Identifying Preferences Using a Conjugate Preparation

by

Daniel John Sheridan

A thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Science

Auburn, AL
May 2023

Approved by

Dr. John T. Rapp, Chair, Professor, Psychology
Dr. M. Christopher Newland, Professor, Psychology
Dr. Sarah Richling, Associate Clinical Professor, Psychology

Abstract

Recently, Davis et al. (2021) reported that a conjugate preparation involving response force was a useful assessment for measuring the relative value of stimulus preference. The purpose of the current investigation was to replicate and extend Davis et al. (2021) by examining 98 participants' preference for five pictorial stimuli. First, researchers used a verbal multiple stimulus without replacement (VMSWO) preference assessment with each participant to identify high preference (HP) and low preference (LP) pictorial stimuli. Next, participants viewed each pictorial stimulus presented in a randomized order on a computer while using a hand dynamometer that measured the amount of force exerted to increase or maintain the visual clarity of each pictorial stimulus. Results indicated a statistically significant correlation between participants' rank order of pictorial stimuli from the VMSWO assessment and the mean and peak force order from the conjugate assessment. Overall, individual results showed that over 75% of participants' HP stimuli, LP stimuli, or both from the VMSWO corresponded with the amount of force exerted to view them. Findings from the current study are consistent with those from Davis et al. (2021). Additional findings and implications for future research are discussed.

Keywords: conjugate reinforcement, MSWO, response force, stimulus preference

Acknowledgments

First, I would like to thank my lab mates, Anna Kate, and Ashley, for their never-ending support, feedback, and encouragement with my thesis–you two are the best lab mates. Next, I would like to thank Dr. Rapp for his patience, guidance, and support. I would also like to thank my siblings–Greg and Leah, and my mum, Michelle - for all their encouragement during my time here in Auburn. I would like to acknowledge and thank my close friend Dr. Rasha Baruni. You have been a great source of inspiration for me. Last, thank you to my committee members, Dr. Newland and Dr. Richling; your feedback has been invaluable.

Table of Contents

Abstract 2

Acknowledgments 3

List of Tables 6

List of Figures 7

Introduction 8

Chapter 1: Literature Review 10

- Schedules of Reinforcement 10
- Conjugate Schedules 12
- Response Force 13
- Evaluation of Concept 14
- Applications of Conjugate Schedules 16
- Hypotheses 25

Chapter 2: Method 26

- Participants and Setting 26
- Apparatus 26
- VMSWO Preference Assessment 27
- Conjugate Preference Assessment 28
- Experimental Design 29
- Dependent Variables 30
- Inter-rater Reliability 31
- Statistical Analyses of Group Data 31
- Visual Analysis of Individual Participant Data 32

Graph Categorization 33

Results 36

Discussion 42

References 46

List of Tables

Table 1 Sociodemographic Characteristics of the Participants....... 54

Table 2 Participants' Mean Preference and Force Ranks across the Five Pictorial Stimuli....... 55

Table 3 Results of Spearman's Rank Correlation....... 56

List of Figures

Figure 1 Example data Illustrating Responding on the Conjugate Schedule............................. 57

Figure 2 Scatterplot of Mean Force Rank by Preference Order Rank....................................... 58

Figure 3 Scatterplot of Peak Force Rank by Preference Order Rank 59

Figure 4 Dot plot of Mean Force by VMSWO Rank Orde.. 60

Figure 5 Dot plot of Peak Force by VMSWO Rank Orde 61

Figure 6 Dot plot of Mean Force by Stimulus Presentation Order 62

Figure 7 Dot plot of Peak Force by Stimulus Presentation Order 63

Figure 8 Box plot of Mean Force Across Pictorial Stimulus... 64

Figure 9 Box plot of Peak Force Across Pictorial Stimulus 65

Figure 10 Representative Graphs Depicting HP and LP Correspondence 66

Figure 11 Representative Graphs Depicting HP only Correspondence.................................... 67

Figure 12 Representative Graphs Depicting LP only Correspondence 68

Figure 13 Representative Graphs Depicting Undifferentiated Responding 69

Figure 14 Representative Graphs Depicting Decreasing Trend 70

Introduction

Researchers have underscored how the experimental analysis of behavior (EAB) and applied behavior analysis (ABA) have become somewhat “detached” from one another despite the utility one can offer the other (Mace & Critchfield, 2010; Marr, 2018). EAB investigates basic principles and processes of behavior and ABA addresses issues of social importance using the principles and procedures of behavior analysis. Translational research seeks to bridge this detachment between basic and applied work by producing innovative and creative methods that address socially important issues (Critchfield, 2011; Mace & Critchfield 2010). To that end, translational research may provide an avenue to study more unique and novel schedules of reinforcement (e.g., schedules of covariation) and their influence on operant behavior (Mace & Critchfield, 2010; Vollmer, 2011).

As outlined by Ferster and Skinner (1957), different schedules of reinforcement produce different patterns of behavior. Indeed, schedules of reinforcement have received a great deal of attention from both basic and applied research (Ferster & Skinner, 1957; Lattal & Neef, 1996; Pierce & Cheney, 2013). Much of this research has focused on the episodic relationship between a stimulus, response, and consequence (Saunders, 2020). However, less is known about the non-episodic relationship between responses that co-vary with stimuli (i.e., schedules of covariation).

Conjugate reinforcement and punishment are a type of schedule of covariation wherein the rate, amplitude, and/or intensity of the stimulus is tied to a particular dimension of a relevant response (Rapp, 2008; Rovee-Collier & Capatides, 1979). That is, changes in continuous responding produce changes in the reinforcer. An example of conjugate reinforcement could be an individual who blows bubbles of various sizes whereby the individual controls the covariation between response (e.g., blowing bubbles) and reinforcer (e.g., different-sized bubbles). Here, the effect would be the varying air speeds blown through a circular wand to produce different sized bubbles (small, medium, and large).

Lindsley (1956) had the goal of developing a basic research tool to study and measure both simple and complex behaviors that occur in a continuous manner. Since Lindsley's (1957) original conjugate preparation, researchers have fashioned a variety of simple and dynamic conjugate preparations to (a) examine the motor development of infants (Rovee & Rovee, 1969; Siqueland & Delucia, 1969), (b) increase socially reinforcing stimuli (e.g., eye contact and speech [Lindsley, 1963; Nathan et al., 1964, 1968]), (c) increase exercise behavior (Caouette & Reid, 1991; Deochand et al., 2020), (d) assess stereotypical behavior of individuals with intellectual disabilities (Switzky & Haywood, 1973; Rapp et al., 2004), and (e) evaluate stimulus preference using frequency or response force measures (Davis et al., 2021; Falligant et al., 2018, 2020; MacAleese et al., 2015).

Although researchers have demonstrated that conjugate schedules can be a useful operant procedure to study natural contingencies, research is limited, and further experimentation is warranted. Therefore, the purpose of the current investigation was to replicate and extend a study by Davis et al. (2021) to examine correspondence between ranked scores produced by a verbal preference assessment for pictorial stimuli and ranked response forces from a conjugate assessment for the same pictorial stimuli.

Chapter 1

Literature Review

Schedules of Reinforcement

Schedules of reinforcement are fundamental to the analysis of behavior as they specify the temporal and behavioral conditions under which reinforcers will be delivered (Ferster & Skinner, 1957). Continuous reinforcement is the simplest schedule arrangement as this contingency specifies the relevant operant(s) to receive reinforcement every time (Pierce & Cheney, 2013). However, not every operant specified by a continency will be reinforced, especially in the natural environment. Intermittent schedules of reinforcement specify that some, but not all, responses will be reinforced (Honig & Staddon, 1977; Pierce & Cheney, 2013). These schedules are further classified according to the dimensions specified by the schedule arrangement.

Catania (2007) noted that the three basic schedule types are (a) ratio (number of responses), (b) interval (time when responses should be emitted), and (c) differential. The response requirement for ratio and interval schedules may be either fixed or variable. Ratio schedules are dichotomized into fixed- or variable-ratio and specify the emission of a required number of responses for reinforcement or punishment (Pierce & Cheney, 2013). Similarly, fixed- or variable-interval schedules depend on the specified time in the arrangement. With differential schedules, only some dimensions of behavior are eligible for consequences. These schedules typically involve (a) positive or negative reinforcement, (b) positive or negative punishment (Sizemore & Maxwell, 1983), and (c) extinction along some dimension of behavior (Pierce & Cheney, 2013). Notably, an operant response class may be reinforced on more than just a single schedule of reinforcement (i.e., FR, VR, FI, VI). Concurrent schedules of reinforcement involve choosing to respond on one of two or more simple schedules that are simultaneously available (Honig & Staddon, 1977; Pierce & Cheney, 2013). Although a review of concurrent schedules of reinforcement is beyond the scope of this study, it is important to note that these analytic procedures have been instrumental in the study of choice and preference (see Honig & Staddon, 1977 for a review).

The forgoing schedules have been used to study various dimensions of behavior such as topography, response rate, periodicity of responding, and time engaged in a specific behavior (Mace et al., 2021). Ratio, interval, and differential schedules are considered episodic wherein the stimulus and response relation are separate, discrete events (Saunders, 2020; Williams & Johnston, 1992). These discrete relations differ from non-episodic events where stimuli and responses co-vary (Saunders, 2020). Schedules of covariation tend to be less cited and studied, especially conjugate schedules (Jones, 2016; MacAleese et al., 2015; Saunders, 2020).

According to Williams and Johnston (1992), schedules of covariation are those in which the "dimension of responding determines the amount of the consequent stimulus dimension from moment-to-moment" (p. 207). Williams and Johnston described three types of schedules of covariation: (a) correlated, (b) synchronous, and (c) conjugate. Briefly, correlated schedules specify that the amount of reinforcement is contingent on the total summed amount of responding. For example, when a person jabs a punch bag machine that converts the force of the jab into a response force score. Synchronous schedules specify that access to reinforcing stimulus is synced with a particular response (Diaz de Villegas et al., 2020). That is, if the response continuously occurs the stimulus is delivered, if the response stops, the stimulus is terminated until the response occurs again (i.e., all or none). For example, wearing a protective mask produces access to a preferred movie, but removal of the mask results in termination of the movie until the mask is put back on (McHugh et al., 2022). Conjugate schedules involve properties of a response-reinforcer relation being directly proportional to each other (Diaz de Villegas et al., 2020). For example, playing a virtual reality game wherein a person must engage in a variety of different physical movements to access and/or avoid different types of audio and visual stimulation.

Conjugate and synchronous schedules of reinforcement are distinguishable from each other. With synchronous schedules of reinforcement, continuous reinforcer consumption is directly synced with continuous responding. That is, if a performance criterion is not continuously met or exceeded, access to the reinforcer is terminated. However, with conjugate schedules of reinforcement, reinforcer consumption is proportionate to some dimension of continuous operant responding (Rapp, 2008). Reinforcer consumption co-varies because of the required moment-to-moment adjustments in responding wherein responding must meet or exceed a target criterion to maintain access to the reinforcer. If responding falls below the target criterion, a lesser value or lower quality of the reinforcer is consumed. Both schedules exist on a continuum with the possibility of subcategories. For example, a progressive synchronous schedule can involve incremental access to or loss of a stimulus. We consider this a subcategory due to the additional progressive component that alters the rate at which a stimulus is accessed or lost. That is, both synchronous and conjugate schedules require a certain response criterion to be met or maintained to produce continuous access to or avoid loss of some or all the stimulus.

Conjugate Schedules

Conjugate schedules involve a response-consequence relation occurring along a continuum wherein the relation covaries such that the intensity, magnitude, and/or amplitude of the response is proportional to the consequent stimulus change (Rapp, 2008; Weisberg & Rovee-Collier, 1998). Changes in ongoing responding produce corresponding changes in the consequent event. Thus, with ratio, interval, and differential reinforcement schedules, the relation between a reinforcer and the response is episodic, whereas, with conjugate reinforcement schedules (and schedules of covariation), the relation between a reinforcer and response is non-episodic (Lattal, 2010).

Similar to episodic types of reinforcement, conjugate schedules can be sub-classified as positive and negative conjugate reinforcement (Saunders, 2020). An example of conjugate positive reinforcement would be an individual who goes sightseeing in the countryside while cycling. As positive conjugate reinforcement, the effect could be the different cycle speeds the individual travels while viewing preferred scenery (e.g., slower speed to view cottages) relative to non-preferred scenery (e.g., faster speed when viewing an empty field). An example of conjugate negative reinforcement would be an individual who fans themself on a hot day. As negative conjugate reinforcement, the effect could be the speed (i.e., fast or slow) and the direction (i.e., up, down, left, and right) the fan is manipulated in order to decrease their temperature. Thus, with conjugate schedules the response-reinforcer relation is dynamic.

Although conjugate punishment exists in both theory and research, there little is known about it both within a basic and applied context (see Rapp, 2008 for a discussion). Therefore, this study will review some of the literature on conjugate schedules of reinforcement and the operant dimensions it has been used to study.

