, and the materials needed to conduct the session (i.e., apparatus, timer, data collection sheet, reinforcers).

2.2 Apparatus and Materials

The equipment used for the experiments was a Tekscan Flexi Force load sensor embedded in a switch press button. With this device, the sensor captured the force of each response emitted by each participant. This information was transmitted wirelessly with the use of software developed by Tekscan (i.e., Economical Force). The sensor was calibrated using standard weights (e.g., 2.5 and 9 lb.) on a weekly basis to correct for any measurement drift in the load sensor and to ensure the accuracy of measurement over time. This equipment was the same equipment developed and utilized in the study by Rooker (2010). For both experiments, data sheets were designed for each experimental condition to measure the dependent and independent variables.

2.3 Pre-experimental Assessments

The next section describes the pre-experimental assessments and procedures conducted with parents and participants.

2.3.1 Interview with caregivers. The experimenter met with the caregiver of each participant to conduct an interview on the participant's preferences. The experimenter used the Reinforcer Assessment for Individuals with Severe Disabilities (RAISD; Fisher, Piazza, Bowman, & Amari, 1996) to identify 8 to 10 potential preferred items.

2.3.2 Paired-choice preference assessment. The top 8 to 10 items identified by caregivers in the RAISD were evaluated using a paired-choice preference assessment (Fisher et al., 1992). The purpose of the paired-choice preference assessment was to determine a hierarchy of preferred items. The experimenter chose the top 3 to 4 items as reinforcers for the experimental sessions with participants. The results of the paired choice preference assessment for the three participants are shown in Figure 2.1.

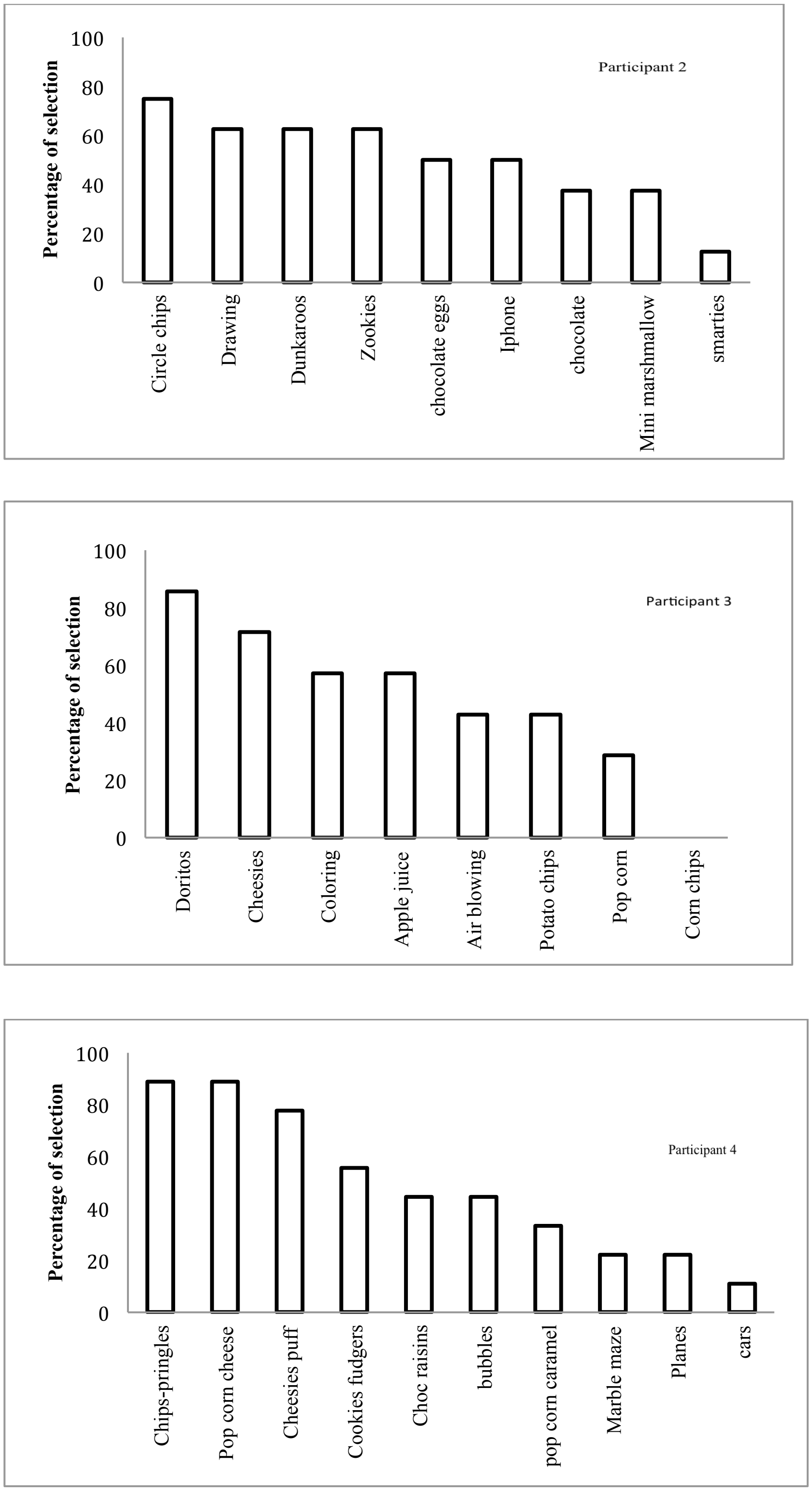

Figure 2.1. Percentage of selection of preferred items during paired-choice preference assessment for Participants 2, 3 and 4.

2.3.3 Assessment of language skills. Participants' language skills were assessed using the Behavior Language Assessment Form (BLAF; Sundberg & Partington, 1998). The purpose of the BLAF was to gather information on 12 basic language-related skills (e.g. requesting, labeling, matching to sample). The participants' behaviour analyst completed the BLAF for each individual. For Participant 2, the BLAF revealed that the participant would give 5 responses without engaging in disruptive behaviour, could easily imitate any fine or gross motor movements, and could follow many instructions and point to at least 100 items, actions, persons, or adjectives. For Participant 3, the BLAF revealed that the participant would work for 10 minutes at a table without disruptive behaviour, could easily imitate fine or gross motor movements, and could follow many instructions and point to at least 100 items, actions, persons, or adjectives. For Participant 4 the BLAF revealed that the students would give 5 responses without engaging in disruptive behaviour, would imitate several fine and gross motor movements on request, and would follow instruction and point to at least 25 items.

2.3.4 Discrimination training. I conducted simple discrimination training to teach each participant the button pressing response. The discrimination training involved the presentation of the button (i.e., discriminative stimulus), the button covered (i.e., stimulus delta, S^{Δ}), the response, and the maintaining consequence (Green, 2001). A correct response was defined as the contact between one finger of the participants with the button pressed with a sufficient amount of pressure to produce an audible "click" (.07 lbs.). An incorrect response was defined as contact with the hand on any part of the device other than the button.

Each session of discrimination training consisted of five trials. During the first session of discrimination training, I modeled the response while simultaneously stating, "Do this." After modeling the response, I asked the participant to press the button by stating, "hit the target."

When the participant engaged in a correct response within 3 seconds of me uncovering the target, I delivered immediate access to a preferred item. I withheld access to preferred items following incorrect responses (i.e., pressing any surface or insufficient pressure on the button). If the participant did not engage in a response within 15 seconds of me uncovering the device, I delivered the verbal prompt "hit the target." Participant 2 and 3 achieved mastery criteria on the button pressing response in one experimental session. Participant 4 required two experimental sessions to acquire the response and achieve criteria.

2.4 Response Measurement and Interobserver Agreement

After each session was concluded, I calculated the primary dependent variable; that is, the mean peak response force using the recorded data of the ELF-2 on the force of each instance of button pressing. Each response produced a different amount of force over the course of the response cycle. Peak force was defined as the greatest amount of force that was recorded during each response cycle. I obtained the mean peak force by adding all the peak forces and dividing this number by the total number of responses in the session. At the end of each session, I also calculated the mean response rate (responses per minute, RPM) from the recorded data. Also for the purpose of study, I defined three levels of force; (a) low levels of force were below 1 lb; (b) moderate levels of force were > 1 but < 3 lb; and (c) high levels of force were > 3 lb.

A trained observer calculated interobserver agreement (IOA) for button press responses. A frequency-within-interval recording procedure was used to obtain the IOA score during each experimental session. The rate of response was calculated by dividing the total number of responses by the duration of each session. Interobserver agreement was undertaken with the experimenter and a second independent observer reviewing video data of responses for 25% of experimental sessions balanced across phases. Using the frequency of responses within 10-s interval, the experimenter calculated the proportional agreement by comparing the frequency within each interval. When there was a disagreement, a proportional agreement was obtained by dividing the larger number of responses into the smaller number. The percentage of agreement was calculated by adding all the fractions of disagreements to the number of agreements in the session. The experimenter divided the sum by the total number of intervals. The result was multiplied by 100% to yield reliability scores per session. The mean reliability scores for button presses were as follows for each participant: Participant 2, 96%; Participant 3, 95%; and Participant 4, 97%.

2.5 General Procedure

The same general procedures were used for Experiments 1 and 2. Prior to each experimental session, three preferred items in bowls on the table for the participant. Throughout the experiment, Participant 2 self-delivered the reinforcer after she met the response requirement for the reinforcement phase in Experiment 1 (i.e., variable ratio reinforcement). Participant 3 self-delivered reinforcement for the first three phases of Experiment 2 (i.e., variable ratio reinforcement, continuous reinforcement, and extinction; however, at the start of the repetition of these three phases, Participant 3 began to over-deliver the reinforcer. Following this, I introduced control of the delivery of reinforcement for this participant. Participant 4 was not able to self-deliver the reinforcer. Accordingly, I controlled the delivery of reinforcement during the six phases of Experiment 2.

During each session the participant sat at the table with the apparatus placed on the table approximately at 0.25 meters from the participant. I stood across the table and was the only one present during the study to deliver instructions and provide reinforcement. However during experimental sessions, audible comments from a classroom in close proximity could be heard.

At the commencement of the session: (a) the student sat at the table; (b) the camera was activated; (c) the ELF system was initiated; (d) the timer was started, and (e) the apparatus with the instruction “Go, hit the target.” was uncovered.

After a participant completed the target response requirement (depending on the schedule of reinforcement in place), I covered the device, and provided access to the reinforcer. Once the participant consumed the reinforcer, I lifted the cover and exposed the target within 3 seconds of the participant having his hands free to press the button.

The duration of each session was approximated 5 min. On a few occasions (less than 5 instances), I re-delivered the instruction “hit the target” as the participant was not engaging in the response. None of the sessions reached termination criterion for problem behaviour. A two-minute break was implemented after each 5- min session. Each day, I conducted 3 sessions.

2.6 Treatment Integrity

Treatment integrity was evaluated on 30% of the sessions. Procedural fidelity was obtained by randomly selecting 30% of the videotaped sessions of each participant. A trained independent observer validated procedural fidelity by observing 2 out of 5 minutes of each video. The independent observer used a Yes-No checklist to assess whether the independent variable was implemented with fidelity in each trial of the two-min interval under scrutiny.

Table 2.2 shows the results on the fidelity of implementation of the independent variable obtained for the three participants.

Table 2.2. Fidelity of Implementation across Participants.

Independent Variable	P002	P003	P004
Experimenter lifts the cover and exposes the target within three seconds of participant putting reinforcer in mouth and showing hands free.	97%	98%	92%
Experimenter covers the target within 3 seconds of completion of response requirement.	96%	99%	100%
Participant gains access to reinforcer 3 seconds after completion of response requirement	96%	98%	100%
During extinction, experimenter withholds reinforcement following each instance of response	100%	100%	100%

3 CHAPTER Experiment 1

The purpose of Experiment 1 was to examine the effects of variable schedules of reinforcement on the force and rate of response during extinction. The experiment provided an analog for clinical situations in which problem behaviour was maintained by intermittent reinforcement and subsequently placed on extinction. One participant (Participant 2)) took part in Experiment 1.

3.1 Experimental Design

An ABAB reversal design was used to evaluate the impact of intermittent reinforcement schedules on the force and rate of responses during extinction. The design had two conditions: A, consisting of intermittent reinforcement; and B, extinction. These conditions were repeated once within the reversal design. To minimize potential sequence effects, I kept the conditions in place only until stability criteria were met for each experimental phase.

3.2 Procedure

Procedures for the two conditions of Experiment 1 are described below.

3.2.1 Intermittent reinforcement. During each five-minute session, I delivered reinforcers for target behavior. In the early stages of the experiment, the participant was reinforced on a VR3 schedule. If the participant did not require a second prompt to engage in the response, I moved to the next schedule of reinforcement (i.e., VR3 to VR5). At the conclusion of the first day of sessions in Experiment 1, Participant 2 reached the criteria to move to the VR5 schedule of reinforcement. During the intermittent reinforcement phase, the criteria for reversing to the extinction phase were three consecutive data points showing a stable level of response.

3.2.2 Extinction. During extinction, I no longer delivered or gave access to preferred reinforcers contingent on correct responses. During this phase, the criteria for returning to the intermittent reinforcement phase were two consecutive sessions of zero or near-zero rates of the response.

3.3 Results for Experiment One

Figure 3.1 shows the results of force and rate under variable ratio (VR5) and extinction (EXT). During the first VR5 phase, moderate levels of force (i.e., > 1 lb. and < 3 lb.) were observed with a temporary increase of force followed by a rapid decline. Stable, low levels of force (i.e., < 1 lb.) were observed at the end of the VR5 phase. The average level of force during the first VR5 phase was 1.32 lb. Rate of response exhibited a stable, moderate level with little to no variability and a slight increasing trend. Average rate during the first VR5 phase was 21.46 responses per minute (RPM). Rate and force covaried in opposite directions; that is, as rate gradually increased and remained stable, force decreased and stabilized.

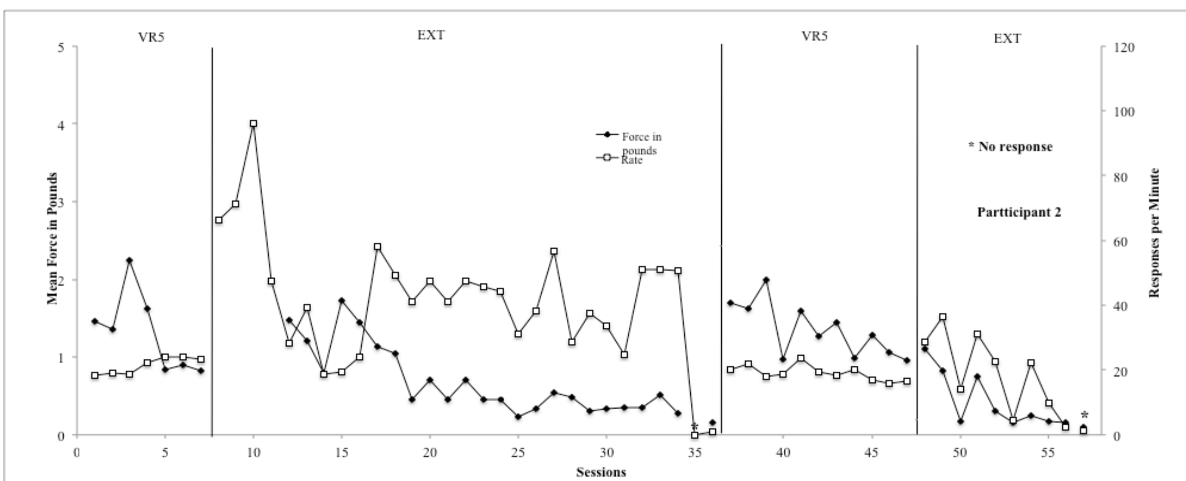

Figure 3.1. Data on peak response force and response rate under conditions of VR5 EXT for Participant 2. *Note*: VR5= variable ratio; EXT = extinction.

Upon introduction of the EXT phase, an initial high rate of response by Participant 2 interfered with the recording of force data when using the force measurement apparatus. As a consequence, data on force were not accurately recorded for the first 5 EXT sessions. I stabilized the device by using Velcro to attach it to the table and by adding soft pads between the sensor and cover to remove unwanted vibration caused by the high rate of response. In addition, I used a Blue Band Aid sticker to replace the blue sticker originally used to direct the response of the participant to the target. After stabilization of the apparatus and change in visual cue for responses, accurate measurement of force data was observed. Once accurate measurement of force was established, sessions 6 and 7 of the EXT phase showed evidence of an initial moderate increase in level of force followed by a gradual reduction of force, consistent with a pattern of extinction burst followed by reduction in responding. Force remained low for the rest of the EXT phase. In comparison to the previous VR5 phase, during the EXT phase the average level of force decreased to 0.64 lb., representing a 0.68 lb. average decrease in force.

During the first EXT phase, response rate presented a more complex pattern that required analysis and an adjustment in research procedures. At the start of the EXT phase, an extinction burst of approximately 100-RPM (responses per minute) was evidenced. After this dramatic increase in response rate, a steeply decreasing trend and lower level of responses was evident across the next 6 sessions. However, a sudden upsurge of rate occurred during session 17 that lasted until session 34. Across these next 18 sessions, the rate of response manifested a high level with moderate variability. Average rate during these 18 sessions was 43 RPM. Given these unexpected results, I hypothesized that although the tangible reinforcer was removed there inadvertently might be another functional reinforce maintaining the behaviour. More specifically, I hypothesized that my presence as the experimenter, who consistently had been giving access to reinforcement, may have acquired reinforcing value. Given this hypothesis, beginning with session 32, after setting up the EXT condition, I removed my presence from the experimental setting. This change in procedure was initially associated by a temporary increase in force for 3 consecutive sessions followed by a dramatic decrease in Participant 2's rate of responses to zero or near zero levels during the 35-36th sessions, and the achievement of criteria for movement to the next phase of the ABAB design. In comparison to the initial VR5 phase, response rate increased to an average of 39.49 RPM, representing an average 18.03 increase in RPM. Similar to the overall pattern of data in the VR5 phase, during the EXT phase, rate and force co-varied in opposite directions until the end of the phase. As rate increased and stabilized at a high level, force decreased and showed a consistent declining trend.

During the second VR5 phase, Participant 2 evidenced a precipitous increase to moderate levels of force followed by a decreasing trend with moderate variability. In comparison to the previous EXT phase, the average level of force increased to 1.35 lb., representing an average 0.61 lb. increase in force. The average level of force during the second VR5 phase closely matched the average level of force during the first VR5 phase. In contrast, Participant 2 evidenced a stable, moderate rate of responding with little variability. In comparison to the previous EXT phase, average rate during the second VR5 phase decreased to 19 RPM, representing a 20.49 lb. average decrease in rate of response. This average rate of response closely matched the average rate during the first VR5 phase. In regard to covariance of force and rate, during the second VR5 phase, force showed a moderate level that decreased over sessions while rate showed a moderate level that maintained throughout the phase. These patterns also closely matched the pattern of covariance evidenced in the first VR5 phase.

During the second EXT phase, Participant 2 evidenced a slight increase in force compared to the last session in the previous VR5 phase, thus exhibiting little to no extinction burst upon re-introduction of the EXT phase. Force then showed a decreasing trend to near zero levels by the end of the phase. The average level of force during the second EXT phase was .40.

This represented an average 0.95 lb decrease in force in comparison to the previous VR5 phase. In contrast to force data, Participant 2 showed an immediate increase in rate of response, consistent with an extinction burst. This high rate of responding was followed by a decreasing trend to near zero levels by the end of the phase. In comparison to the previous VR5 phase, the average rate during the second EXT phase decreased somewhat to 17.26 RPM, representing a 1.74 reduction in RPM. Interestingly, in the first EXT phase, Participant 2 reached criteria for termination of the phase (i.e., zero or near zero levels of response) in 29 sessions while in the second EXT phase, Participant 2 reached termination criteria in one-third the time, 10 sessions. This more rapid movement to extinction levels of response may be attributed to learning that took place during the first extinction phase (i.e., a multiple treatment interaction effect) paired with the revision in procedure that removed all sources of reinforcement (i.e., tangible and experimenter attention). In regard to covariation during the second EXT phase, force and rate showed parallel patterns; that is, a relatively high level decreasing to near zero levels by the end of the phase.

Figure 3.2 shows the percentage of levels of response force during the first and the last day of the two EXT phases. Levels of response force ranged from a low of 0.50 lb. to a high of > 3.5 lb. During the first day of the first EXT phase, Participant 2 exhibited 60% of responses in the low range of force and the remaining 40% of responses distributed across moderate to high ranges of force. During the last day of the first EXT phase, Participant 2 showed an increase to 90% of responses in the low ranges of force, a decrease to 10% of responses in the moderate ranges of force, and a decrease to 0% of responses in the highest range of force (i.e., > 3.5 lb.).