Response Force

Initially, research involving conjugates schedules investigated response rate to reinforcer dimensions (e.g., Lindsley, 1957, 1962; Rovee, & Rovee, 1969; Siqueland & Delucia, 1969). For instance, Rovee and Rovee (1969) used a mobile conjugate reinforcement task in which the rate of infant foot kicks was proportional to the rate of movement of an overhead mobile. Relatedly, researchers used conjugate reinforcement as a method to study the rate and force of infant sucking responses (Siqueland & DeLucia, 1969). More recently, a study by MacAleese et al. (2015) found that the rate of key pressing to access visual stimulation came under the control of a conjugate schedule (see also Jones, 2016). However, operant dimensions like response force have been shown to be useful and meaningful operant dimensions to investigate (e.g., Davis et al., 2021, Falligant et al., 2018, 2020; Notterman & Mints, 1965; Zarcone et al., 2009).

Response force has been studied in both non-humans (e.g., Fowler et al., 1994; Notterman & Mintz, 1965; Zarcone et al., 2009) as well as humans (e.g., Davis et al., 2021; Deochand et al., 2020; Falligant et al., 2018, 2020). Recently, researchers have explored response force as a measure of the value of relative stimulus preference in a conjugate preparation. For instance, Deochand et al. (2020) reported that access to higher- or lower-quality of audio and visual stimulation impacted the punch force and speed of eight boxers. Falligant et al. (2018, 2020) found response force to be a reliable measure of reinforcer value for audiovisual stimuli. Davis et al. (2021) found that participants' preference for visual stimuli corresponded to the amount of force exerted to view pictures within a stimulus category.

Conjugate schedules provide a useful framework to study relevant dimensions of behavior which can contribute to our understanding of behavior that varies from moment-to-moment such as stimulus preference. To that end, a brief review of some of the historical and current literature on conjugate schedules is warranted.

Evaluation of Concept

Initially, Lindsley (1957) examined sleep cycles using a conjugate reinforcement preparation. Participants could control the intensity at which a tone was continuously played by pressing a device. By analyzing participants' sleep onset, sleep duration, and frequency of button pressing with this arrangement, Lindsley was able to study the effects of sleep deprivation. Lindsley named this type of schedule “conjugate reinforcement” (Saunders, 2020). Lindsley (1962) and Morgan and Lindsley (1966) provided additional evidence for the effects of conjugate reinforcement producing stable and continuous responding. Across both studies, the authors found that the participants emitted higher rates of hand-switching to view preferred television shows and to listen to music, respectively. Although these studies more closely resembled an FR-1 schedule, the authors progressed these procedures by utilizing one-operandum and two-operanda techniques.

The one-operandum technique consists of one stimulus being produced by high or accelerating rates of responding, and a different stimulus being produced by low or decelerating rates of responding (Rapp, 2008). The two-operanda technique consists of two responses both of which produced different consequence events (Rapp, 2008). Thus, the one-operandum and two-operanda techniques can provide a better demonstration of experimental control relative to traditional preference assessment procedures when evaluating reinforcer efficacy (see Rapp, 2008 for a review). These earlier studies resulted in researchers investigating the influence of conjugate schedules on behavior such as early-developing operants.

In a now classic preparation, Lipsett et al. (1966) used a conjugate preparation to examine panel-pressing of 12-month-old infants. Lipsett and colleagues sat infants in front of a dark screen that would illuminate contingent on infants meeting a specific response rate. They found that infant panel-pressing came under the control of the schedule as rates of responding differed across the reinforcement and withdrawal conditions. In a similar study, Rovee and Rovee (1969) evaluated the rate of infant leg movements in response to a mobile device placed above their cribs. Most infants in the experimental group nearly tripled their foot-kicking responses both within initial and across sessions compared to those in the control group. Siqueland and DeLucia (1969) used a visual stimulus to condition infants non-nutritive sucking where strength of sucking (i.e., force) was directly proportional to the brightness of the visual stimuli. Interestingly, the response criterion for reinforcement required infants to adapt the rate and force of their sucking depending on which group they were assigned (Rapp, 2008). For one group of infants, presentation of the visual stimulus was contingent upon an increase in the rate and force of their sucking, while for the other group, presentation of the visual stimulus was contingent upon a decrease in the rate and force of their sucking. The study found that infants rapidly met the sucking response criterion which resulted in access to visual reinforcement. Overall, these studies revealed that early-developing operants can be sensitive to conjugate preparations which serve as reinforcement (Rapp, 2008; see Weisberg & Roove-Collier, 1998 for a review).

Applications of Conjugate Schedules

Conjugate schedules have been described and studied across different contexts as a method for (a) decreasing problem behavior (Rapp, 2008; Switzky & Haywood, 1973), (b) increasing physical activity (Caouette & Reid, 1991; Deochand et al., 2020), and (c) assessing stimulus preference (Davis et al. 2021; Falligant et al., 2018, 2020; Lovitt, 1967; MacAleese et al., 2015; Voltaire et al. 2005)**.** Although conjugate paradigms have been used to examine a variety of socially important behavior both within and outside the field of behavior analysis, a review of all the literature is beyond the scope of this study. Rather, the current section will describe some noteworthy applications of conjugate schedules.

Behavioral Intervention for Problem Behavior

In many cases, the assessment and treatment of stereotypic behavior may be warranted as it can profoundly impact an individual's daily functioning and impede the development of important skills (e.g., academic and vocational [Cook & Rapp, 2018]). Lovaas et al. (1987) suggested that automatically reinforced behaviors may be under the control of conjugate reinforcement. That is, highly repetitive, restrictive, and rigid responding may be conjugately reinforced and thus produce stereotypic behavior. Conjugate schedules have been utilized as an assessment tool for automatic reinforcement (Rapp, 2008; Rapp et al., 2004; Switzky & Haywood, 1973).

Switzky and Haywood (1973) examined the effects of a conjugate positive reinforcement procedure using a two-operanda technique with 18 intellectually disabled individuals. Across two conditions – low-motion and high-motion, participants were provided noncontingent access to a preferred movie but responding to produce adequate illumination was reinforced under a conjugate schedule. Continuous access to the preferred movie with optimal illumination required participants to either (a) withhold engaging in gross motor activities or (b) engage in gross motor activities. Higher rates of motor activity were maintained when high rates were conjugately reinforced during the high-condition and lower rates of motor activity occured during the low-motion condition. The results from the low-motion condition indicated that the movie served as a competing stimulus for motor movements and hence, this could be used to decrease levels of stereotypy (Rapp, 2008).

Similarly, Rapp et al. (2004) used a concurrent-operants design and conjugate positive reinforcement preparation to assess the stereotypic behavior (body movements and reflective surface observing) of one autistic individual. The study compared two conditions: a controlled video condition and an uncontrolled (yoked) video condition. The controlled video condition functioned as a conjugate arrangement because the participant could observe and control the intensity and duration of his stereotypic behavior in real-time on a TV screen. Thus, continuous access to visual stimulation of stereotypic behavior was proportional to the duration and intensity of the participant's stereotypy. The uncontrolled video condition consisted of previously recorded sessions of the participant engaging in stereotypic behavior, hence this condition functioned as a non-contingent reinforcement (NCR) condition. The participant allocated a greater percentage of time to observing and engaging in stereotypic behavior during the controlled condition (i.e., conjugate arrangement) relative to the uncontrolled (i.e., NCR) condition.

Physical activity

Within the natural environment, conjugate arrangements can be observed to occur among everyday response-consequence interactions, which include physical exercise and activity. Garber (2019) noted that around 45% of U.S. adults are insufficiently active, which contributes to health problems such as obesity. Although limited, there is some research to support the use of conjugate schedules to improve exercise behavior (Deochand et al., 2020).

In a study by Caouette and Reid (1991), the authors examined the effects of three types of auditory stimuli delivered for peddling a stationary bike at specified rates. The study consisted of exposing 13 participants with an intellectual disability, separated into three groups, to three types of auditory stimulation: white noise, pink noise, and preferred music. With the exception of one participant, the authors found that the music condition produced the highest and most stable increases in bike pedaling relative to the other two conditions (i.e., white, and pink noise). Notably, this study most likely utilized a synchronous schedule as participants were only reinforced when they reached a pre-determined performance criterion. Moreover, this finding is noteworthy because many individuals with developmental disabilities tend to be overweight, inactive, or both (Hsieh et al., 2017). This study demonstrated the positive effects of this preparation for individuals who present with some form of an intellectual disability.

In a more recent study, Deochand et al. (2020) utilized both a positive and negative conjugate preparation to examine the punching behavior of eight participants. Deochand and colleagues had participants jab a punching bag wherein the volume and speed of music was related to each participant's response force. That is, punch speed and force negatively covaried with music speed and volume. If participants did not meet their punch-speed goals then the music tempo would progressively increase (up to 3.0 faster after 10 below goal responding; Deochand et al.,2020). Similarly, if participants did not meet their punch-force goals then the music volume progressively decreased (volume could drop down to 10% of the original volume). Importantly, speed and force contingencies could be in effect simultaneously or independently of each other. The results of the study showed that relative to baseline, the conjugate preparation increased the average punch force and speed for five out of the eight participants. However, the observed increase in response force and speed was not assessed for maintenance across longer periods (i.e., days and weeks). It is unclear whether improved performance occurred as a result of the audio stimulus, visual stimulus, or both. Deochand et al. speculated that conjugate schedules are particularly well-suited for the area of physical exercise because they can be embedded with preferred stimuli.

The studies reviewed within this section either directly or indirectly assessed each participant’s preference for stimuli. Stimulus preference is an important operant because the reinforcing value of a stimulus is influenced by ongoing motivating operations (Laraway et al., 2014). Thus, the identification and utilization of valued events or stimuli is important to increase the efficacy of interventions (Rapp, 2008). The next set of studies will focus on stimulus preference and conjugate schedules.

Stimulus Preference

A preference assessment is a method utilized by clinicians, practitioners, and professionals alike to identify preferred and non-preferred stimuli, with the presumption that preferred stimuli are more likely to function as reinforcers. Cooper et al. (2020) outlined general types of preference assessments: (a) single stimulus approach (e.g., Pace et al., 1985), (b) paired-stimulus preference assessment (e.g., Fisher et al., 1992), (c) multiple stimulus without replacement (MSWO) (e.g., DeLeon et al., 1999), and (d) multiple stimulus with replacement (e.g., DeLeon & Iwata, 1996). Such preference assessment methods tend to yield one-dimensional outcomes (e.g., number of times selected, or duration of time engaged with item) and can be time-consuming to complete (Cooper et al., 2020). Identifying preferred stimuli alone does not mean that those stimuli will function as reinforcers, however (Davis et al., 2021). Given the sensitivity of behavior to conjugate schedules, these arrangements may be more suited to evaluating reinforcer efficacy as continuous responding is required to access a reinforcing stimulus (Rapp, 2008).

MacAleese et al. (2015) examined preference for picture categories across three experiments involving conjugate positive reinforcement, extinction, and conjugate negative punishment, respectively, for 13 undergraduate participants. In Experiment 1, participants were exposed to a seven-component multiple schedule wherein continuous key pressing on one key resulted in a change to the percent clarity value (e.g., 20%) of a picture, and pressing the other key resulted in a switch to a different picture. Results from Experiment 1 showed that participants’ response rates on the visual-clarity key inversely covaried with the intensity of the reinforcer. In Experiment 2, participants were exposed to a similar phase as Experiment 1, but with the addition of an extinction phase. Participants’ key presses rapidly increased during reinforcement (i.e., visual clarity) and decreased during extinction. In Experiment 3, participants were exposed to a conjugate negative punishment condition wherein key presses resulted in a decrease in visual clarity. They found participants' responses on the visual-clarity key decreased (i.e., negative punishment) during this condition. MacAleese et al. did not evaluate whether access to a non-preferred visual stimulus would produce differential responding across conditions and thus, provide stronger evidence for the utility of conjugate preparations to identify preference.

In a similar study, Jones (2016) evaluated the effects of highly preferred picture categories on conjugately negative reinforced key pressing with nine undergraduate students. The study involved a six-component multiple schedule associated with different picture fade-out percentages (e.g., 10%). Across all conditions, participants saw the pictures at maximum clarity, and they needed to press a key to maintain or increase clarity, otherwise, the picture would diminish according to the fade-out condition in effect. In general, participants’ responding tended to change as a function of the fade-out condition in effect. Although Jones conducted a systematic preference assessment and identified preferred and non-preferred picture categories, only preferred picture categories were included in the preparation. Jones also reported that although inconsistencies between participants' response latencies and fade-out values occurred, they were unsure as to why response latencies were insensitive to fade-out values.