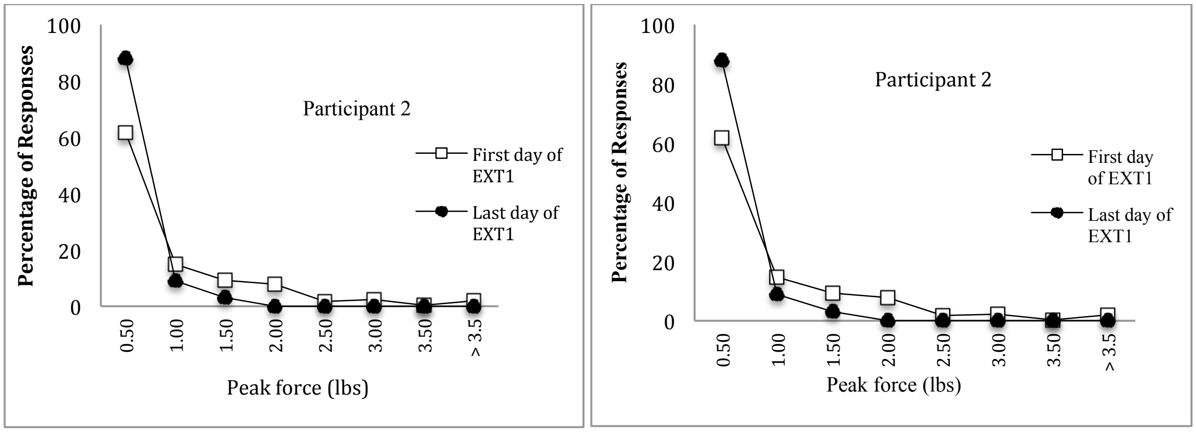

Figure 3.2. Percentage of distribution of *response force* for Participant 2 on the first and last day of extinction before the rate of response dropped to zero or near zero levels.

During the second EXT phase, Participant 2 showed a similar pattern with a different distribution of force that could be attributed to the occurrence of a smaller number of responses. During the first day of the second EXT phase, Participant 2 exhibited 20% of responses distributed across low ranges of force and the remaining 80% distributed across moderate to high ranges of force. During the last day of the second EXT phase, Participant 2 showed an increase to almost 60% of responses in the low ranges of force and a decrease to 40% of responses in the moderate to high ranges of force.

In summary during the VR5 phase, force showed initial high levels, which decreased to lower levels by the end of the phase. Rate showed moderate, stable levels throughout the phase. During the EXT phase, force showed an increase in comparison to the last data point in the VR5 phase, offering evidence of an extinction burst. This was followed by a decrease in force to low or near zero levels by the end of the phase. Rate also showed an increase in comparison to the last data point in the VR5 phase, offering additional evidence of an extinction burst. This was followed by a gradual (first EXT phase) or relatively rapid (second EXT phase) decrease to near zero levels across the EXT phase. The gradual decrease in rate of response during the first EXT phase was attributed to an unanticipated extraneous source of additional reinforcement (i.e., experimenter presence) which one removed, was associated with a decrease in rate of response to near zero levels. In regard to the distribution of force levels during the extinction phases, Participant 2 engaged in more forceful responses during the first day of the EXT phase and fewer forceful responses during the last day of the EXT phase.

4 CHAPTER Experiment 2

The purpose of Experiment 2 was to examine the effects of a variable ratio schedule of reinforcement followed by a continuous schedule of reinforcement on force and rate of responses during extinction. The difference between Experiment 1 and Experiment 2 was the introduction of a continuous schedule of reinforcement (CRF) before introducing extinction. This model provided an analog for clinical situations in which problem behaviour that was maintained by intermittent reinforcement is placed on a pretreatment strategy of continuous reinforcement before being placed on extinction.

4.1 Experimental Design

An ABCABC reversal design was used to evaluate the impact of intermittent reinforcement followed by a continuous reinforcement schedule on the force and rate of responses during extinction. The design had three conditions: A, consisting of a VR5 schedule of reinforcement; B, consisting of a continuous schedule of reinforcement (CRF 1); and C, extinction. These conditions were repeated once within the design.

4.2 Procedure

Procedures for the three conditions of Experiment 2 are described below.

4.2.1 Intermittent reinforcement. The procedures of intermittent reinforcement were identical to those described in Experiment 1. During each five-minute session delivered reinforcers for target behavior. In the first session of the experiment, the participant was reinforced on a VR3 schedule. If the participant did not require a second prompt to engage in the response, I moved to the next schedule of reinforcement (i.e., VR3 to VR5). Criteria for moving to the continuous reinforcement phase were three consecutive data points showing a stable level of response.

4.2.2 Continuous reinforcement. I delivered reinforcement to the participant following each correct response, (i.e., CRF 1 schedule of reinforcement). Criteria to move to the extinction phase were, as before, three consecutive data points showing a stable level of response.

4.2.3 Extinction. These conditions were identical to that described in Experiment 1. During extinction, I no longer delivered or gave access to preferred reinforcers contingent on correct responses. As before, the criteria for returning to the intermittent reinforcement phase were two consecutive sessions of zero or near-zero rates of the response.

4.3 Results for Experiment Two

The results for Participant 3 and Participant 4 are shown below.

4.3.1 Participant 3. Figure 4.1 shows the results for Participant 3 of force and rate under variable ratio (VR5), continuous reinforcement (CRF) and extinction (EXT conditions. During the first VR5 phase, high levels of force were observed with a temporary increase of force followed by an abrupt decline. A decreasing trend to low and moderate levels of force was observed during the last four sessions of the VR5 phase. The average level of force during the first VR5 phase was 1.28 lb. Participant 3 evidenced an increasing trend in rate of response from initial low levels to moderate levels by the end of the phase. Average rate during the first VR5 phase was 21.9 RPM. Rate and force covaried in opposite directions; that is, as rate increased and stabilized, force decreased and stabilized.

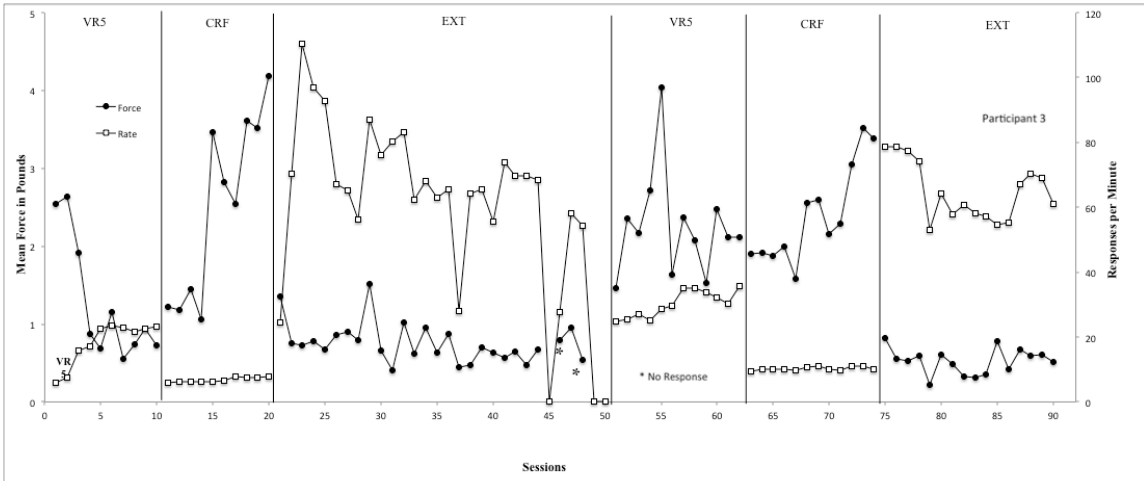

Figure 4.1. Data on peak response force and response rate under conditions of VR5, CRF, and EXT for Participant 3. *Note*: CRF= continuous reinforcement; VR5 = variable ratio 5; EXT = extinction.

Upon introduction of the first CRF phase, Participant 3 showed moderate levels of force that dramatically increased to very high levels by the end of the phase. In comparison to the previous VR5 phase, the average level of force during the first CRF phase increased to 2.51 lb., representing an average increase of 1.23 lb. In contrast to force data, Participant 3 exhibited a low and stable level of rate of response throughout the CRF phase. In comparison to the previous VR5 phase, the average rate during the CRF phase decreased to 6.9 RPM, representing an average decrease of 15.0 RPM. During the phase, rate and force covaried differently. While force evidenced a steep, increasing trend from moderate to very high levels, rate showed a low and stable level throughout the phase.

Upon introduction of the first EXT phase, Participant 3 evidenced a precipitous drop in force to low levels in the first session, followed by a low and stable trend for the next 7 sessions. A sudden upsurge in force occurred during the next session but this was followed by a decrease to low to moderate levels of force across the next 18 sessions. In comparison to the previous

CRF phase, during the EXT phase the average level of force decreased to 0.73 lb., representing an average decrease of 1.78 lb.

In contrast to force during the first EXT phase, Participant 3's response rate presented a more complex pattern that bears description and analysis. Overall, the average rate of response during the first EXT phase increased to 60.1 RPM. This represented a leap of 53.2 RPM compared to the previous CRF phase A gradual, decreasing trend from very high levels to zero levels, with much variability, can be seen across the 29 sessions within the phase. However, a within phase analysis reveals a cyclical pattern of steeply increasing rates of response followed by steeply decreasing rates of response. This pattern is described below followed by an analysis of the pattern and a description of a modified condition based on this analysis.

At the onset of the EXT phase, response rate increased dramatically across 3 sessions to an exceedingly high level (i.e., 110 RPM), providing evidence of an extinction burst. Response rate then showed a steeply decreasing trend across the next 5 sessions to lower but still high levels (55-60 RPM). A second escalation of rate occurred during session 29 to 85 RPM but decreased to 28 RPM over the next 8 sessions. A third escalation of rate occurred at session 38 to 60 RPM and rose to 70 RPM over the next 6 sessions but then fell to a rate of zero (0) during session 45. A final escalation of rate occurred at session 46 to 55 RPM but then fell again to a rate of zero (0) during the final two session of the EXT phase.

In regard to analysis, I hypothesized that the recurring pattern of increasing rate followed by decreasing rate was due to the presence of an additional source of reinforcement that served to maintain and strengthen responding. Although I removed access to the tangible reinforce during EXT, I did not remove myself from the experimental room. I was visible to the participant during the first 13 sessions. I hypothesized that my presence as the experimenter, who consistently had been giving access to reinforcement, may have acquired reinforcing value. Given this hypothesis, beginning with session 14, after I set up the EXT condition, I removed myself from the experimental setting. This change in the experimental condition was associated with an acceleration of the cycle of increasing and decreasing rates of responding until Participant 3 fell to a zero rate of responding during sessions 49 and 50, thus finally meeting the criteria for termination of the phase. Regarding covariation during the first EXT phase, force and rate covaried differently. As rate increased to very high levels and then gradually decreased in a cyclical pattern to zero levels, force evidenced a moderate level that gradually decreased to lower levels of force with little variability.

During onset of the second VR5 phase, Participant 3 exhibited an immediate increase in level of force followed by a steeply increasing trend to very high levels of force across four sessions. Force then fell to moderate levels, which stabilized by the end of the VR5 phase. In comparison to the previous EXT phase, the average level of force increased to 2.26 lb., representing an average increase of 1.53 lb. During the reversal to VR5, the rate of response immediately increased to moderate levels of approximately 30 RPM, and then gradually climbed to approximately 40 RPM. In comparison to the previous EXT phase, the average rate of response decreased to 30.3 RPM. This represented an average decrease in rate of 29.7 RPM. When comparing the first and second VR5 phases, Participant 3 showed an increase of 8.4 RPM during the second VR5 phase.

During onset of the second CRF phase, Participant 3 evidenced a small, stable decrease in force that rose to high levels of force (> 3.0 lb.) across eight subsequent sessions. In comparison to the previous VR5 phase, the average level of force increased slightly to 2.4 lb. representing an average increase of .14 lb. The overall level and trend of force data closely matched that of the first CRF phase. During the second CRF phase, Participant 3 showed an immediate and substantial drop in response rate to low, stable levels, which continued throughout the phase. In comparison to the previous VR5 phase, the average rate during CRF decreased to 10 RPM, representing an average decrease of 20.3 RPM. The low, stable level of rate of responses matched that observed in the first CRF phase.

Upon reintroduction of the second EXT phase, Participant 3 evidenced a precipitous reduction in level of force to low levels that remained consistently low over the next 16 EXT sessions. In comparison to the previous CRF phase, the average level of force during the reversal to EXT decreased to 0.53 lb., representing an average decrease of 1.83 RPM. By comparison, the level of force observed in the first EXT was 0.73 lb. This represented a minimal decrease of 0.20 lb. during the second EXT phase. Upon reintroduction of the second EXT phase, Participant 3 showed an immediate increase in rate of response, consistent with an extinction burst, to 78.8 RPM. This rate was stable at that level until session 79 when a drop in rate to 53.2 RPM occurred. This level of rate remained stable until session 87, when rate of response rose to approximately 70 RPM at the end of the phase. In comparison to the previous CRF phase, average rate during the second EXT phase increase to 61 RPM, representing an average increase of 51 RPM. This average rate of response during the second EXT phase closely matched the average rate during the first EXT phase.

Due to time limitations, in consultation with my thesis supervisor, I terminated the study after 16 sessions in the second EXT phase (session 90 overall). For this reason, a data path for rate leading to the criterion for termination of the EXT phase (2 consecutive sessions with zero to near zero responses) was not observed.

Figure 4.2 shows the percentage of levels of force for Participant 3, ranging from a low of

0.50 lb. to a high of > 3.5 lb., during the first and the last day of the two EXT phases. During the first day of the *first* EXT phase, Participant 3 exhibited 53% of responses in the low range of force, while the remaining 47% of responses were distributed across the moderate to high ranges of force. During the last day of the *first* EXT phase, Participant 3 showed 55% of responses in the low range, similar to the first day of EXT. However, Participant 3 exhibited 45% of responses in the moderate ranges, and no responses in the high range of force.

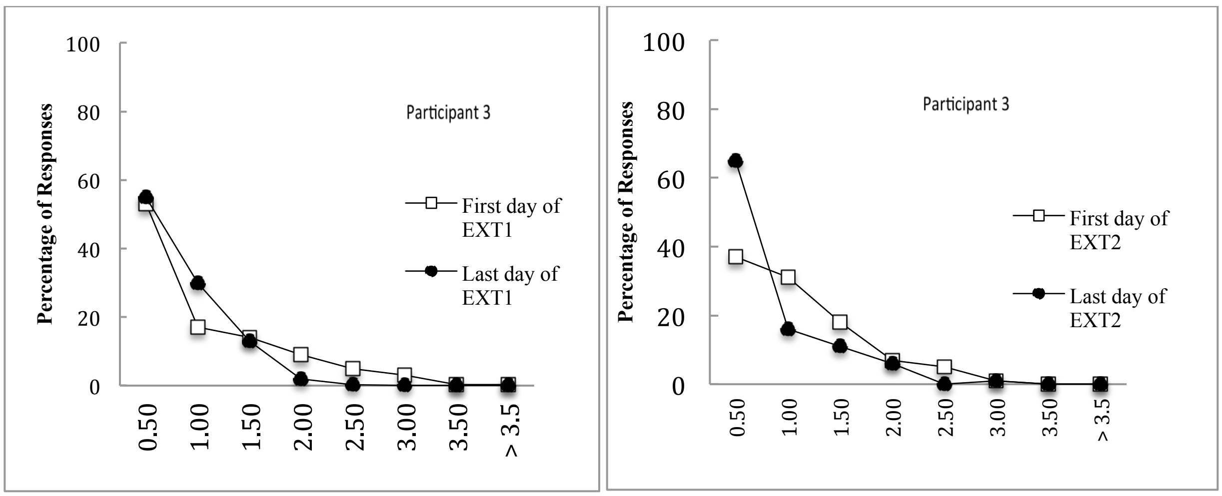

Figure 4.2. Relative frequency distribution of *peak force* of response for *Participant 3* on the first and last day of extinction 1 and extinction 2 respectively, before the rate drops to zero or near zero levels.

During the first day of the *second* EXT phase, Participant 3 showed 37% of responses distributed across a low range of force and the remaining 63% across moderate levels of force. Interestingly, responses within the high range of force were not observed on the first day of the second EXT phase. During the last day of the *second* EXT phase, Participant 3 showed an increase to 65% of responses in the low range of force with a corresponding decrease to 35% of responses in the moderate range of force.

In summary, during Experiment 2 with Participant 3, the VR5 phase and CRF phase preceding the EXT phase were associated during EXT with a precipitous decrease in force to low, stable levels, and a precipitous increase in rate to high levels that appeared to be resistant to extinction. Across the two EXT phases, percentage of different levels of force on the first and last days of the EXT phase, ranging from low to high, offer evidence that Participant 3 was responding more forcefully during the first session and less so during the final session.

4.3.2 Participant 4. Figure 4.3 shows the results for Participant 4 of force and rate of response during VR5, CRF and EXT phases that are repeated in the ABCABC single case reversal design. During the first VR5 phase, Participant 4 exhibited moderate to high levels of force within a cyclical pattern of increase and decrease in force with high variability. An overall decreasing trend to low levels of force can be seen through session 13. However, beginning with session 14, a dramatic rise in force to high levels was observed that stabilized during the last 2 sessions of the VR5 phase. Across the VR5 phase, the average level of force was 1.88 lb. At the start of the VR5 phase, Participant 4 evidenced a relatively low rate of response (i.e., 10 RPM) that increased steadily across the phase to a moderate rate of response (i.e., 15-20 RPM). The average rate during the VR5 phase was 16.29 RPM.

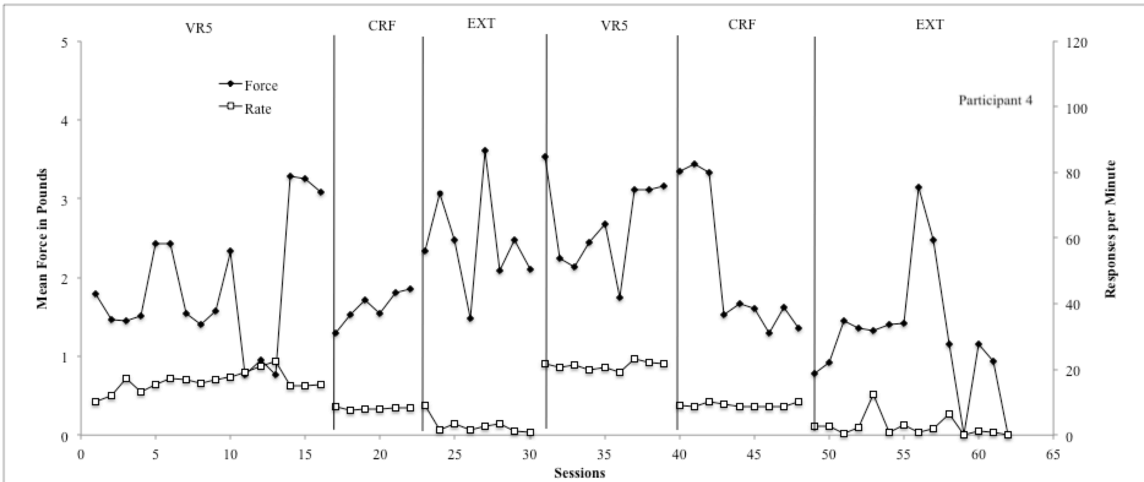

Figure 4.3 Data on peak response force and response rate under conditions of VR5, CRF, and EXT for Participant 4. *Note*: CRF= continuous reinforcement; VR5 = variable ratio 5; EXT = extinction.

During the first CRF phase, Participant 4 showed an immediate decline to a moderate level of force. In addition, a slight accelerating trend was evidenced. Variability remained minimal. In comparison to the previous VR5 phase, the average level of force during the first CRF phase decreased slightly to 1.73 lb. During the first CRF phase, Participant 4 evidenced a stable, low level of rate of response. In comparison to the previous VR5 phase, the average rate of response deceased to 8.23 RPM, representing an average decrease of 8.06 RPM. In regard to covariance of force and rate during the first CRF phase, force maintained a moderate increasing trend with minimal variability while rate maintained a low, stable level.

During the first EXT phase, Participant 4 evidenced an immediate increase to moderate to high levels of force with much variability across the first 5 sessions, suggesting that an extinction burst occurred. This was followed by a sharp decrease to moderate levels of force that stabilized during the last 3 sessions of the EXT phase. In comparison to the previous CRF phase, the average level of force increased to 2.47 lb., representing a 0.74 lb. average increase in force.

During the first session of the EXT phase, Participant 4 evidenced a slight increase in rate compared to the last session in the CRF phase. Participant 4 then showed a precipitous decline in rate to low levels that remained stable until the end of the phase. In comparison to the previous CRF phase, the average rate of response during EXT decreased to 2.09 RPM, which represented an average decrease of 5.33 RPM. Force and rate during EXT covaried in different directions; that is, force showed high and variable levels while rate of response showed a consistent decreasing trend with little variability.

A reversal to a second VR5 phase was implemented after the first EXT phase. Participant 4 exhibited an immediate increase to a high level of force (i.e., > 3). However, this just as swiftly dropped to moderate levels of force (i.e., between 1 and 2 lb.). In comparison to the previous EXT phase, the average level of force increased to 2.69 lb., representing a 0.22 lb. average increase in force. During the VR5 phase, Participant 4 showed an immediate increase in response rate to moderate levels that maintained throughout the phase. In comparison to the previous EXT phase, the average rate of response for Participant 4 increased to 21.16 RPM, which represented an average increase of 19.07 RPM.

In terms of covariation during VR5, Participant 4 showed different patterns of force and rate of response. Force began at a high level but decreased to a moderate level before rising and stabilizing at a high level at the end of the phase. Rate of response, however, began at a moderate level and maintained, with only modest variability, this level throughout the phase.

During the second CRF phase, Participant 4 showed a slight increase in force across the first three sessions when compared to the high level of force evidenced during the final three sessions of the previous VR5 phase. However, during the 4th session, a precipitous drop in force to a moderate level was observed and this level of force remained stable for the remainder of the

CRF phase. In comparison to the previous VR5 phase, the average level of force in the second CRF phase decreased to 2.13 lb., which represented a 0.56 lb. average decrease in force.