The MacAleese et al. (2015) and Jones (2016) study demonstrated the potential utility of conjugate preparations for identifying individual preferences for specific stimuli using rate measures. Conjugate schedules have been used to assess individual preference for stimuli using response dimensions other than rate. For example, Falligant et al. (2018) used a force measure to evaluate audiovisual reinforcer efficacy within a conjugate framework. The authors had participants rank audiovisual stimuli (i.e., videos) from 1 to 15 with 1 indicating the highest preferred video and 15 indicating the lowest preferred video. In Experiment 1, Falligant et al. used a force-transducer (a knob) to measure the amount of force participants exerted to amplify the sound of audiovisual stimuli. They found that participants' force responses tended to decrease as the volume of the audiovisual increased. In Experiment 2, the authors evaluated participants' response maintenance for either high-preferred (HP) or low-preferred (LP) audiovisual stimuli when conjugate changes in the volume were provided contingent on the amount of force exerted on the force-transducer. Participants' responding tended to be higher for the HP audiovisual stimuli relative to the LP audiovisual stimuli. In Experiment 3, extinction-induced variability was evaluated wherein responding on the force transducer did not produce changes in audiovisual stimuli. The results showed more variability in response force during the extinction component relative to previous reinforcing components. Interestingly, this study indicated that conjugate arrangements may be suited to detecting extinction across different response dimensions (e.g., response rate, response force; Falligant et al., 2020).

In a follow-up study, Falligant et al. (2020) evaluated participants' response acquisition and extinction using the same force transducer as Falligant et al. (2018) across two experiments with audiovisual stimuli. Falligant et al. (2020) asked each participant to rank their preference for different video categories, yielding a rank order of HP and LP stimuli. In Experiment 1, the authors measured each participants' response force across a series of reinforcement and extinction components. Experiment 1 replicated the results from Falligant et al. (2018) wherein participants' responding revealed an inverse relation between volume-multiplers and peak response force. In Experiment 2, the authors evaluated (a) how responding on a force transducer varied when changes in the volume of the audiovisual stimuli occurred either response-independently or response-contingently on transducer pressing and (b) if changes occurred in participant responding during extinction due to prior exposure to response-dependent or response-independent volume changes. The mean response force was higher for extinction that followed response-independent reinforcer delivery relative to response-contingent reinforcer delivery.

Although Falligant et al. (2018, 2020) demonstrated the utility of conjugate arrangements with a different dimension of behavior, both studies were limited in that they only surveyed participant's preference for audiovisual stimuli rather than utilize a systematic preference assessment (e.g., DeLeon & Iwata, 1996) or identify breakpoints for stimuli produced on a progressive ratio schedule (Stafford et al., 1998).

Davis et al. (2021) extended the work of MacAleese et al. (2015) and Falligant et al. (2018) by using a progressive ratio schedule embedded within a conjugate arrangement to measure response force of individual preference for visual stimuli. First, the authors used a verbal multiple stimulus without replacement (VMSWO) to assess participants' preference for different picture categories. The VMSWO assessment produced a preference hierarchy of visual stimuli (e.g., street art, animals, office furniture, and cars). Next, the authors had each participant use a hand dynamometer to view different visual stimuli. For participants to maintain or increase the visual clarity of an image on the screen (i.e., negative conjugate reinforcement), they would have to meet the specific force criterion. For instance, images on the screen were programmed to fade at a rate of 10% per second. Thus, participants needed to apply force to the dynamometer at a ratio of 10% transparency per 1kg force, every second to maintain or increase clarity. Hence, the progressive schedule component of the study. Although this study described a progressive conjugate schedule, it is more likely that the authors used a progressive synchronous schedule.

To evaluate correspondence between the VMSWO and participant's force responding, Davis et al. (2021) arranged results into six categories: decreasing trend, nonresponders, HP and LP correspondence, HP only correspondence, LP only correspondence, and undifferentiated. Overall, the authors found that participants' HP and LP stimuli corresponded to the amount of force exerted to view those stimuli. Notably, the conjugate reinforcer assessment took approximately 5 min to complete and required little instruction for participants. Thus, it could be argued that conjugate preparations may be a more efficient way to assess reinforcer efficacy compared to general types of preference assessments (see Cooper et al., 2020), for a review). Although the Davis et al. study included pictures they assumed to be preferable to view (e.g., street art) relative to the other picture categories (e.g., office furniture) more research is warranted. Studies involving stimuli that are less arbitrary than those utilized in the Davis et al. study may provide more information and evidence regarding the sensitivity and generality of these preparations in detecting specific patterns of behavior such as pictures of people.

Hypotheses

This investigation sought to replicate and extend the Davis et al. (2021) study by examining correspondence between participants' rank scores produced by a VMSWO preference assessment for pictorial stimuli to the response force exerted to view those same pictorial stimuli. Although this study sought to evaluate less arbitrary stimuli (i.e., pictures of people) than those used in the Davis et al. study, our primary interest was in comparing the rank scores from a VMSWO assessment to the response force rankings produced by a progressive synchronous schedule. To that end, we hypothesized that there would be (a) a correlation between participants’ rank order from the VMSWO assessment and the mean response force exerted to view those pictures, (b) no correlation between participants’ rank order from the VMSWO assessment and stimulus presentation order, and (c) no correlation between participants’ mean force rank and stimulus presentation order.

Chapter 2

Methods

Participants and Setting

Undergraduate students were recruited from a university using an online platform for research participation. Prior to conducting the experiment in person, participants completed a COVID-19 screening questionnaire via the telephone or in person (obtained from: https://cws.auburn.edu/ovpr/pm/irb-covid19-precautions). If participants did not present with COVID-19 symptoms, sessions were conducted in a 10 m x 7 m research room. As an extra precautionary measure, both researchers and participants had to:

1. Sanitize their hands.
2. Wear face masks during the session.
3. Sanitize research equipment after each use.

An information letter, providing an overview of the study was given to each participant. Researchers recruited consent from participants once they had read the letter and asked questions. Participants received extra credit for completing the study.

Apparatus

As this study was a replication and extension of Davis et al. (2021), the apparatus was similar. Following the VMSWO assessment, Custom software written in Labview™ (NI, Austin, TX, USA) was used for programming events and data collection. For the measurement of force, researchers connected a hand dynamometer (Vernier, Beaverton, OR, USA) with a 1.3 m cord to a custom interface and data acquisition card equipped with a14-bit A/D converter (USB-6009, NI, Austin, TX, USA). During the experimental task, the participant observed pictorial stimuli on a computer screen while holding the hand dynamometer. Software sampled forces from the dynamometer at 20 samples per second and reported the average and maximal force obtained for each 20-sample window. The dynamometer's operative range was 0 to 60 kg. The smallest change that could be detected in our system was about 0.004 kg. However, previous tests with the dynamometer indicated it naturally fluctuated by 0.1 kg about zero even at rest, so this could be regarded as the level of noise in the system (Davis et al., 2021). The conjugate schedule updated second by second. At the end of each second, a collection of 20 force sample readings were averaged together to yield the average force over the second. This average force determined the transparency setting for the next second. The recordings were coupled with the transparency of the image and the duration it remained on the screen.

VMSWO Preference Assessment

As described by Davis et al. (2021), the VMSWO assessment is a measure of preference adapted from MSWO procedures utilized by Deleon and Iwata (1996). Researchers presented pictorial stimuli in the form of flashcards, on a table, and asked the participant "which picture would you like to view the most". Each time a pictorial stimulus was selected, that stimulus was removed from the array, and the remaining stimuli re-ordered. This process continued until one pictorial stimulus remained or until the participant indicated they did not want to look at any pictures from the array. The entire process was repeated three times, with a different starting order each time. Typically, the VMSWO assessments took about 5-10 min to complete, and the same pictorial stimuli were used across all participants. The preference assessment results yielded a hierarchy of relative preference. The following set of instructions were read aloud to each participant prior to conducting the VMSWO:

> This test is examining how your handle squeezing changes while viewing different pictures on a computer monitor. Before we start the program and working with the computer and grip, we first need to find out what kind of pictures you would like to view

> during the experiment. I need to ask you a series of questions to determine this. To start I will show you a picture that is representative of each type of picture you will view on the computer (show pictures for 5s each and state the category name, e.g., "Children") Now that you've seen all the categories I am going to present an array of flashcards with the picture category names on them. I will ask you to choose which type of picture you would like to look at the most from the array, and you will need to pick up the flash card. I will re-arrange the cards each time you choose, and we will run through the same procedure 3 times in total. If you do not want to look at pictures for any of the categories, then tell me and we can start the next round. Do you have any questions (answer questions)?

Researchers answered any questions participants asked prior to conducting the VMSWO assessment. The pictorial stimuli consisted of (a) child female (CF), (b) adolescent male (Adol.M), (c) young adult female (YAF), (d) adult male (AM), and (e) elderly female (EF). All pictures were of fully clothed individuals. Davis et al. arbitrarily selected pictures they believed would and would not be of interest to participants (e.g., street art and office furniture, respectively). By contrast, we selected pictures of individuals as viewing humans may be a phylogenetically important event (PIE; Baum, 2012). Evaluating this novel stimulus class may give rise to more distinct patterns of responding in the conjugate arrangement that was not observed with arbitrary stimuli in the Davis et al. study. Following the preference assessment, participants were directed to a laptop, and the researcher initiated the computer program and hand dynamometer component of the study.

Conjugate Preference Assessment

Following the VMSWO, researchers directed participants to a laptop with a hand dynamometer. Researchers then read the following instructions aloud to each participant:

> I will pull up the program and give the handle to you when it is ready to go. Remember, you can take a break between each picture, but please stay seated until the program indicates it is finished. I will hold the handle for you if you want to take a break so that you do not accidentally start the next picture. Please only squeeze that handle (point to dynamometer) with one hand. You should use only your dominant hand for squeezing.

> You should remain at the computer for the entire time the program is running. At times it may seem like the program is not working, but I will be monitoring it the whole time, so don't worry. We will run through one session with five trials. Do you have any questions (answer questions, then, once participant is seated)?

Researchers answered questions and then handed the dynamometer to the participant. The researcher monitored the session to ensure the program started, continued, and ended with the appropriate pre-programmed cues (i.e., “squeeze lightly to begin”).

Sessions involved participants exerting force using the hand dynamometer to determine the duration and presentation of each stimulus. As described by Davis et al. (2021), when the dynamometer detects a force >0.5kg, the program started, and the first image appeared. The software showed the image at 100% clarity and used the force recording to determine the percentage of clarity of the stimulus. If *no* force was applied, the picture on the screen faded at a rate of 10% per second until it reached >90% transparency. To maintain or restore visual clarity, participants needed to apply force to the dynamometer at a ratio of 10% transparency per 1kg force. However, the clarity continued to decline at a rate of 10% per second and required greater response force to maintain clarity. Once an image reached >90% transparency, the trial ended, and the force requirement reset. The program randomly presented each pictorial stimulus one time to each participant (see Figure 1 which illustrates responding on the conjugate schedule). Each session took approximately 20 min to complete.

Experimental Design

Researchers evaluated the correspondence between participants' preference for the five pictorial stimuli as determined by the VMSWO assessment and their peak and mean force responding to view each stimulus via the hand dynamometer using a combined within-subjects group design. Specifically, this study compared each participant’s VMSWO rank of the five pictorial stimuli to the response force exerted to view them using a variation of a single-case randomization design (Davis et al., 2021; Kazdin, 2011; Levin et al., 2012).

Dependent Variables

As this study was a replication and extension of the Davis et al. (2021) investigation, the dependent variables were similar. The primary dependent variables of interest were (a) the percentage of selected pictorial stimuli from the VMSWO assessment and (b) the mean and peak response force (kg) from the conjugate assessment.

VMSWO Preference Assessment

Researchers collected data on the percentage selected of pictorial stimuli during the VMSWO preference assessment. As previously noted, participants' selection of stimuli yielded a hierarchy of preferences. That is after participants selected all pictorial stimuli in order of preference, the stimulus selected for the highest percentage of trials was first-ranked, the stimulus selected for the second highest percentage of trials was second-ranked, and so on.

Hand Dynamometer

Participants' mean and peak response force were measured using the hand dynamometer. Once an image appeared on the screen, participants needed to exert the required amount of force via the hand dynamometer to maintain or increase the visual clarity of each pictorial stimulus. However, if participants did not exert enough force, the pictorial stimulus would continue to become more transparent until the trial ended. For the same reasons described by Davis et al. (2021), researchers used ordinal measures to convert mean and peak force responses into rank orders. Typically, ordinal measures are used to assess preference (e.g., DeLeon et al. 1999) because it allows a direct comparison between the two measures with differing units (i.e., preference and force). This continued until all stimuli had been rank-ordered based on participants' mean response force. Researchers created separate graphs depicting each participant's mean and peak response force and VMSWO rank order.