During the second CRF phase, Participant 4 showed a rate of response that was low and stable throughout the phase. In comparison to the previous VR5 phase, the average rate of response decreased to 9.13 RPM, representing an average 12.03 decrease in rate of response. During the second CRF phase, force and rate evidenced a similar pattern of covariation after the third session, in which force was stable at a moderate level and rate of response was stable at a low level.

During the second EXT phase, Participant 4 exhibited an immediate decrease in force to low levels in session 49, followed by an increasing trend that reached a high level of force during session 56, an increase that may represent a delayed extinction burst. After this increase, Participant 4 evidenced a steep decrease in force to low and zero or near zero levels, with the termination criteria being reached during sessions 61 and 62. In comparison to the previous CRF phase, the average level of force decreased to 1.25 lb., which represents a 0.88 lb. average decrease in force. Similar to force data, Participant 4 showed an immediate decrease in rate of response followed by a variable pattern that evidenced a decreasing trend across the final phase of the ABCABC design. During session 53, the brief elevation of rate to a moderate level may represent a weak extinction burst that quickly returned to low rates of responding. The termination criteria of zero to near zero rates of response were observed in sessions 61 and 62. In comparison to the previous CRF phase, the average rate during the second EXT phase decreased to 2.57 RPM, representing a 6.56 reduction in average RPM.

A parallel pattern of covariance between force and rate was observed during the second EXT. That is, force and rate presented high levels of variability with initially an indeterminate trend. However, in terms of level, force was recorded at higher levels while the rate remained at low to moderate levels.

Summarizing the results of Participant 4 in Experiment 2, force showed variability across moderate to high levels of force during VR5 phases. During CRF phases, Participant 4 exhibited moderate levels of force with relatively stable levels by the end of the phase. During the EXT phases, immediate or delayed extinction bursts of force were observed. In regard to rate of response, during the VR5 phases, Participant 4 demonstrated moderate to high levels of rate of response with an increasing trend. In contrast, CRF phases evidenced low, stable rates of response. Finally, during the two EXT phases, rate of response quickly fell to very low levels, a result consistent with the laws of behavior as they relate to extinction and its effects.

5 CHAPTER Discussion

5.1 Summary of Results

For each participant and experiment, I examined the pattern of force and rate data in each reversal design to determine if a functional effect was documented across four dimensions of results after onset of EXT after VR5 (Experiment 1) or after VR5 + CRF (Experiment 2). These dimensions were: (a) immediacy of effect during EXT; (b) average level during EXT; (c) trend during EXT; and (d) variability during EXT.

In Experiment 1, the following research question was investigated: In clinical populations, does the introduction of a variable ratio schedule before the implementation of extinction affect the level, trend and/or variability of force and rate of response during extinction? Results of Experiment 1 are interpreted below.

In regard to immediacy of effect *for force* during EXT following VR5, results for Participant 2 documented a basic effect during the first EXT phase, as an immediate increase in force was observed at the onset of the EXT phase. However, an immediate increase in force was not observed at the onset of the second EXT phase. Thus, a functional effect was not documented for immediacy of effect when moving from VR5 to EXT. The absence of an immediate increase in force at the onset of the second EXT phase may be attributed to multiple treatment interference.

In regard to changes in average level of force from VR5 to EXT, a decrease in average level was observed in both the first and second EXT phase, which suggests a functional effect for average level of force. However, the 5 missing sessions at the start of the first EXT phase due to instrumentation problems make this assertion less certain.

In regard to trend of force, the EXT phases did not show a change in trend following VR5, with both conditions revealing a decreasing trend. Thus, a functional effect for trend of force was not observed

In regard to variability of force, the EXT phases did not show a change in variability following VR5, with both conditions revealing a moderate amount of variability in force. Thus, a functional effect for variability of force was not observed.

In regard to an immediacy of effect for *rate of response* during EXT following VR5, onset of both the first and second EXT phases evidenced an immediate and dramatic increase in rate of responding. These results document a functional relation between a previous VR5 schedule of reinforcement and an immediate increase in rate at the onset of EXT.

In regard to average level of rate of response during EXT following VR5, although Participant 2 showed an increase in level of rate during the first EXT phase, this increase in level was not replicated during the second EXT phase. Thus, a functional relation between a previous VR5 and a change in average level of rate of response was not demonstrated. The absence of an increase in rate of responding during the second EXT phase may be attributed to multiple treatment interference effects, as Participant 2's prior exposure to the first EXT phase may have served as an establishing operation that decreased the value of responding during the second onset of EXT conditions

In regard to the trend of *rate of response* during EXT following VR5, both EXT phases evidenced a decreasing trend in rate of responding in contrast to a slightly increasing or stable trend during the previous VR5 phases. These results indicate a functional relation between a previous VR5 schedule and a decreasing trend in rate of responding during EXT.

In regard to variability of rate of response during EXT following VR5, both EXT phases evidenced an increase in variability relative to the previous VR5 schedule, thus documenting a functional relation between a previous VR5 schedule and an increase in variability of rate of response during EXT.

Overall, results documented a functional relation between a VR5 schedule of reinforcement and an immediate increase in rate of response during EXT, a decrease in trend of rate of response during EXT, and an increase in variability of rate of response during EXT. No clear functional relations were documented for force of response across immediacy of effect, level, trend and variability during EXT.

In Experiment 2, the following research question was investigated: In clinical populations, does the introduction of a variable ratio schedule followed by the implementation of a continuous schedule before the implementation of extinction affect the level, trend and/or variability of force and rate of response during extinction? Results of Experiment 2 for Participant 3 and Participant 4 are interpreted below.

In regard to immediacy of effect *for force* during EXT following CRF, results for Participant 3 showed an immediate and abrupt decrease of force across the first and second introduction of EXT after VR5 + CRF, which demonstrated a functional effect for immediacy of effect when moving from VR5 + CRF to EXT.

In regard to changes in average level of force from VRF + CRF to EXT, a dramatic decrease in average level was observed in both the first and second EXT phase, which suggests a functional effect for average level of force.

In regard to trend of force, following a steeply increasing trend in VR5 + CRF phases, a drop to low levels of force with a relatively stable trend was manifested in both the first and the second EXT phase. Therefore, a functional effect was documented for trend.

In regard to variability of force, high variability in force in both VR5 + CRF phases changed to low levels of force with low variability during both EXT phases. Thus, a functional effect for variability of force was observed.

In regard to immediacy of effect for *rate of response* during EXT following VR5 + CRF, onset of both the first and second EXT phases evidenced an immediate and dramatic increase in rate of responding. These results document a functional relation between previous VR5 + CRF schedules of reinforcement and an immediate increase in rate at the onset of EXT.

In regard to average level of rate of response during EXT following VR5 + CRF, Participant 3 showed a sharp increase to a high level of rate during the first EXT phase that was replicated during the second EXT phase. Thus, a functional relation between a previous VR5 + CRF and an increase in average level of rate of response was demonstrated.

In regard to the trend of rate of response during EXT following VR5 + CRF, both EXT phases manifested a high level and decreasing trend in rate of responding in contrast to the low level and stable trend during the immediately previous CRF phases. These results indicate a functional relation between the previous VR5 + CRF schedules and a decreasing trend in rate of responding during EXT.

In regard to variability of rate of response during EXT following VR5 + CRF, both EXT phases showed a clear increase in variability of rate of response compared to the immediately previous CRF phases which showed a low, stable level of rate of response. Given these results, a functional relation was observed between previous VR5 + CRF schedules and an increase in variability of rate of response during EXT.

Overall, results for Participant 3 documented a functional relation between a VR5 + CRF schedule of reinforcement and: (a) an immediate decrease in force during EXT, (b) a decrease in average level of force during EXT, (c) a change in trend of force to low and stable levels during EXT, and (c) a change in variability of force to low and stable levels of force during EXT. Results also documented a functional relation between a VR5 + CRF schedule of reinforcement and (a) an immediate increase in rate of response during EXT, (b) a decreasing trend in rate of response during EXT, and (c) a significant increase in variability of rate of response during EXT.

In regard to immediacy of effect *for force* during EXT following VR5 + CRF, results for Participant 4 documented a basic effect during the first EXT phase, as an immediate increase in force was observed at the onset of the EXT phase. However, at the onset on the second EXT phase an immediate decrease in force was observed. That is, there was an immediate effect but in opposite direction. Thus, a functional effect was not documented for immediacy of effect when moving from VR5 + CRF to EXT. The presence of a decrease in force at the onset of the second EXT phase may be attributed to multiple treatment interference.

In regard to changes in average level of force from VR5 + CRF to EXT an increase of level force is recorded during the first EXT phase. However, the second EXT phase showed a decrease in level of force. Participant 4 documented a basic effect during the first and second EXT phase. However, since the change in level was in opposite direction, a functional effect was not demonstrated.

In regard to trend of force, Participant 4 showed a slightly decreasing trend during the first introduction of EXT, and a decreasing trend during the second introduction of extinction. Therefore, a functional effect was documented for trend.

In regard to variability of force during EXT after VR5 + CRF, the EXT phases evidenced an increase in variability during the first and second introduction of EXT. Thus, a functional effect for variability of force after VR5 + CRF was observed.

In regard to an immediacy of effect for *rate of response* during EXT following VR5 + CRF, onset of the first EXT phase documented a substantial decrease in level by the second session within the EXT phase; during the second EXT phase, Participant 4 evidenced an immediate decrease in rate of responding. These results document a functional relation between previous VR5 + CRF schedules of reinforcement and an immediate decrease in rate at the onset of EXT.

In regard to average level of rate of response during EXT following VR5 + CRF, Participant 4 showed a decrease in level of rate during both the first and second EXT phases. Thus, a functional relation between previous VR5 + CRF conditions and a decrease in average level of rate of response was demonstrated.

In regard to the trend of *rate of response* during EXT following VR5 + CRF, a stable trend during the previous CRF phases was followed by a stable or slightly decreasing trend during the following EXT phases. Due to the absence of meaningful change between conditions, a functional effect between the immediately preceding CRF and a change in the trend of the rate of response during EXT was not documented.

In regard to variability of rate of response during EXT following VR5 + CRF, both the previous CRF phases and the following EXT phases showed a similar pattern of little to no variability. Therefore, a functional relation between the immediately preceding CRF schedule of reinforcement and a change in the variability of the rate of response during EXT was not documented.

Overall, results for Participant 4 documented a functional relation between the preceding CRF schedule of reinforcement and a decrease in trend of force during EXT. A functional effect also was documented between the preceding CRF and an increase in the variability of force during EXT. However, a functional relation was not documented between the preceding CRF schedule of reinforcement and an immediate change in force level at the onset of EXT, or in average level of force during EXT.