Statistical Analyses of Group Data

IBM SPSS version 29 and R Studio's R Stats Package (version 3.6.2) were used to conduct all analyses. Spearman's Rank-Order Correlation (Gravetter & Wallnau, 2017) was used to evaluate the correspondence between participants' stimulus ranks from the VSMWO preference assessment and mean force output to view stimuli. Davis et al. (2021) used mean force output only for group analyses because they found (a) high correspondence between mean and peak force, (b) mean and peak force values were similar, and (c) it avoided duplication and thus reduced the probability of obtaining false positives. However, we conducted the same statistical analyses using peak force output as it was not the case that mean and peak force values subsumed each other.

VMSWO Rank and Mean and Peak Force Order

A Spearman's Rank-Order test was conducted to examine if there was a statistically significant correlation between participants' VMSWO and mean and peak force rank order. Researchers predicted that there *would* be a correlation between the amount of force participants exerted to view their highest-ranked pictorial stimulus and the amount of force exerted to view their lowest-ranked pictorial stimulus.

VMSWO Rank and Stimulus Presentation Order

There was a possibility that a first-ranked pictorial stimulus from the VSMWO assessment would appear as the first picture presented by the computer program. A Spearman's Rank-Order Correlation was used to examine if there was a correlation between participants' VMSWO rank order and the stimulus presentation order (Davis et al., 2021). Researchers predicted that there *would not* be a statistically significant correlation between VMSWO rank and stimulus presentation order.

Mean and Peak Force Rank Order and Stimulus Presentation Order

It may be that participants exerted the highest amount of force to view the stimulus in the first position and the least amount of force to view the stimulus in the lowest position, perhaps due to physical fatigue (Davis et al., 2021). A Spearman's Rank-Order test was conducted to examine if there was a statistically significant correlation between participants' mean and peak force order and stimulus presentation order. Researchers predicted that there *would not* be a statistically significant correlation between participants' mean and peak force and the stimulus position.

Graph Categorization

The rank orders from the VMSWO assessment and the mean and peak response forces for each pictorial stimulus from the conjugate assessment were examined graphically. Thereafter, researchers placed each graph into a specific category.

For each participant, researchers categorized graphs using the VMSWO rank order of pictorial stimuli and mean response force (kg) used to view images. To that end, researchers arranged graphs according to the six categories (described below) developed by Davis et al. (2021). Graphs were sorted into one corresponding category once, only. For example, if a graph was placed into the HP and LP correspondence category, it was not also sorted into the HP or LP only categories. Additionally, we designated stimuli according to their rank from the VMSWO assessment. The first- and second-ranked pictorial stimuli from the VMSWO assessment were designated as high preference (HP) stimuli and the fourth- and fifth-ranked pictorial stimuli were designated as low preference (LP) stimuli. Designating stimuli this way allowed researchers to identify if (a) the highest mean force corresponded with either VMSWO rank one or two, or both, and (b) the lowest mean force corresponded with either rank four or five, or both. In other words, if a participant exerted the highest-ranked force to view the two highest rank pictorial stimuli from the VMSWO assessment, this would count as a match for two HP stimuli. Similarly, if a participant exerted the lowest rank force to view the two lowest-ranked pictorial stimuli from the VMSWO assessment, this would count as a match for the two LP stimuli. Additionally, researchers counted a match between a HP item and the highest response force rank if the participant exerted the highest mean force to view either their first or second-ranked item from the VMSWO assessment. Likewise, we counted a match between an LP item and the lowest response force if the participant exerted the lowest mean force to view either their fourth or fifth-ranked item from the VMSWO assessment.

Nonresponders

Some participants could squeeze the hand dynamometer and immediately release their grip as soon as the session began. When the participant's peak force did not surpass 0.5 kg to view any of the pictorial stimuli, researchers placed a graph in this category. None of the participants appeared to be non-responders based on achieving the minimum force value.

HP and LP Correspondence

Graphs were placed into this category when a HP stimulus from the VMSWO assessment produced the highest mean force and when a LP stimulus produced the lowest mean force. This category included graphs that conveyed strong correspondence between the VMSWO and the conjugate assessments.

HP Only Correspondence

Graphs were placed into this category when a HP stimulus from the VMSWO assessment produced the highest mean force, but a LP stimulus did not produce the lowest mean force. Graphs in this category showed strong correspondence between the highest mean force to view a HP stimulus but no correspondence between the lowest mean force and an LP stimulus.

Decreasing Trend

This category was used to sort graphs that displayed participants' mean force decreasing across either four or five or five of five stimulus categories in order of stimulus presentation. Graphs in this category showed strong correspondence between the stimulus presentation order generated by the software program and mean response force. For example, a participant who exerted the highest mean force to view the first-presented stimulus, the second-highest mean force to view the second-presented stimulus, the third-highest mean force to view the third-presented stimulus, and so on. Instead, graphs in this category were indicative of low reinforcer value, physical fatigue, stimulus satiation, or some combination thereof.

LP Only Correspondence

Graphs in this category involved a LP stimulus from the VMSWO assessment producing the lowest mean force, but a HP stimulus did not produce the highest mean force. Graphs in this category showed strong correspondence between the lowest mean force to view a LP stimulus but did not show correspondence for the highest mean force to view a HP stimulus.

Undifferentiated

Graphs in this category did not show discernible relations between response force and stimulus rank from the VMSWO assessment. In addition, graphs in this category did not display correspondence between mean force and stimulus presentation order.

Results

Table 1 displays the socio-demographic characteristics across participants. Of the 98 participants, 76.5% were female (*n* = 75), 23.5% were male (*n* = 23), and across both males and females, the average age was 18 years (*M* = 18.82, *SD* = 1.077). The sample comprised 78.6% (*n* = 77) White, 3.1% (*n* = 3) Black, 3.1% (*n* = 3) East Asian, 1% (*n* = 1) Southeast Asian, and 1% (*n* = 1) Hispanic participants.

Table 2 shows the mean preference ranks from the VMSWO assessment and the average mean and peak force ranks across the five pictorial stimuli for all 98 participants. Participants tended to rank CF and YAF as the highest-ranked stimuli from the VMSWO assessment. Similarly, participants exerted the highest average mean and peak force to view CF and YAF during the conjugate assessment. In contrast, participants tended to rank AM and EF as the lowest-ranked pictorial stimuli from the VMSWO assessment. However, participants exerted the lowest average mean and peak force to view Adol.M and EF during the conjugate assessment. The results of a spearman's rank-order correlation test revealed no significant correlation for participants' gender and the five visual stimuli.

Figures 2 and 3 show heatmaps, created using R Studio's GGplots, of the mean and peak force rank by VMSWO rank order across all participants, respectively. A darker shaded tile denotes a relatively high percentage of occurrences between measures (e.g., agreement between mean or peak force rank and VMSWO rank) whereas the lighter shaded tile denotes a relatively low percentage of occurrences between measures. In general, participants' HP stimuli from the VMSWO (i.e., first- or second-ranked) tended to be the same stimuli they exerted the most force to view. By contrast, participants' LP stimuli from the VMSWO (i.e., fourth- or fifth-ranked) tended to be the same stimuli they exerted the least force to view.

Table 3 shows the results of Spearman's Rank-Order Correlation test. Prior to conducting statistical analyses, data were winsorized to remove outliers (Wu & Zuo, 2009). Results of the Spearman's test showed a small ($r = .225$) to medium ($r = .358$) positive correlation for VMSWO Rank 1-5 by Peak Force Rank 1-5 and Mean Rank 1-5, which were both statistically significant at $p < .001$, respectively. In contrast, the result of Spearman's test for VMSWO Rank 1-5 by Stimulus Order 1-5 was not statistically significant ($r = .070$, $p = .125$). Similarly, the result of Spearman's test for Stimulus Order 1-5 by Mean Force Rank 1-5 was not statically significant ($r = .105$, $p = .298$), suggesting the stimulus presentation order did not influence mean force ranks. However, the result of the Spearman's test showed a small ($r = .050$) positive correlation for Stimulus Order 1-5 by Peak Force Rank 1-5 that was statistically significant at $p < .019$, suggesting that the stimulus presentation order was very weakly correlated with *peak* force exertion.

Figures 4-7 depict the dot plot distribution and spread of mean and peak response force measures across both VMSWO rank order and stimulus presentation order. Black circles denote participants' force responding and red circles denote the average force value across rank and presentation order. Specifically, Figures 4 and 5 display the distribution and spread of mean and peak force values on the y-axis across and VMSWO Rank Order (1-5) on the x-axis. For Figure 4, the average mean force values decreased across VMSWO ranks in order from first-ranked (left) to fifth-ranked (right) stimulus. In general, participants' mean force responding decreased in accordance with the rank order of pictorial stimuli from the VMSWO assessment. Similarly for Figure 5, the average peak force values decreased across VMSWO ranks in order from first-ranked (left) to fifth-ranked (right). In general, participants' average peak force responding decreased in accordance with the rank order of pictorial stimuli from the VMSWO assessment.

Figures 6 and 7 display the distribution and spread of mean and peak force values on the y-axis across Stimulus Presentation Order (1-5) on the x-axis. For Figure 6, the distribution and spread of participants' mean force responding did not vary due to presentation order. In other words, the order in which pictorial stimuli were presented did not influence participants' mean force responding. For Figure 7, although the distribution and spread of participants’ peak force responding are visually similar to that of Figure 6, Spearman’s test indicated a weakly correlated statistical significance between peak force and stimulus presentation order.

Figures 8 and 9 display the box plot distribution of mean and peak force measures for each pictorial stimulus. Both figures include the outliers that had previously been Winsorized for statistical testing. For Figure 8, participants exerted the highest amount of mean force to view CF and YAF (3.5 kg and 3.4 kg, respectively). In contrast, participants exerted the lowest amount of mean force to view Adol.M and EF (2.5 kg and 2.4 kg, respectively) as depicted by the mean line. Figure 9 shows participants exerted the highest peak force to view CF and YAF (6.0 kg and 5.8 kg, respectively) as depicted by the mean line. By contrast, participants exerted the lowest peak force to view Adol.M and EF (4.7 kg and 4.4 kg, respectively) as depicted by the mean line.

Figures 10-13 depict the rank order for each pictorial stimulus during the VMSWO assessment in order from first-ranked (left) to fifth-ranked (right). To reiterate, researchers sorted graphs according to the VMSWO rank order and the mean response force. In general, results for each of the 98 participants showed correspondence between the rank order from the VMSWO and the mean force rank measurements. Figure 10 depicts representative graphs that fit the HP and LP correspondence category. Responding by 49 (50%) participants met the criteria to be placed into this category. For example, results in the upper panel of Figure 10 show P04 exerted the highest mean force to view the VMSWO first-ranked pictorial stimulus. In addition, P04 exerted the lowest mean force to view the fifth-ranked pictorial stimulus. Similarly, results in the bottom panel of Figure 10 show P57 exerted the highest mean force to view the VMSWO first-ranked pictorial stimulus and the lowest mean force to view the VMSWO fifth-ranked pictorial stimulus. Of those 49 participants, 26.5% had two HP and two LP matches, 24.5% had two HP and one LP matches, 22.4% had one HP and two LP matches, and 26.5% had one HP and one LP match.

Figure 11 depicts representative graphs that fit the HP only correspondence category. Responding by 14 participants (14.3%) met the criteria to be placed into this category. For example, results in the upper panel of Figure 11 show P07 exerted the highest mean force to view the VMSWO second-ranked pictorial stimulus but exerted the lowest mean force to view the first-ranked pictorial stimulus, hence P07 fit the criteria to be placed into the HP only category. Similarly, results in the bottom panel of Figure 11 show P62 exerted the highest mean force to view the VMSWO second-ranked pictorial stimulus but the lowest mean force to view the VMSWO first-ranked pictorial stimulus, hence P62's force responding met the criteria to be placed into this category. Of those 14 participants, 14.3% had two HP matches and 85.7% had one HP match. When combined with HP responses by participants from the HP-LP category (*n* = 63), 42.9% of participants had two HP matches and 57.1% had one HP match.

Figure 12 depicts representative graphs that fit the LP only correspondence category. Responding by 13 participants (13.3%) met the criteria to be placed into this category. For example, results in the upper panel of Figure 12 show P06 exerted the lowest mean force to view the VMSWO fourth and fifth-ranked pictorial stimulus and exerted the highest mean force to view the third-ranked pictorial stimulus. Hence P06 met the criteria to be placed into the LP only category. Similarly, results in the bottom panel of Figure 12 show P77 exerted the lowest mean force to view the VMSWO fifth-ranked pictorial stimulus and exerted the highest mean force to view the VMSWO third-rank pictorial stimulus. Of those 13 participants, 30.8% had two LP matches and 69.2% had one LP match. When combined with LP responses by participants from the HP-LP category (*n* = 62), 48.4% of participants had two LP matches and 51.6% had one HP match.