Results on rate of responding documented a functional relation between the preceding CRF schedule of reinforcement and an immediate decrease in rate during the onset of EXT. A functional effect also was documented between the preceding CRF and a decrease in average level of rate of responding during EXT. However, because a stable trend was observed during both CRF and EXT conditions, a functional relation between the previous CRF and changes in trend during EXT was not documented. Also, because a similar pattern of variability was evident in both the CRF and EXT conditions, a functional relation between the previous CRF schedule of reinforcement and changes in variability during EXT was not documented.

5.2 Findings in Relation to Literature

The present study offers new evidence on the effects of schedules of reinforcement on the force of the response. However, some conflicting conclusions with the existent literature can be put forward. For example, for Participant 3, the mean peak force observed during extinction was consistently lower after CRF. In the case of Participant 4, the results were mixed, as during the first EXT phase there was evidence of an increase in force that was not replicated during the second EXT phase. Previous research (Blixt & Ley, 1969; Morris, 1968; Notterman, 1959; and Notterman & Mintz, 1965) documented higher forces during EXT than during CRF. Skinner (1938) concluded that organisms engaged in minimal response effort to produced reinforcement during CRF, however, the participants exposed to the sequence VR5-CRF exhibited responses well above the limit required to receive reinforcement (0.07 lb).

Skinner (1938) also stated that organisms exhibited sudden increases in force upon the introduction of EXT. Contradictory results were observed in the participants of this study. For example, Participant 2 exhibited increased levels of force during the first EXT phase but not during the second EXT phase. Participant 3 consistently demonstrated low levels of force across both extinction phases. Lastly, Participant 4 evidenced high levels of force during the first EXT but this level of force was not replicated during the second EXT. Skinner (1938) advanced that intermittent schedules of reinforcement produced higher levels of force than continuous schedules of reinforcement. In regards to VR5 followed by EXT, Participant 2 did not show higher levels of force during EXT than during VR5. Similarly, Participant 3, showed lower levels of force during EXT than during CRF. Conversely, Participant 4 exhibited higher levels of force during the first EXT phase than during CRF but lower levels of force during the second EXT phase than during the second CRF phase.

Lerman and Iwata (1996) argued that a history of intermittent reinforcement would produce greater resistance to extinction, increased variability and elevated rates of response. The results recorded in Participant 2 partially corroborated these findings. Higher levels of rate, with increase variability and a long extinction process, were documented across the first EXT phase. Unfortunately, this initial result was not replicated in the second introduction of EXT.

Notterman and Mintz (1965) concluded that as extinction progressed the force and variability of force would increase; Participant 4 confirmed this results, as this participant exhibited an increase in force and variability during EXT. However, Participant 2 and 3 showed mixed results; Participant 2 exhibited low force and slight variability that subsided to a stable pattern. Participant 3, showed an overall low level of force and high variability with a tendency toward stability toward the end of the phase.

By comparing the results of the present study with the extant literature, some conflicting findings appear to have been found. However, we should keep in mind that the present study introduced novel combinations of schedules of reinforcement as independent variables (i.e. VR5-CRF), and VR5 alone. Unfortunately, no research currently available has specifically examined the effects of variable ratio on the force and rate of response or the combination of VR5 and CRF on the force and rate of response. Therefore, the reader should take these results as preliminary but worthy of clinical consideration.

5.3 Implications

Analysis of the results of this study offer four implications for practitioners working with individuals who display severe problem behaviour or for researchers who are interested in the analysis of force of problem behaviour.

5.3.1 Covariation between force and rate. Results across the three participants demonstrated systematic variance between schedules of reinforcement operating prior to extinction and changes in level, trend, and/or variability in force and rate of the response. Most importantly, force and rate, as a result of the introduction of one or two schedules of reinforcement, varied systematically but differently for each individual. For example, during EXT, Participant 2 and 3, exhibited a stable level low level of force, while rate was elevated and variable. However, Participant 4 during EXT exhibited high levels of force with decreased rate. In addition, during EXT, while Participants 3 and 4 evidenced extinction bursts in rate, Participant 4, in contrast, exhibited an extinction burst in force but low and near zero levels of rate. Therefore, I concluded that the influence of schedules of reinforcement on force and rate varied independently and differently for each individual. The clinical implication for behaviour analysts is to include a measure of force in addition to rate when conducting a functional assessment of severe problem behaviour for the purpose of developing a behaviour support plan. In clinical settings, behaviour analysts need to be critically aware of the possibility of an extinction burst in force or rate, and ensure that safeguards are in place to prevent injury or damage.

5.3.2 Systematic component analysis. Another implication is related to the value of conducting in a clinical setting a component analysis of function-based intervention components prior to implementing an intervention that includes an extinction procedure implemented by natural agents in natural settings (e.g., parents at home, teachers at school, staff in group home). The purpose the component analysis would to assess the level of risk for an extinction burst characterized by high force and/rate and then instituting appropriate safeguards in the natural settings based on the level of risk. During a functional assessment, practitioners identify the functions of problem behaviour and then design a treatment package that is consistent with the principles of behaviour and renders problem behaviour *irrelevant, ineffective, and inefficient* at achieving its function (Horner, 2000). A function-based treatment package typically includes preventative, teaching, and reinforcement strategies, as well as a component to withhold access to the functional reinforcer for problem behaviour (i.e., extinction). Current evidence-based practice in the treatment of severe problem behaviour indicates that such a multicomponent treatment plan is necessary and sufficient to treat problem behaviour.

Given current best practice in the treatment of severe problem behaviour. I suggest that following a functional assessment and prior to implementing a function-based behaviour support plan, clinicians conduct a systematic component analysis as described in Horner and Sturmay

(2010). The purpose of the component analysis would be to identify the level of risk associated with the introduction of extinction as part of a multicomponent treatment package; that is, to assess the force and rate of response on introduction of extinction *after* other elements of the treatment package were implemented. Extending beyond the focus of this study (i.e., schedules of reinforcement), I recommend that core components comprised of a prevention strategy, teaching strategy *and* schedule of reinforcement be implemented first, with the force and response measured during one 5 min session in this condition. Following exposure to core extinction component would be implemented and force and rate of response would be again measured in one 5 min session. To ensure the safety of the person with ASD and the implementer of the conditions, the component analysis would be conducted by a behaviour analyst and take place in a clinical setting with sufficient safeguards in place to prevent injury or property destruction.

The results of the component analysis could be summarized in terms of three levels of risk. Low or a green level of risk would indicate that during implementation of extinction, the individual exhibited near zero levels of force and rate and thus requires few precautions in regard to implementing the full treatment package, including extinction, by natural agents in natural settings. A moderate or yellow level of risk would indicate that the individual engaged in levels of force or rate that were elevated during extinction, and that these levels posed some risk for injury or property destruction. This result of the component analysis would prompt moderate safeguards to prevent injury or property destruction during implementation of the treatment package by natural agents in natural settings. Lastly, high or a red level of risk would indicate that during implementation of extinction, the individual engaged in high levels of force and/or rate, and thus required a comprehensive safety plan to be in place prior to implementation of the full treatment package in natural settings by natural agents. The safety plan may include, for example, the behaviour analyst implementing the plan in the clinic or natural setting until stimulus control over adaptive behaviour was gained, and then transferring stimulus control to natural agents in the setting. Alternatively, the safety plan might involve putting into place procedural safeguards to ensure the safety of the individual with a disability and plan implementers during initial implementation of the plan until problem behaviour is reduced to low and safe levels. The key message is that a component analysis can help to determine the level of risk prior to plan implementation and allow for the design of a safety plan to matches the level of risk and thus prevents injury or property destruction.

5.3.3 Extinction and extinction bursts. Across the three participants, only one participant exhibited a clear extinction burst in force (Participant 4). An extinction burst in force may occur even when little to no extinction burst in rate occurs (i.e., first EXT phase for Participant 4). One clinical consideration derived from these results relates to problem behaviour. Clinicians need to be aware of the possibility of an increase in force during the onset of extinction even when rate shows a low level and decreasing trend. For example, Participants 4, showed forceful responses over extinction although the rate during CRF and EXT was low and stable. As stated in the introduction of this study, self-injurious behaviour, as an example of problem behaviour, is defined by its magnitude. Imagine a scenario in which an individual with ASD engages in an instance of head banging at the onset of an extinction procedure that is so forceful that he or she produces a physical injury that detrimentally alters their quality of life for years into the future. Mindful attention to the possibility that force of response may co-vary independently of rate of response can assist behaviour analysts in the design of interventions procedures that include extinction but also safeguards to prevent injury due to the force of response.

Even when EXT may be an effective treatment to decrease problem behaviour (Ducharme & Van Houten, 1994; Lerman & Iwata, 1996), the effects of extinction on force need to be considered before introducing an extinction-based treatment. Previous research findings have confirmed that extinction bursts occur less when extinction is implemented along with other interventions (Lerman et al., 1999). In an attempt to mitigate the undesirable effects of extinction, practitioners usually include extinction as part of a multicomponent treatment package (i.e., along with antecedent interventions, differential reinforcement, etc.; Lerman et al., 1999).

Although increases in force during different schedules of reinforcement and extinction have been demonstrated in humans and non-humans organisms, it is not clear why extinction is associated with higher levels of force and increased variability. Notterman and Mintz (1965) and Skinner (1938) advanced two possible explanations. The first explanation is based on the evolutionary value of forceful responses; that is, responses with increased magnitude might be more likely to receive reinforcement thus emitting forceful responses represents an evolutionary adaptation of organisms. The other theory based its explanation on the differentiation of forceful responses as a result of a history of reinforcement. If forceful responses are consistently reinforced, their probability of occurrence will increase over time. Likewise, if weaker responses do not receive reinforcement, they will eventually decrease over time and may be extinguished. One can appreciate the biological nature of the first theory and the learning theory foundation of the second. These explanations, as the authors pointed out, might not exclude but complement each other.

5.3.4 Schedules of reinforcement and problem behaviour

5.3.4 Schedules of reinforcement and problem behaviour. Overall, a more fine-grained analysis of results suggests that schedules of reinforcement may account for erratic and unpredictable instances of problem behaviour. Intense episodes of SIB, aggression and/or property destruction (i.e., high levels of force) could reflect extinction (Notterman & Mintz, 1965) or the influence of the ordinal position of the response (Pinkston & McBee, 2014). Notterman and Mintz suggested that the occurrence of forceful responses could be related to periods of extinction (i.e., withholding delivery of reinforcement) naturally occurring within a variable ratio schedule of reinforcement. Conversely, Pinkston and McBee (2014) suggested that the position of the response within the response cycle might determine the force of emission. For clinical purposes, it is important to identify the schedule of reinforcement operating to accurately predict the likelihood of occurrence of intense behavioural episodes in the course of assessment and treatment. The results observed in Participant 3, offered an example of how behaviour maintained by a variable ratio schedule present an abrupt increase in the level of force of response followed by steady moderate levels of force. In clinical practice, families report that the child was doing well for 3 or 4 days, then, without any identified event, the child presented an episode of intense problem behaviour that lasted several days. Similar patterns of variability of force during VR5 were evidenced with Participant 2 and 4. A variable ratio schedule represents a combination of periods of reinforcement with extinction; thus, as Notterman and Mintz (1965) noted, increases in force and rate might be explained as extinction effects and managed accordingly. Hence, the force of response appears to be tied directly to the schedule of reinforcement and warrants independent assessment.