Figure 13 depicts representative graphs that fit the undifferentiated correspondence category. Responding by 15 participants (15.3%) met the criteria to be placed into this category For example, results in the upper panel of Figure 13 show P12 exerted the highest mean force to view the VMSWO third-ranked pictorial stimulus and exerted the lowest mean force to view the second-ranked pictorial stimulus, suggesting that no discernable differences across mean force responding occurred. Similarly, results in the bottom panel of Figure 13 show P31 exerted the highest mean force to view the VMSWO fourth-ranked pictorial stimulus and exerted the lowest mean force to view the VMSWO third-rank pictorial stimulus, again suggesting that no discernable differences across mean force responding occurred. Overall, 15.3% of participants met the criteria to be placed into this category.

Figure 14 depicts the presentation order in which pictorial stimuli were viewed during the conjugate assessment. Responding by 7 participants (7.1%) met the criteria to be placed into this category. For example, results in the upper panel of Figure 14 show P43's mean response force decreased across the order of stimulus presentation and did not correspond with any other category. Similarly, results in the bottom panel of Figure 14 show P84's mean response force decreased across the order of four of five stimulus presentations and did not correspond with any other category. These patterns may suggest physical fatigue from force exertion, low reinforcer value, stimulus satiation, or a combination (Davis et al., 2021). Overall, 7.1% of participants met the criteria to be placed into this category.

Results showed that 76.6% of participants' mean force responding met criteria to be placed into either the HP-LP category, HP only category, or LP only category during the conjugate assessment.

Discussion

This study replicated and extended Davis et al. (2021) by comparing participants' VMSWO rank scores to the mean force scores for the same five pictorial stimuli from a brief conjugate preparation. Individual results indicated HP and LP stimuli from the VMSWO assessment corresponded with the highest and lowest mean force of responding for 64.3% and 63.3%, respectively. Consistent with our hypothesis, group results revealed a statistical significance between participants' VMSWO and mean force rank scores. Furthermore, there was *not* a statistically significant correlation for either (a) VMSWO rank and stimulus presentation order or (b) stimulus presentation order and mean force rankings, which was consistent with our prediction. However, there *was* a statistically significant correlation between participants' stimulus presentation order and peak force rankings. Although the strength of this correlation was very weak, the latter finding was not consistent with our prediction.

The results of this investigation contribute to the preference assessment and conjugate reinforcement literature in at least two ways. First, this is the third study to utilize a progressive synchronous schedule to identify stimulus preference. To that end, the pictorial stimuli used within the current study were unique in that no previous study, to our knowledge, has examined pictures of people within this type of preparation. Consistent with the findings from previous studies (e.g., Cook et al., under review; Davis et al., 2021; Falligant et al., 2018, 2020), the results from this study provide evidence that response force can be a meaningful operant to measure when examining stimulus preference using a conjugate paradigm. Second, like previous reports (e.g., Cook et al, under review; Davis et al., 2021), participants within the current study required little instruction to complete the conjugate assessment. However, more research is required to further validate the efficiency and improve the outcomes of conjugate assessments.

The results from this investigation may be of clinical utility and benefit to practitioners and experienced service-providers. First, the efficiency of the assessment could facilitate faster identification of reinforcers used as part of individual- or group-based educational and behavioral programming. This could be particularly beneficial in settings where there is a shortage or high turnover of staff such as juvenile detention centers (Sheridan et al., 2022) or residential facilities (McHugh et al., 2022). Second, in contrast to traditional preference assessments (e.g., Deleon et al., 1999; Fisher et al., 1992) that yield unidimensional outcomes (e.g., percent selected), conjugate preparations provide information or yield products based on continuous responding (Rapp, 2008). In turn, this can provide information on reinforcer efficacy and consumption.

Although the results of this study are promising, there are some limitations worth noting. First, it may be the case that the vocal S^d "which one would you like to view the most" lacked context regarding specific properties or features of the pictorial stimuli (e.g., affect). As a result, this may have contributed to the number of undifferentiated responders (*n* = 15)[1]. However, over 75% of participants demonstrated discernible patterns of responding across the HP-LP, HP only, and LP only categories. Thus, in most cases, the preparation demonstrated some sensitivity to and correspondence with participants' VMSWO rankings. Second, although we did not demonstrate within-subject replications of increased response force, stimulus presentation order was *not* significantly correlated with mean VMSWO rankings. Thus, our results provided validation of the conjugate assessment through outcomes that correspond with VMSWO outcomes (Cook et al., under review; Davis et al., 2021). Third, and similarly reported by Cook et al. (under review), some participants' data may indicate minor carry-over effects during stimulus presentation. For example, P06 appeared to be responding to what were previously

---

[1] Several participants asked if there were criteria they should follow when selecting from the array of pictorial stimuli. Researchers redirected such questions and repeated the vocal S^d.

higher-ranked stimuli just before the presentation of lower-ranked stimuli. This is reflected by the difference between mean and peak force responses. Finally, the progressive schedule component of the preparation may have caused physical fatigue for some participants and affected response force rankings. To that end, Cook et al. noted that conjugate preparations may have a limit on the number of stimuli that can be assessed, especially those examining response force.

Findings from this study give rise to at least four avenues for future research with conjugate schedules and stimulus preference. First, given that our study revealed a weak between stimulus presentation order and peak force rank, future researchers should determine the benefit of including a pre-exposure trial (PET). A PET can allow participants to experience the consequences associated with the preparation using a neutral stimulus (i.e., a crosshair) prior to conducting the assessment. As a result, participants may calibrate their responding differently across successive trials. If so, a PET could serve as an important step towards improving the outcomes from this type of preparation. Relatedly, future researchers should determine the extent to which conjugate preparations using response force produce effects like fatigue. Investigating such variables is important given the influence they can have on assessment outcomes. This could be examined by identifying the number of trials or duration of time at which participants self-report and/or demonstrate physical fatigue (e.g., wincing).

Second, future research should examine the efficiency of conjugate assessments as this could facilitate faster identification of reinforcers used as part of individual- or group-based educational and behavioral programming. This could be particularly beneficial as the assessment is completely automated and requires little time to set up. Third, future researchers could examine the effects of a conjugate preparation on health outcomes. For instance, the conjugate consortion group is currently exploring the impact of auditory stimuli on conjugately reinforced physical exercise (e.g., running). Fourth, Jarmolowicz et al. (2016) noted that progressive ratio schedules are akin to hypothetical purchase tasks (i.e., how much a reward is worth across elevating costs per unit) in terms of how each evaluates reinforcer consumption. Thus, future researchers could examine to what extent there is correspondence between a hypothetical purchasing task and a conjugate assessment. It may be that conjugate preparations can be used to further validate outcomes with instruments examining preference.

References

Baum W. M. (2012). Rethinking reinforcement: Allocation, induction, and contingency. *Journal of the experimental analysis of behavior, 97*(1), 101–124. https://doi.org/10.1901/jeab.2012.97- 101

Caouette, M., & Reid, G. (1991). Influence of auditory stimulation on the physical work Output of adults who are severely retarded. *Education and Training in Mental Retardation*, *26*(1), 43–52. http://www.jstor.org/stable/23878631

Catania, A. C. (2007). Learning, 4th edition. Upper Saddle River, NJ, Prentice-Hall.

Cook, J. L., Baruni, R. B., Pinkston, J. W., Rapp, J. T., & Miltenberger, R. G. (2022). Comparing stimulus preference and response force in a conjugate preparation: a replication with auditory stimulation [manuscript submitted for publication]. Department of Psychology, University of Manitoba.

Cook, J. L, Rapp, J. T. (2018) To what extent do practitioners need to treat stereotypy during academic tasks? *Behavior Modification, 44 (2),* 228-264. DOI: 10.1177/0145445518808226.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2020). *Applied Behavior Analysis (3rd Edition).* Hoboken, NJ: Pearson Education.

Critchfield T. S. (2011). Translational contributions of the experimental analysis of behavior. *The Behavior Analyst*, *34*(1), 3–17. https://doi.org/10.1007/BF03392227

Davis, W. T., Rapp, J. T., Brogan, K. M., Pinkston, J. W., & Chinnappan, B. (2021). Comparing stimulus preference and response force in a conjugate preparation. *Journal of the Experimental Analysis of Behavior*, *116*(1), 96–113. https://doi.org/10.1002/jeab.705

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for

Assessing reinforcer preferences. *Journal of Applied Behavior Analysis,29(4),* 519-533. https://doi.org/10.1901/jaba.1996.29-519

DeLeon, I. G., Iwata, B. A., Conners, J., & Wallace, M. D. (1999). Examination of ambiguous stimulus preference with duration-based measures. *Journal of Applied Behavior Analysis, 32(1)*, 111–114. https://doi.org/10.1901/jaba.1999.32-111.

Deochand, N., Costello, M. S., & Fuqua, R. W. (2020). Real-time contingent feedback to enhance punching performance. *The Psychological Record, 70*(1), 33–45. https://doi.org/10.1007/s40732-019-00357-2

Diaz de Villegas, S. C., Dozier, C. L., Jess R. L., &Foley, E. A. (2020). An evaluation of synchronous reinforcement for increasing on-task behavior in pre-school children. *Journal of Applied Behavior Analysis, 53(3),* 1660-1673. https://doi.org/10.1002/jaba.696

Falligant, J.M., Rapp, J.T., Brogan, K.M., & Pinkston, J.W. (2018). Response force in conjugate schedules of reinforcement. *The Psychological Record,68(4),* 525-536. https://doi.org/10.1007/s40732-018-0298-8

Falligant, J. M., Rapp, J. T., Brogan, K. M., & Pinkston, J. W. (2020). Extinction and response force in conjugate schedules. *The Psychological Record, 70*,109-121. https://doi.org/10.1007/s40732-020-00374-6

Ferster, C. B., & Skinner, B. F. (1957). Schedules of reinforcement. Englewood Cliffs, NJ: Prentice-Hall Inc.

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 and profound disabilities. *Journal of Applied Behavior Analysis, 25(2)*, 491–

498. https://doi.org/10.1901/jaba.25-491.

Fowler, S. C., Davison, K. H., & Stanford, J. A. (1994). Unlike haloperidol, clozapine slows and Dampens rats' fore limb force oscillations and decrease force output in a press-while-licking behavioral tasks. Psychopharmacology, 116, 19-25. https://doi.org/10.1007/BF02244866

Garber C. E. (2019). The health benefits of exercise in overweight and obese patients. *Current Sports Medicine Reports*, 18(8), 287–291. https://doi.org/10.1249/JSR.0000000000000619

Gravetter, F., & Wallnau, L., (2017). Statistics for the behavioral sciences. 10th Edition, Cengage Learning, Boston, MA.

Honig, W. K, & Staddon, J. E. R. (1977). Handbook of operant behavior. *Englewood Cliffs, N.J.: Prentice-Hall.*

Hsieh, K., Hilgenkamp, T., Murthy, S., Heller, T., & Rimmer, J. (2017). Low levels of physical activity and sedentary behavior in adults with intellectual disabilities. *International Journal of Environmental Research and Public Health*, *14(12*), 1503. https://doi.org/10.3390/ijerph14121503

Jarmolowicz, D. P., Lemley, S. M., Mateos, A., & Sofis, M. J. (2016). A multiple-stimulus-without-replacement assessment for sexual partners: Purchase task validation. *Journal of Applied Behavior Analysis*, *49*(3), 723–729. https://doi.org/10.1002/jaba.313

Jones, L. D. (2016). Conjugate Reinforcement: The effects of stimulus clarity (Order No. 10161332). Available from ProQuest Dissertations & Theses Global. (1842425545).

http://spot.lib.auburn.edu/login?url=https://www.proquest.com/dissertations-theses/conjugate-reinforcement-effects-stimulus-clarity/docview/1842425545/se-2

Kazdin, A. E. (2011). Single-case research designs (2nd ed.). New York, NY: Oxford University Press.

Laraway, S., Snycerski, S., Olson, R., Becker, B., & Poling, A. (2014). The motivating operations concept: Current status and critical response. *The Psychological Record, 64*(3), 601–623. https://doi.org/10.1007/s40732-014-0080-5

Lattal K. A. (2010). Delayed reinforcement of operant behavior. *Journal of the Experimental Analysis of Behavior*, *93*(1), 129–139. https://doi.org/10.1901/jeab.2010.93-129

Lattal, K. A., & Neef, N. A. (1996). Recent reinforcement-schedule research and applied behavior analysis. *Journal of Applied Behavior Analysis*, *29*(2), 213–230. https://doi.org/10.1901/jaba.1996.29-213

Levin, J. R., Ferron, J. M., & Kratochwill, T. R. (2012). Nonparametric statistical test for single-case systematic and randomized ABAB...AB and alternating treatment intervention designs: New development, new directions. Journal of School Psychology, 50, 599-624.https://doi.org/10.1016/j.jsp.2012.05.001

Lindsley, O. R. (1956). Operant conditioning methods applied to research in chronic schizophrenia. *Psychiatric Research Reports,5*, 118-139.

Lindsley, O. R. (1957). Operant behavior during sleep: A measure of deep sleep. *Science,126 (3268)*, 1290-1291. https://doi/10.1126/science.126.3286.1290

Lindsley, O. R. (1962). A behavioral measure of television viewing. *Journal of Advertising Research*, *2*(3), 2-12.

Lindsley, O. R. (1963). Experimental analysis of social reinforcement: terms and methods. *The*

American Journal of Orthopsychiatry, *33(4)*, 624–633. https://doi.org/10.1111/j.1939-0025.1963.tb01010.x

Lipsett, L. P., Pederson, L. J., & DeLucia, C. A. (1966). Conjugate reinforcement of operant responding in infants. *Psychonomic Science, 4,* 66–68.

Lovaas, I., Newsom, C., & Hickman, C. (1987). Self-stimulatory behavior and perceptual reinforcement. *Journal of Applied Behavior Analysis*, *20*(1), 45–68. https://doi.org/10.1901/jaba.1987.20-45

Lovitt, T. C. (1967). Use of conjugate reinforcement to evaluate the relative reinforcing effects of various narrative forms. *Journal of Experimental Child Psychology, 5*(2), 164–171. https://doi.org/10.1016/0022-0965(67)90004-5

MacAleese, K. R., Ghezzi, P. M., & Rapp, J. T. (2015). Revisiting conjugate schedules. *Journal of the Experimental Analysis of Behavior, 104*(1), 63–73. https://doi.org/10.1002/jeab.160

Mace, F. C., & Critchfield, T. S. (2010). Translational research in behavior analysis: Historical traditions and imperative for the future. *Journal of the Experimental Analysis of Behavior,93(3),* 293–312. doi:10.1901/jeab.2010.93-293

Mace, F. C., Pritchard, D., & Penney, H. (2021). Handbook of Applied Behavior Analysis, Second Edition. United States: Guilford Publications.

Marr, M.J. (2018). Bounded in a Nutshell: The Uncertain Future of EAB. *Behavior Analysis: Research and Practice, 18*, 388–397. https://doi.org/10.1037/bar0000121

McHugh, C. L., Dozier, C. L., Diaz de Villegas, S. C., & Kanaman, N. A. (2022). Using synchronous reinforcement to increase mask wearing in adults with intellectual and developmental disabilities. *Journal of Applied Behavior Analysis*, *55(4),* 1157-1171 10.1002/jaba.950.

Morgan, B. J., & Lindsley, O. R. (1966). Operant preference for stereophonic over monophonic music. *Journal of Music Therapy, 3(4*), 135-143. https://doi.org/10.1093/jmt/3.4.135

Nathan, P. E., Schneller, P., & Lindsley, O. R. (1964). Direct measurement of communication during psychiatric admission interviews. *Behavior Research and Therapy*, *2*(1), 49-57.

Nathan, P. E., Smith, S., & Rossi, A. M. (1968). Experimental analysis of a brief psychotherapy relationship. *American Journal of Orthopsychiatry, 38*(3), 482–492. https://doi.org/10.1111/j.1939-0025.1968.tb00583.x

Notterman, J. M., & Mintz, D. E. (1965). Dynamics of response. *Wiley*.

Pace, G. M., Ivancic, M. T., Edwards, G. L., Iwata, B. A., & Page, T. J. (1985). Assessment of stimulus preference and reinforcer value with profoundly retarded individuals. *Journal of Applied Behavior Analysis, 18(3)*, 249–255. https://doi.org/10.1901/jaba.1985.18-249.

Pierce, W. D., & Cheney, C. D. (2013). Behavior analysis and learning. New York, NY: Taylor & Francis.

Rapp, J. T. (2008). Conjugate reinforcement: A brief review and suggestions for applications to the assessment of automatically reinforced behavior. *Behavioral Interventions, 23*, 113–136. https://doi.org/10.1002/ bin.259

Rapp, J. T., Dozier, C. L., Carr, J. E., Patel, M. R., & Enloe, K. A. (2004). Functional analysis of erratic body movement maintained by visual stimulation. Incorporating conjugate reinforcement into a paired-stimulus preference assessment. *Behavior Modification*, 28(1), 118–132. https://doi.org/10.1177/0145445503259260

Rovee-Collier, C. K., & Capatides, J. B. (1979). Positive behavioral contrast in 3-month-old infants on multiple conjugate reinforcement schedules. *Journal of The Experimental Analysis of Behavior, 32*(1), 15–27. https://doi.org/10.1901/jeab.1979.32-15

Rovee, C. K., & Rovee, D. T. (1969). Conjugate reinforcement of infant exploratory behavior. *Journal of Experimental Child Psychology, 8(1)*, 33–39. https://doi. org/10.1016/0022-0965(69)90025-3

Saunders, S. (2020). A Within-Subjects Analysis of Positive and Negative Conjugate Reinforcement (Order No. 27964690). Available from ProQuest Dissertations & Theses Global. (2420759448). http://spot.lib.auburn.edu/login?url=https://www-proquest-com.spot.lib.auburn.edu/dissertations-theses/within-subjects-analysis-positive-negative/docview/2420759448/se-2

Sizemore, O.J., & Maxwell, F.R. (1983). Differential punishment of other behavior: Effects of pause-dependent shock on variable-interval performance. *Animal Learning & Behavior, 11*, 266-274. https://doi.org/10.3758/BF03199657

Sheridan, D. J., Edgemon, A. K., & Rapp, J. T. (2022). Correspondence between resident- and staff-report on the QABF: Do justice-involved youth agree with residential staff? *Behavioral Interventions*, 1– 18. https://doi.org/10.1002/bin.1928

Siqueland, E. R., & DeLucia, C. A. (1969). Visual reinforcement of nonnutritive sucking in human infants. *Science, 165*(3898), 1144–1146. https://doi.org/10.1126/science.165.3898.1144

Stafford, D., LeSage, M. G., & Glowa, J. R. (1998). Progressive-ratio schedules of drug delivery in the analysis of drug self-administration: a review. *Psychopharmacology (Berlin), 139*(169-184). http://web.ebscohost.com/ehost/pdf?vid=8&hid=117&sid=a3f6df65-9270-4b3d-869b-7a059578990d%40sessionmgr107

Switzky, H. N., & Haywood, H. C. (1973). Conjugate control of motor activity in mentally retarded persons. *American Journal of Mental Deficiency*, *77*(5), 567–570

Vollmer, T. R. (2011). Three variations of translational research: Comments on Critchfield (2011). *The Behavior* Analyst, 34(1), 31–35. https://doi.org/10.1007/BF03392231

Voltaire, M., Gewirtz, J. L., & Pelaez, M. (2005). Infant responding compared under conjugate- and continuous-reinforcement schedules. *Behavioral Development Bulletin, 1(1),* 71–79. https://doi.org/10. 1036/h0100564

Weisberg, P., & Rovee-Collier, C. (1998). Behavioral processes of infants and young children. In K. A. Lattal & M. Perone (Eds.), *Handbook of Research Methods in Human Operant behavior* (pp. 325–370). Plenum Press. https://doi.org/10.1007/978-1-4899-1947-2_11

Williams, D. C., & Johnston, J. M. (1992). Continuous versus discrete dimensions of reinforcement schedules: an integrative analysis. *Journal of the Experimental Analysis of Behavior, 58(1)*, 205–228. https://doi.org/ 10.1901/jeab.1992.58-205

Wu, M., & Zuo, Y. (2009). Trimmed and Winsorized means based on a scaled deviation. *Journal of Statistical Planning and Inference*, *139*(2), 350-365. https://doi.org/10.1016/j.jspi.2008.03.039

Zarcone, T. J., Chen, R., & Fowler, S. C. (2009). Effects of differing response-force requirements on food-maintained responding in C57Bl/6J mice. *Journal of the experimental analysis of behavior*, *92*(2), 257–274. https://doi.org/10.1901/jeab.2009.92-257

Table 1

Sociodemographic Characteristics of the Participants

Characteristic	n	%	M	SD
Gender				
Female	75	76.5		
Male	23	23.5		
Age			18.82	1.077
18	45	45.9		
19	20	20.4		
20	9	9.2		
21	9	9.2		
21+	1	1.0		
Missing	13	13.3		
Race				
White	77	78.6		
Black	3	3.1		
East Asian	3	1.0		
Southeast Asian	1	3.1		
Hispanic	1	1.0		
Missing	13	13.3		

Note. Age is in years. Data missing due to a screening error with the online platform.

Table 2

Participants' Mean Preference and Force Ranks across the Five Pictorial Stimuli

Picture stimulus	Mean VMSWO Rank	Mean Force Rank	Peak Force Rank
Child Female	1.96	2.34	2.47
Young Adult Female	2.61	2.34	2.33
Adolescent Male	3.23	3.41	3.09
Adult Male	3.43	3.15	3.01
Elderly Female	3.74	3.65	3.41

Note. $N = 98$. VMSWO = verbal multiple stimulus without replacement. Higher value indicates a lower rank.

Table 3

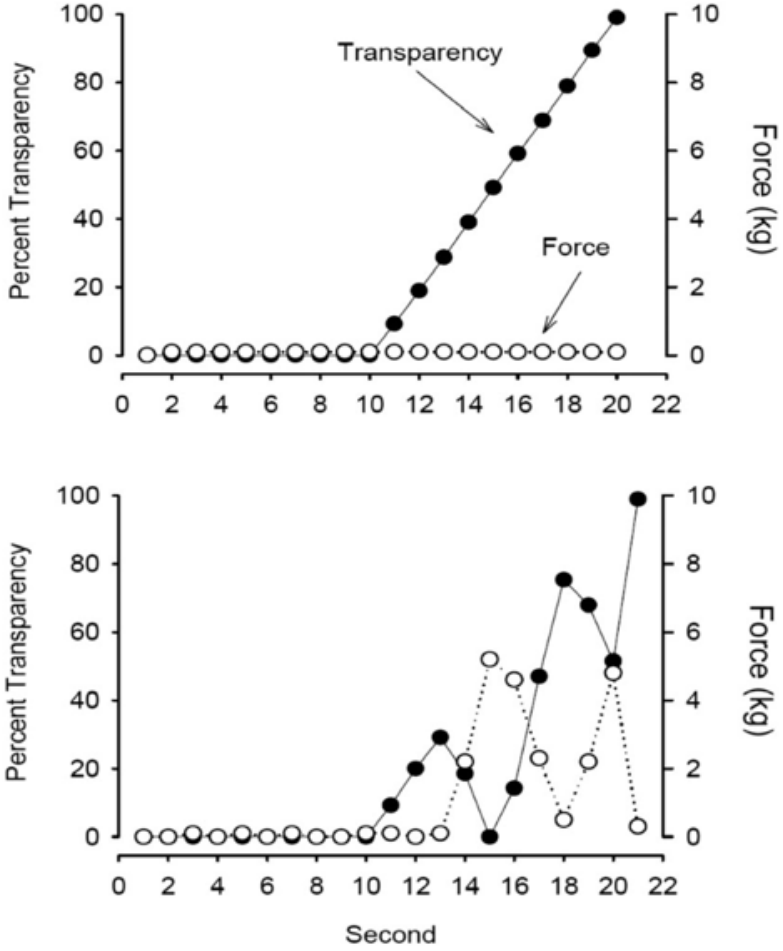
Results of Spearman's Rank Correlation

Comparison	r	n	*p*
VMSWO Rank 1-5 by Mean Force Rank 1-5	.358	490	.001
VMSWO Rank 1-5 by Peak Force Rank 1-5	.225	490	.001
VMSWO Rank 1-5 by Stimulus Order 1-5	.070	490	.125
Stimulus Order 1-5 by Mean Force Rank 1-5	.105	490	.298
Stimulus Order 1-5 by Peak Force Rank 1-5	.050	490	.019

Note. N = 98.