5.4 Unique Contribution to Literature

The results of the present study add to the body of knowledge concerning the force of response during variable ratio schedules, interaction effects of two different schedules of reinforcement, and extinction. This may be the first study that examines the effects of variable ratio schedules on the force of response during conditioning and extinction. The clinical relevance of Experiment 1 resides in the fact that the variable ratio schedule may represent a typical arrangement of contingencies in any natural environment (e.g., family, school, community). Experiment 2 provides an analogue of a clinical intervention in which a pretreatment strategy is introduced (CRF) before the EXT is put in place. Therefore, the results of this study may provide additional insight in the assessment and treatment of problem behaviour. However, the present findings are preliminary as they were observed in a restrictive setting under controlled conditions. The generality of these results needs to be confirmed with other populations and settings.

5.5 Limitations

I identified five limitations that require comment. The first limitation relates to the participants involved in the study. The participants were recruited from a special education school that implements interventions based on Applied Behaviour Analysis. These individuals had been consistently reinforced for showing compliance and adherence to adult instructions. Also, these participants were selected based on the absence of past or a current history of problem behaviour. Hence, the specific history of reinforcement and the instructional setting could have contributed to the results observed.

Additionally, individual differences between participants, such as level of functioning, could limit the generality of findings. For example, we observed that regardless of the

Experiment (1 or 2), participants with a higher level of functioning and a longer history in the school exhibited a lengthier extinction process compared to participants with a lower level of functioning and a shorter history in the school. Given this limitation, more research with other populations is critical to advancing the generality of these findings.

The second limitation relates to the use of a reversal design in the study. These designs are known to cause multiple treatment sequence effects that may account for the differences in performance observed in the experimental conditions (Gast, 2010). The interaction effects of a prior schedule or schedules of reinforcement followed by extinction may have contributed to the effects of the independent variable on force and rate observed in the participants' responses during the *repeated* presentation of a schedule or schedules of reinforcement followed by extinction.

A third limitation relates to the functioning of the measurement device. The TEKSCAN flexi force sensor is extremely sensitive. As I explained in the results section, one participant's higher levels of rate of response destabilized the apparatus, producing inaccurate readings. During these sessions, the device captured feedback from an unidentified source and as a consequence important data were lost during a critical phase of the study.

A fourth limitation identified relates to the possible emergence of a secondary source of reinforcement produced by the measurement device. The apparatus made an audible "click" when 0.07 lb. of pressure were applied to close the switch. The sound paired with the delivery of reinforcement may have acquired secondary reinforcement properties. This may offer a partial explanation for the long extinction phases of Participants 2 and 3. Notterman and Mintz (1965) and Skinner (1938) noted that secondary reinforcing properties of the proprioceptive stimulation and the sound of the lever emerged during their experiments. In this sense, the extinction procedure may not have been fully implemented with Participants 2 and 3 because this extraneous variable was not fully removed from the experimental setting or otherwise accounted for.

A final limitation is related to whether or not a finger press against the target can be generalized to problem behaviour. One can argue that a finger press is not a model that accurately represents problem behaviour in clinical settings. Ethical considerations have historically prevented researchers from studying directly severe problem behavior in humans. However, earlier research has demonstrated that this type of model provides valuable information that can be generalized to clinical settings. Force of aggressive behaviour has been measured using responses against inanimate objects. For example, Hanner and Brown (1955) defined an aggressive response as the increase in the force of a plunger-pushing response. Similarly, Kelly and Hake (1970) elicited an avoidance or escape response using two different response mechanisms. The first, a button press that required a minimum of 1.5 lb. to activate an avoidance response; the second, a 20 lb. punch on a padded surface to accomplish the same purpose. Therefore, it could be argued that button pressing with a finger is comparable to an aggressive response in humans. For example, finger poking with a high level of force against another person could create a physical injury; finger poking against an inanimate object could damage the object or knock it down onto a hard floor surface; and finger poking against one's body could cause a physical self-injury. Thus, although it is reasonable to consider this possible limitation, I believe that the finger poking response is an appropriate and effective analogue to problem behaviour.

5.6 Future Research

Given the study's findings as well as limitations, there are three avenues of future research to consider. First, future research should systematically replicate the study by recruiting participants with a history of problem behaviour. Doing so would provide a clearer understanding of the effects of schedules of reinforcement followed by extinction on force of response. A second line of research should address the unexpected increase of force during CRF. The analysis of inter-response time (IRT) and its interaction with different schedules of reinforcement may have significant implications for clinical practice. A third avenue for future research is related to schedules of reinforcement as independent variables. Research on the effects of variable ratio schedules and continuous reinforcement examined independently in a multiple baseline design across participant may be necessary to confirm the present results. Also, a lengthier implementation of continuous reinforcement may contribute to a better understanding of the benefits of continuous reinforcement as a pretreatment strategy.

Reference

American Psyquiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Baker, B. L., Blacher, J., Crnic, K. A., & Edelbrok, C. (2002). Behavior problems and parenting stress in families of three-year-old children with and without developmental delays. *American Journal on Mental Retardation, 107*, 433-444.

Beavers, G. A., Iwata, B. A., & Lerman, D. C. (2013). Thirty years of research on the functional analysis of problem behavior. *Journal of Applied Behavior Analysis, 46*, 1-21.

Betz, A. M., Higbee, T. S., Kelley, K. N., Sellers, T. P., & Pollard, J. S. (2011). Increasing response variability of mand frames with scripts training and extinction. *Journal of Applied Behavior Analysis, 44*, 357-362.

Blixt, S., & Ley, R. (1969). Force-contingent reinforcement in instrumental conditioning and extinction in children. *Journal of Comparative and Physiological Psychology, 69*, 267-272.

Carr, E. G., & Durand, V. M. (1985). Reducing behavior problems through functional communication training. *Journal of Applied Behavior Analysis, 18*, 111-126.

Crosland, K. A., Zarcone, J. R., Schroeder, S., Zarcone, T., & Stephen, F. (2005). Use of antecedent analysis and a force sensitive platform to compare stereotyped movements and mtor tics. *American Journal of Mental Retardation, 110*, 181-192.

Day, R. M., Rea, J. A., Schussler, N. G., Larsen, S. E., & Johnson, W. L. (1988). A functionally based approach to the treatment of self-injurious behavior. *Behavior Modification, 12*, 565-589.

Dominick, K. C., Davis, N. O., Lainhart, J., Tager-Flusberg, H., & Folstein, S. (2007). Atypical behaviors in children with autism and children with a history of language impairment. *Research in Developmental Disabilities, 28*, 145-162.

Ducharme, J. M., & Van Houten, R. (1994). Operant extinction in the treatment of severe maladaptive behavior: Adapting research to practice. *Behavior Modification, 18*, 139-170.

Durand, V. M., & Merges, E. (2001). Functional communication training: A contemporary behavior analytic intervention for problem behaviors. *Focus on Autism and other Developmental Disabilities, 16*, 110-119.

Emerson. (1992). Self-injurious behaviour: An overview of recent trends in epidemiological and behavioural research. *Mental Handicap Research, 5*, 49-81.

Facon, B., Sahiri, S., & Riviere, V. (2008). A controlled single case treatment of severe long-term selective mutism in a child with mental retardation. *Behavior Therapy, 39*, 313-321.

Farmer, C. A., & Aman, M. G. (2011). Aggressive behavior in a sample of children with Autism Spectrum Disorders. *Research in Autism Spectrum Disorders, 5*, 317-323.

Fisher, W. W., Piazza, C. C., Bowman, L. G., & Amari, A. (1996). Integrating caregiver report with a systematic choice assessment to enhance reinforcer identification. *American Journal of Mental Retardation, 101*, 15-25.

Fisher, W. W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe to profound disabilities. *Journal of Applied Behavior Analysis, 25*, 491-498.

Gast, D. L. (2010). *Single subject research methodology in behavioral sciences.* New York: Routledge.

Goh, H. L., & Iwata, B. A. (1994). Behavioral persistence and variability during extinction of self-injury maintained by escape. *Journal of Applied Behavior Analysis, 27*, 173-174.

Green, G. (2001). Behavior analytic instruction for learners with Autism: Advances in stimulus control technology. *Focus on Autism and other Developmental Disabilities, 16*, 72-85.

Greer, B. D., Neidert, P. L., Dozier, C. L., Payne, S. W., Zonneveld, K. L., & Harper, A. M. (2013). Functional analysis and treatment of problem behavior in early education classrooms. *Journal of Applied Behavior Analysis, 46*, 289-295.

Grow, L. K., Kelley, M. E., Roane, H. S., & Shillingsburg, M. A. (2008). Utility of extinction-induced response variability for the selection of mands. *Journal of Applied Behavior Analysis, 41*, 15-24.

Hagopian, L. P., Fisher, W. W., & Legacy, S. M. (1994). Schedule effects of noncontingent reinforcement on attention-maintained destructive behavior in identical quadruplets. *Journal of Applied Behavior Analysis, 27*, 317-325.

Hagopian, L. P., Fisher, W. W., Sullivan, M. T., Acquisto, J., & LeBlanc, L. A. (1998). Effectiveness of functional communication training with and without extinction and punishment: A summary of 21 inpatient cases. *Journal of Applied Behavior Analysis, 31*, 211-235.

Hagopian, L. P., Rooker, G. W., Jessel, J., & De Leon, I. G. (2013). Initial functional analysis outcomes and modifications in pursuit of differentiation: A summary of 176 inpatient cases. *Journal of Applied Behavior Analysis, 46*, 88-100.

Hall, S., & Oliver, C. (1992). Differential effects of severe self-injurious behaviour on the behaviour of others. *Behavioral Psychotherapy, 20*, 355-365.

Hanley, G. P., Iwata, B. A., & McCord, B. E. (2003). Functional analysis of problem behaviour: A review. *Journal of Applied Behavior Analysis, 36*, 147-185.

Hanley, G. P. (2012). Functional assessment of problem behavior: Dispelling myths, overcoming implementation obstacles, and developing new lore. *Behavior Analysis in Practice, 5*, 54-72.

Hanner, C. F., & Brown, P. A . (1955). Clarification of the instigation to action in the frustration-aggression hypothesis. *Journal of Abnormal and Social Psychology, 51*, 204-206.

Harper, J. M., Iwata, B. A., & Camp, E. M. (2013). Assessment and treatment of social avoidance. *Journal of Applied Behavior Analysis, 46*, 147-160.

Hastings, R. P., & Johnson, E. (2001). Stress in UK families conducting intensive home-based behavioral intervention for their young child with autism. *Journal of Autism and Developmental Disorders, 31*, 327-336.

Hastings, R. P. (2002). Parental stress and behaviour problems of children with developmental disability. *Journal of Intellectual and Developmental Disability, 27*, 149-160.

Horner, J. W., & Sturmey, P. (2010). Component analysis using single-subject experimental designs: A review. *Journal of Applied Behavior Analysis, 43*, 685-704.

Horner, R. H., Carr, E. G., Strain, P. S., Todd, A. W., & Reed, H. K. (2002). Problem behavior interventions for young children with autism: A research synthesis. *Journal of Autism and Developmental Disorders, 32*, 423-446.

Horner, R. H. (2000). Positive behavior supports. *Focus on Autism and other Developmental Disabilities, 15*, 97-105.

Ingersoll, B., & Hambrick, D. Z. (2011). The relationship between the broader autism phenotype, child severity, and stress and depression in parents of children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 5*, 337-344.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1982). Toward a functional analysis of self-injury. *Analysis and Intervention in Developmental Disabilities, 2*, 3-20.

Iwata, B. A., Dorsey, M. F., Slifer, K. J., Bauman, K. E., & Richman, G. S. (1994). Toward a functional analysis of self-injury. *Journal of Applied Behavior Analysis, 27*, 197-209.

Iwata, B. A., & Dozier, C. L. (2008). Clinical application of functional analysis methodology. *Behavior Analysis in Practice, 1*, 3-9.

Iwata, B. A., Pace, G. M., Cowdery, G. E., & Miltenberger, R. G. (1994). What makes extinction work: An analysis of procedural form and function. *Journal of Applied Behavior Analysis, 27*, 131-144.

Iwata, B. A., Pace, G. M., Kalsher, M. J., Cowdery, G. E., & Cataldo, M. F. (1990). Experimental analysis and extinction of self-injurious escape behavior. *Journal of Applied Behavior Analysis, 23*, 11-27.

Iwata, B. A., Pace, G. M., Kissel, R. C., Nau, P. A., & Farber, J. M. (1990). The Self-Injury Trauma (SIT) Scale: A method for quantifying surface tissue damage caused by self-injurious behaviour. *Journal of Applied Behavior Analysis, 23*, 99-110.

Iwata, B. A., Smith, R. S., & Michael, J. (2000). Current research on the influence of establishing operations on behavior in applied settings. *Journal of Applied Behavior Analysis, 33*, 411-418.

Iwata, B. A., & Worsdell, A. S. (2005). Implications of functional analysis methodology for the design of intervention programs. *Exceptionality, 13*, 25-34.

Jackson, D. A., & Wallace, R. F. (1974). The modification and generalization of voice loudness in a fifteen-year-old retarded girl. *Journal of Applied Behavior Analysis, 7*, 461-471.

Kahng, S., Iwata, B. A., & Lewin, A. B. (2002). Behavioral treatment of self-injury, 1964 to

2000. *American Journal on Mental Retardation, 107*, 212-221.

Kanne, S. M., & Mazurek, M. O. (2011). Aggression in children and adolescents with ASD: Prevalence and risk factors. *Journal of Autism and Developmental Disorders, 41*, 926-937.

Kats, D., Payne, L., Parlier, M., & Piven, J. (2013). Prevalence of selected clinical problems in older adults with autism and intellectual disability. *Journal of Neurodevelopmental Disorders, 5*, 1-27.

Kelly, J. F., & Hake, D. F. (1970). An extinction-induced increase in an aggresssive response with humans. *Journal of the Experimental Analysis of Behaviour, 14*, 153-164.

Lerman, D. C., Iwata, B. A., Shore, B. A., & Kahng, S. W. (1996). Responding maintained by intermittent reinforcement: Implications for the use of extinction with problem behaviour in clinical settings. *Journal of Applied Behaviour Analysis, 29*, 153-171.

Lerman, D. C., Iwata, B. A., & Wallace, M. D. (1999). Side effects of extinction:Prevalence of bursting and aggression during the treatment of self-injurious behaviour. *Journal of Applied Behaviour Analysis, 32*, 1-8.

Lerman, D. C., & Iwata, B. A. (1995). Prevalence of the extinction burst and its attenuation during treatment. *Journal of Applied Behavior Analysis, 28*, 93-94.

Lerman, D. C., & Iwata, B. A. (1996). Developing a technology for the use of operant extinction in clinical settings: An examination of basic and applied research. *Journal of Applied Behavior Analysis, 29*, 345-382.

Loman, S. L., & Horner, R. H. (2013). Examining the efficacy of a basic functional behavioral assessment training package for school personnel. *Journal of Positive Behavior Intervention, 16*, 18-30.

Lucyshyn, J. M., Binnendyk, L., Fossett, B., Cheremshynski, C., Lohrmann, S., Elkinson, L., & Miller, L. (2009). Toward an ecological unit of analysis in behavioral assessment and intervention with families of children with developmental disabilities. In S. Wayne, G. Durlap, Sugai G., & R. Horner (Eds.), *Handbook of Positive Behavior Support* (pp. 73-106). Boston: Springer.

MacDonald, J. M., Ahearn, W. H., Parry-Cruwys, D., Bancroft, S., & Dube, W. V. (2013). Persistence during extinction: Examining the effects of continuous and intermittent reinforcement on problem behavior. *Journal of Applied Behavior Analysis, 46*, 333-338.

Mace, F. C. (1994). The significance and future of functional analysis methodologies. *Journal of Applied Behavior Analysis, 27*, 385-392.

Matson, J. L., & LoVullo, S. V. (2008). A review of behavioral treatments for self-injurious behaviors of persons with Autism Sprectrum Disorders. *Behavior Modification, 32*, 61-76.

Matson, J. L., & Vollmer, T. R. (1995). *User's Guide: Questions About Behavioral Function (QABF)*. Baton Rouge, L.A.: Scientific Publishers, Inc.

Mazaleski, J. L., Iwata, B. A., Vollmer, T. R., Zarcone, J. R., & Smith, R. G. (1993). Analysis of the reinforcement and extinction components in DRO contingencies with self-injury. *Journal of Applied Behavior Analysis, 26*, 143-156.

McClintock, K., Hall, S., & Oliver, C. (2003). Risks markers associated with challenging behaviours in people with developmental disabilities: A meta analytic study. *Journal of Intellectual Disability Research, 47*, 405-416.

McGill, P. (1999). Establishing operations: Implications for the assessment, treatment, and prevention of problem behavior. *Journal of Applied Behavior Analysis, 32*, 393-418.

McInotosh, K., Borgmeir, C., Anderson, C. M., Horner, R. H., Rodriguez, B. J., & Tobin, T. J. (2008). Technical adequacy of the functional assessment checklist. *Journal of Positive Behavior Intervention, 10*, 33-45.

Mintz, D. E. (1962). Force of response during ratio reinforcement. *Science, 138*, 516-517.

Morris, J. P. (1968). Changes in response force during acquisition and extinction in retarded children. *American Journal of Mental Deficiency, 73*, 384-390.

Newcomer, L. L., & Lewis, T. J. (2004). Functional behavioral assessment: An investigation of assessment reliability and effectiveness of function-based interventions. *Journal of Emotional and Behavioral Disorders, 12*, 168-181.

Newell, K. M., Challis, J. H., Boros, R., & Bodfish, J. W. (2002). Further evidence on the dynamics of self-injurious behaviors: Impact forces and limb motions. *American Journal of Mental Retardation, 107*, 60-68.

Newell, K. M., Sprague, R. L., Pain, M. T., Deutsch, K. M., & Meinhold, P. (1999). Dynamics of self-injurious behaviors. *American Journal on Mental Retardation, 104*, 11-21.

Northup, J., Broussard, C., Jones, K., George, T., Vollmer, T. R., & Herring, M. (1995). The differential effects of teacher and peer attention on the disruptive classroom behavior of three children with a diagnosis of attention deficit hyperactivity disorder. *Journal of Applied Behavior Analysis, 28*, 227-229.

Notterman, J. M., & Mintz, D. E. (1965). *Dynamics of Response*. New York: John Wiley & Sons, Inc.

Notterman, J. M. (1959). Force emission during bar pressing. *Journal of Experimental Psychology, 58*, 341-347.

O'Neill. R. E., Albin, R. W., Storey, K., Horner, R. H., & Sprague, J. R. (2015). Functional assessment and program development for problem behavior: A practical handbook. Stamford, CT: Cengage Learning.

Pelios, L., Morren, J., Tesch, D., & Axelrod, S. (1999). The impact of functional analysis methodology on treatment choice for self-injurious and aggressive behavior. *Journal of Applied Behavior Analysis, 32*, 185-195.

Pinkston, J. W., & McBee, L. N. (2014). Force dynamics in fixed-ratio schedules. *Behavioural Processes, 103*, 112-116.

Rooker, G. W. (2010). *Analysis of response force in translational and applied settings* (Unpublished dissertation). University of Florida, Gainesville, .

Skinner, B. F. (1938). *The Behavior of Organisms: An Experimental Analysis*. Oxford, England: Appleton-Century.

Skinner, B. F. (1953). *Science and Human Behavior*. New York: Macmillan.

Sundberg, M. L., & Partington, J. W. (1998). *Teaching Language to Children with Autism or other Developmental Disabilities*. Pleasant Hill, CA: Behavior Analysts, Inc.

Thomason-Sassi, J. L., Iwata, B. A., Neidert, P. L., & Roscoe, E. M. (2011). Response latency as an index of response strength during functional analysis of problem behavior. *Journal of Applied Behavior Analysis, 44*, 51-67.

Thompson, R. H., & Iwata, B. A. (2007). A comparison of outcomes from descriptive and functional analysis of problem behavior. *Journal of Applied Behavior Analysis, 40*, 333-338.

Touchette, R., MacDonald, F., & Langer, S. (1985). A scatter plot for identifying stimulus control for problem behavior. *Journal of Applied Behavior Analysis, 18*, 343-351.

Trotter, J. R. (1956). The physical properties of bar-pressing behaviour and the problem of reactive inhibition. *Quarterly Journal of Experimental Psychology, 8*, 97-106.

Vollmer, T. R., Iwata, B. A., Zarcone, J. R., Smith, R. G., & Mazaleski, J. L. (1993). The role of attention in the treatment of attention-maintained self-injurious behavior: Noncontingent reinforcement and differential reinforcement of other behavior. *Journal of Applied Behavior Analysis, 26*, 9-21.

Wulber, M., Nyman, B. A., Snow, D., & Owen, Y. (1973). The efficacy of stimulus fading and contingency management in the treatment of elective mutism: A case study. *Journal of Applied Behavior Analysis, 6*, 435-441.

Zeiler, M. (1977). Schedules of reinforcement. In W.K. Honig & J.E.R. Staddon (Eds.), *Handbook of Operant Behavior* (pp. 201-232). Englewood Cliffs, NJ: Prentice Hall.