Figure 1

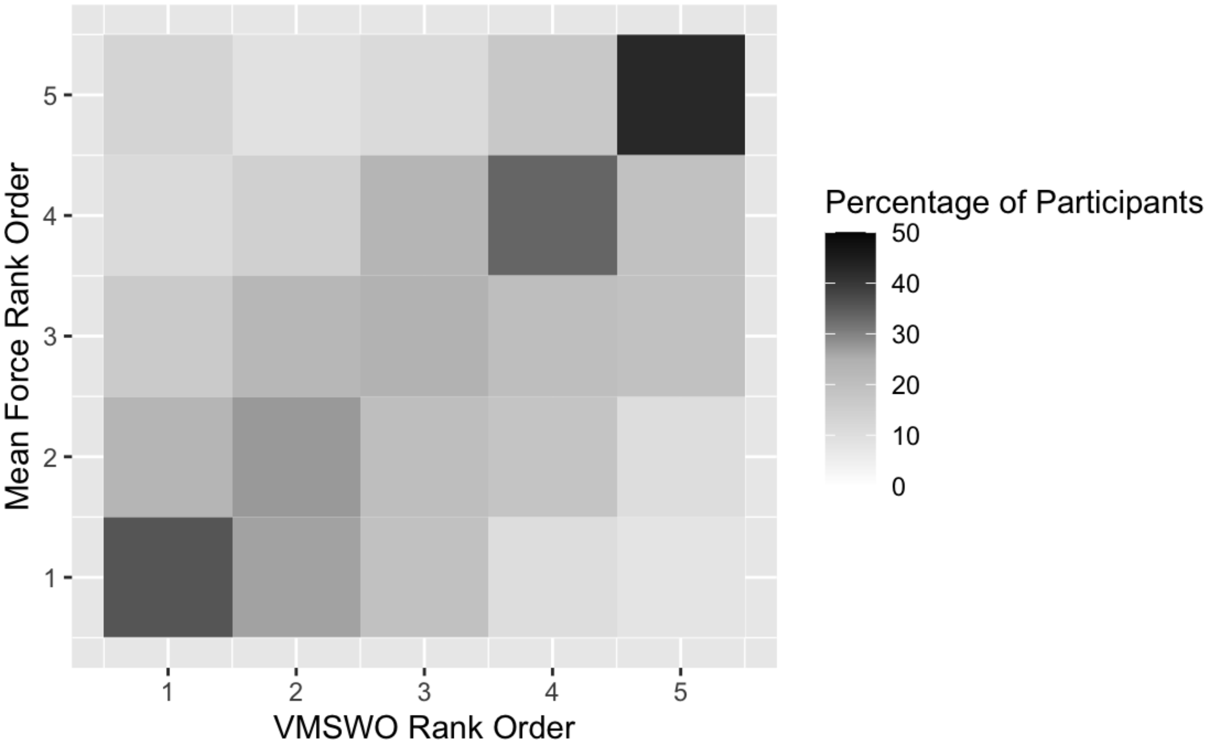
Example data Illustrating Responding on the Conjugate Schedule



Note. Illustrative figure previously appeared in the Davis et al. (2021) paper. The top figure depicts a trial with no force exerted. The bottom figure depicts a trial with force exerted. For both panels, the pictorial stimulus at 0% transparency is clearly visible, and at 100% transparency is no longer visible.

Figure 2

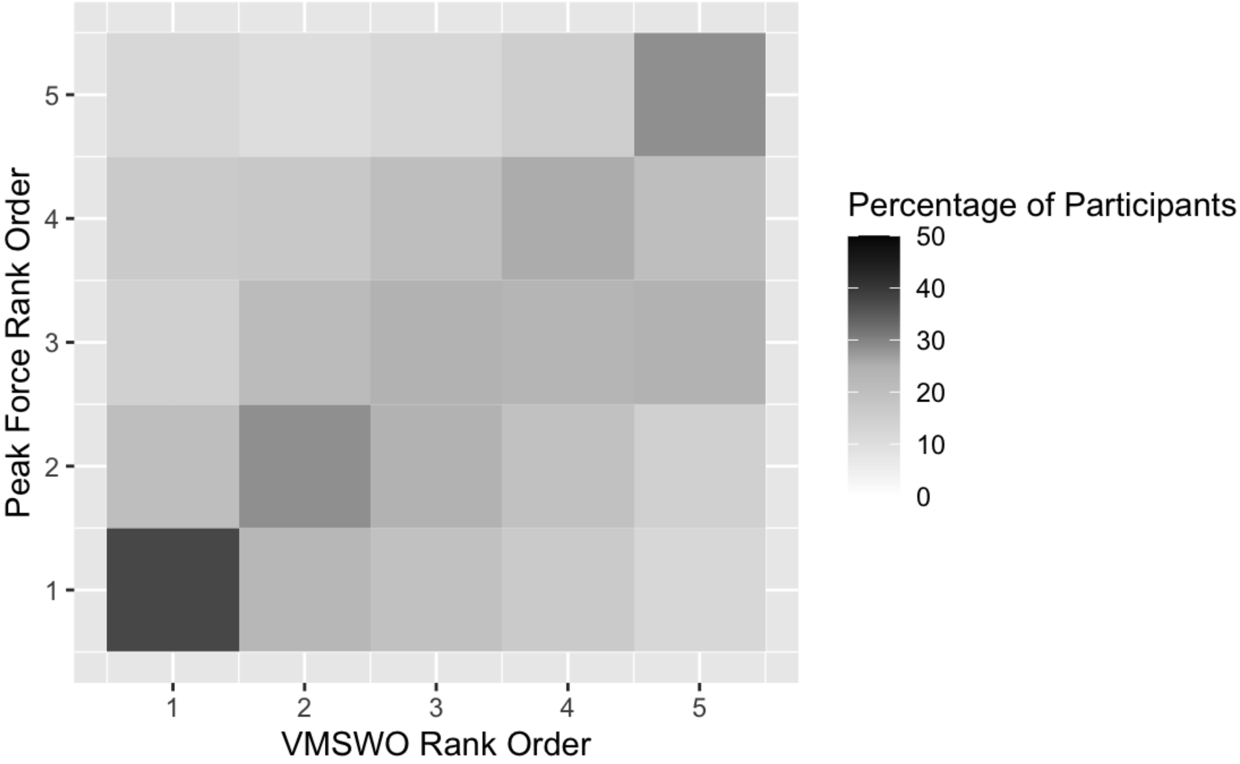
Scatterplot of Mean Force Rank by Preference Order Rank



Note. *N* = 98. Increasingly darker tiles contain higher frequencies of agreement between each measure whereas increasingly lighter tiles contain lower frequencies of agreement between each measure.

Figure 3

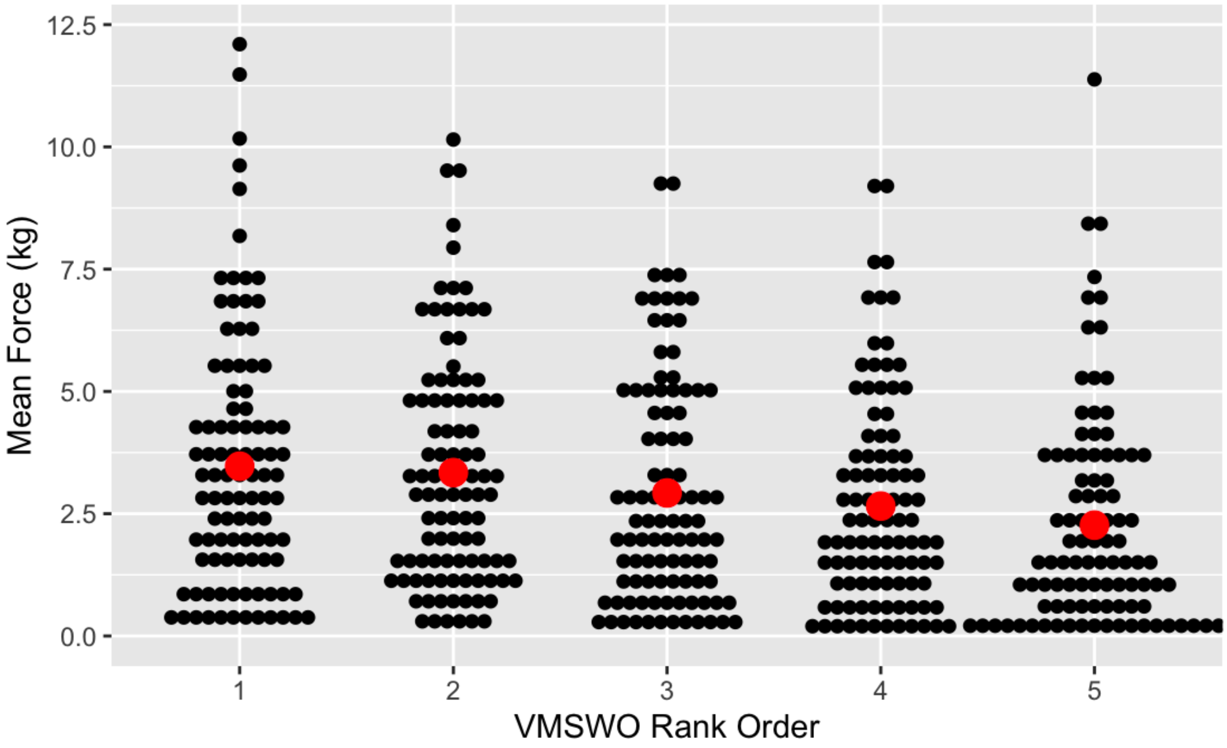
Scatterplot of Peak Force Rank by Preference Order Rank



Note. *N* = 98. Increasingly darker tiles contain higher frequencies of agreement between each measure whereas increasingly lighter tiles contained lower frequencies of agreement between each measure.

Figure 4

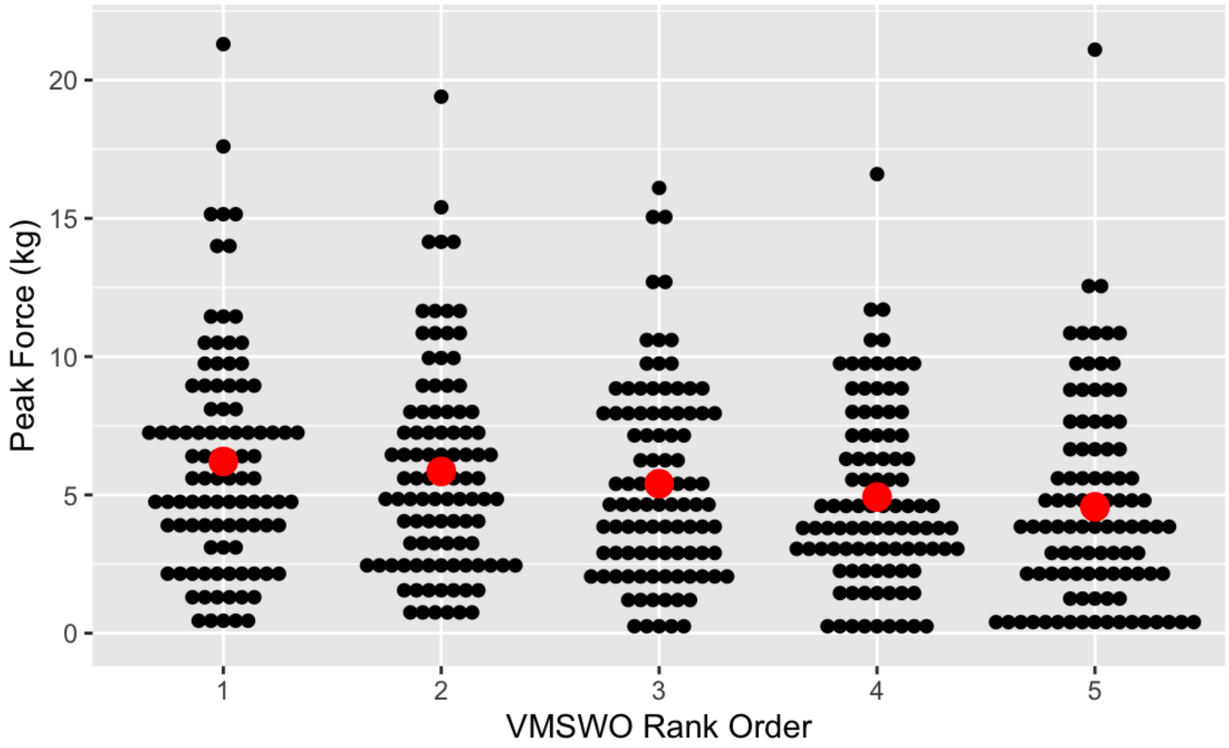
Dot plot of Mean Force by VMSWO Rank Order



Note. *N* = 98. Black data points depict the distribution of Mean Force responses by VMSWO Rank Order. Red data points depict average mean force responses by VMSWO Rank Order.

Figure 5

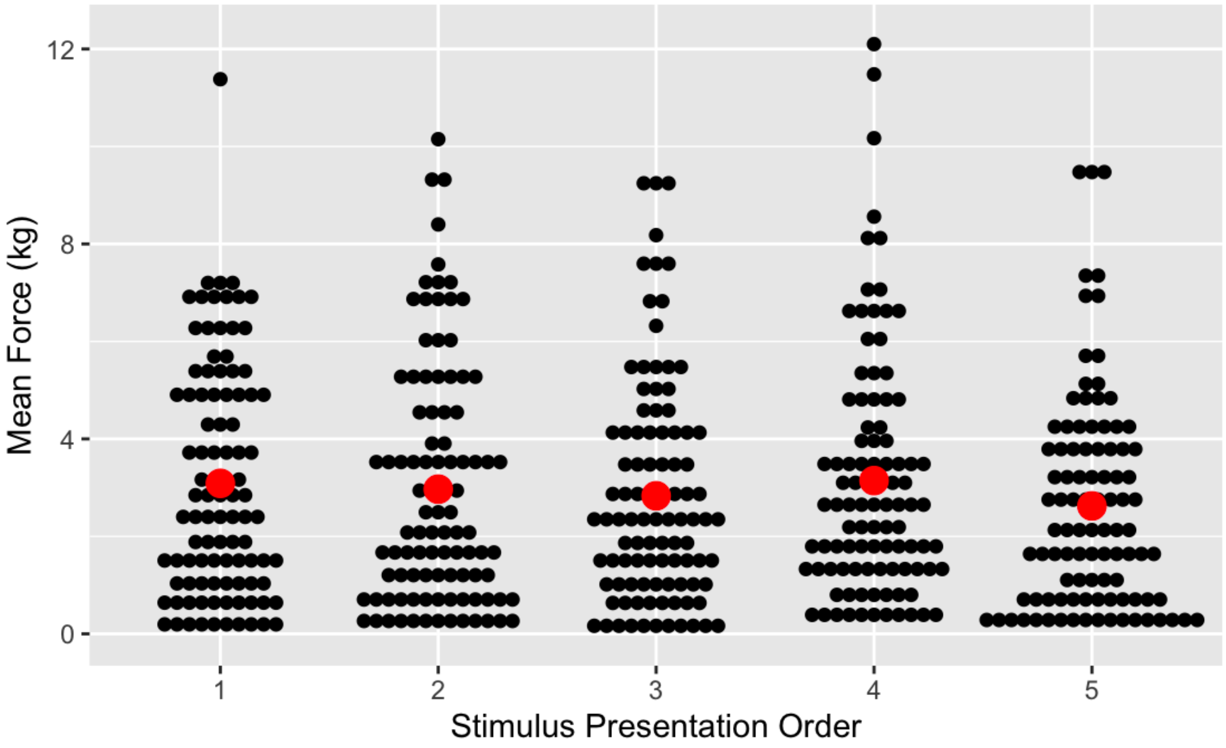
Dot plot of Peak Force by VMSWO Rank Order



Note. *N* = 98. Black data points depict the distribution of Peak Force responses by VMSWO Rank Order. Red data points depict average peak force responses by VMSWO Rank Order.

Figure 6

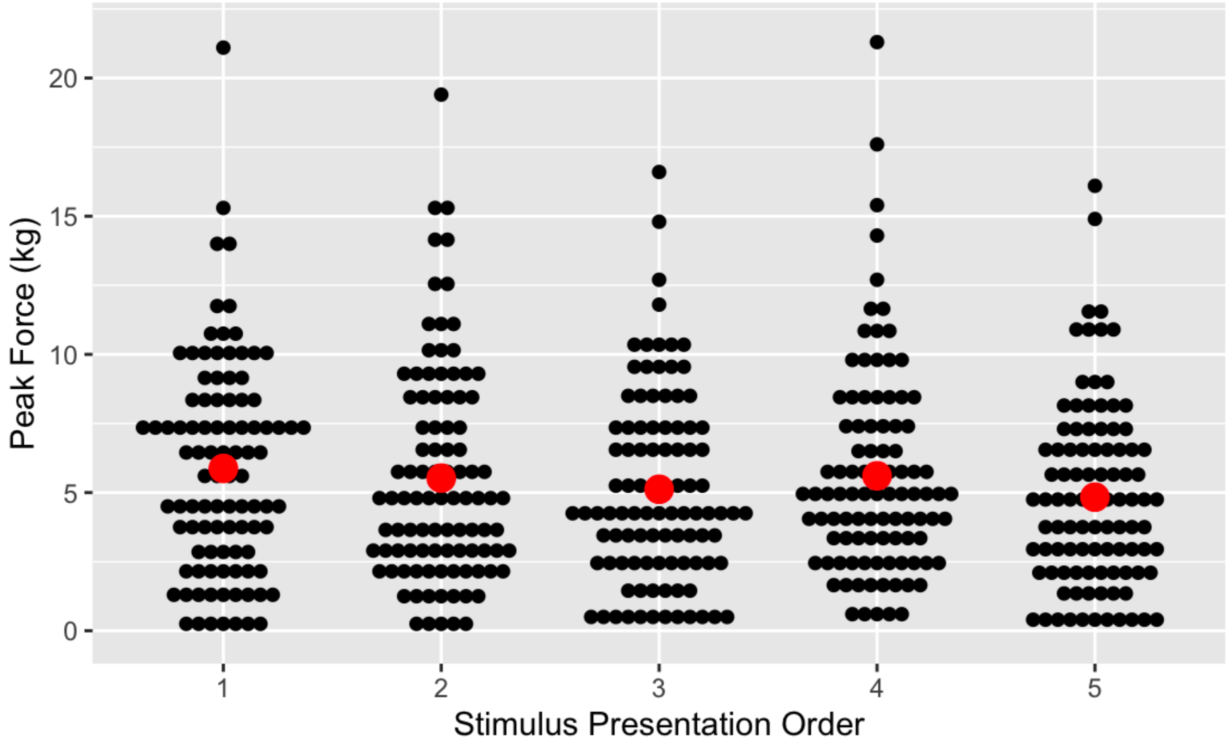
Dot plot of Mean Force by Stimulus Presentation Order



Note. *N* = 98. Black data points depict the distribution of Mean Force responses by Stimulus Presentation Order. Red data points depict average Mean Force responses by Stimulus Presentation Order.

Figure 7

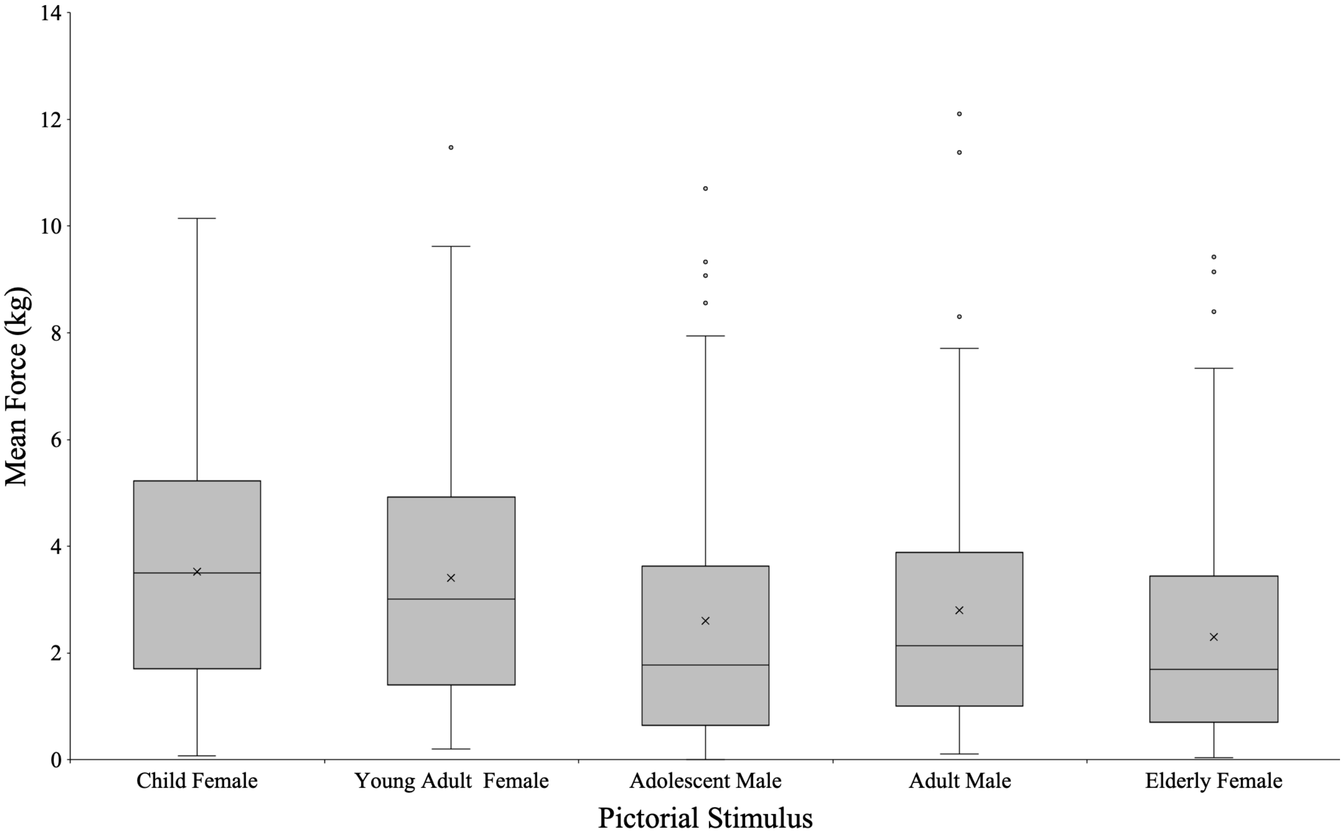
Dot plot of Peak Force by Stimulus Presentation Order



Note. $N = 98$. Black data points depict the distribution of Peak Force responses by Stimulus Presentation Order. Red data points depict average Peak Force responses by Stimulus Presentation Order.

Figure 8

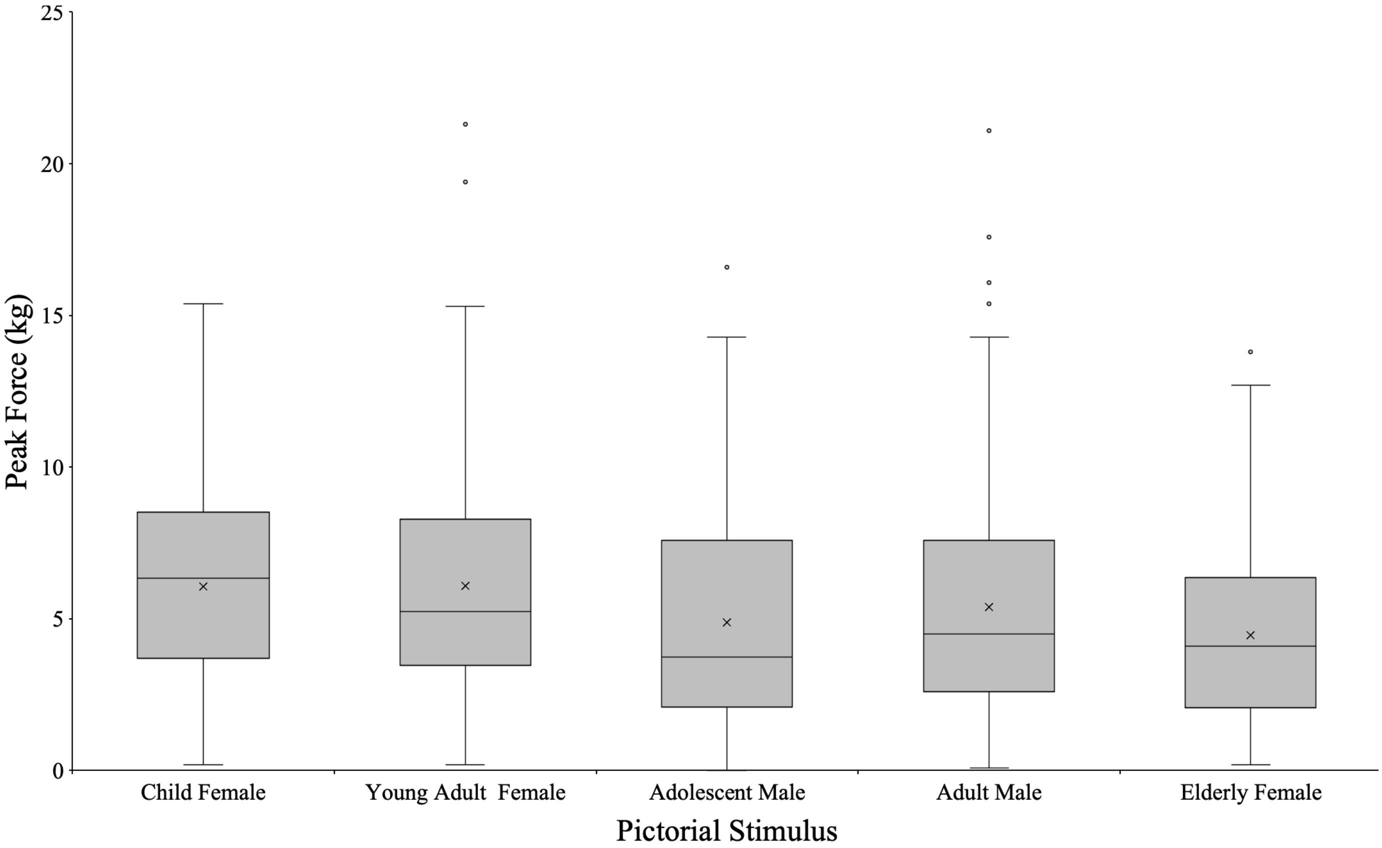
Box plot of Mean Force Across Pictorial Stimulus



Note. N = 98. Stimulus presentation order varied across participants. Black dots depict outliers for each pictorial stimulus.

Figure 9

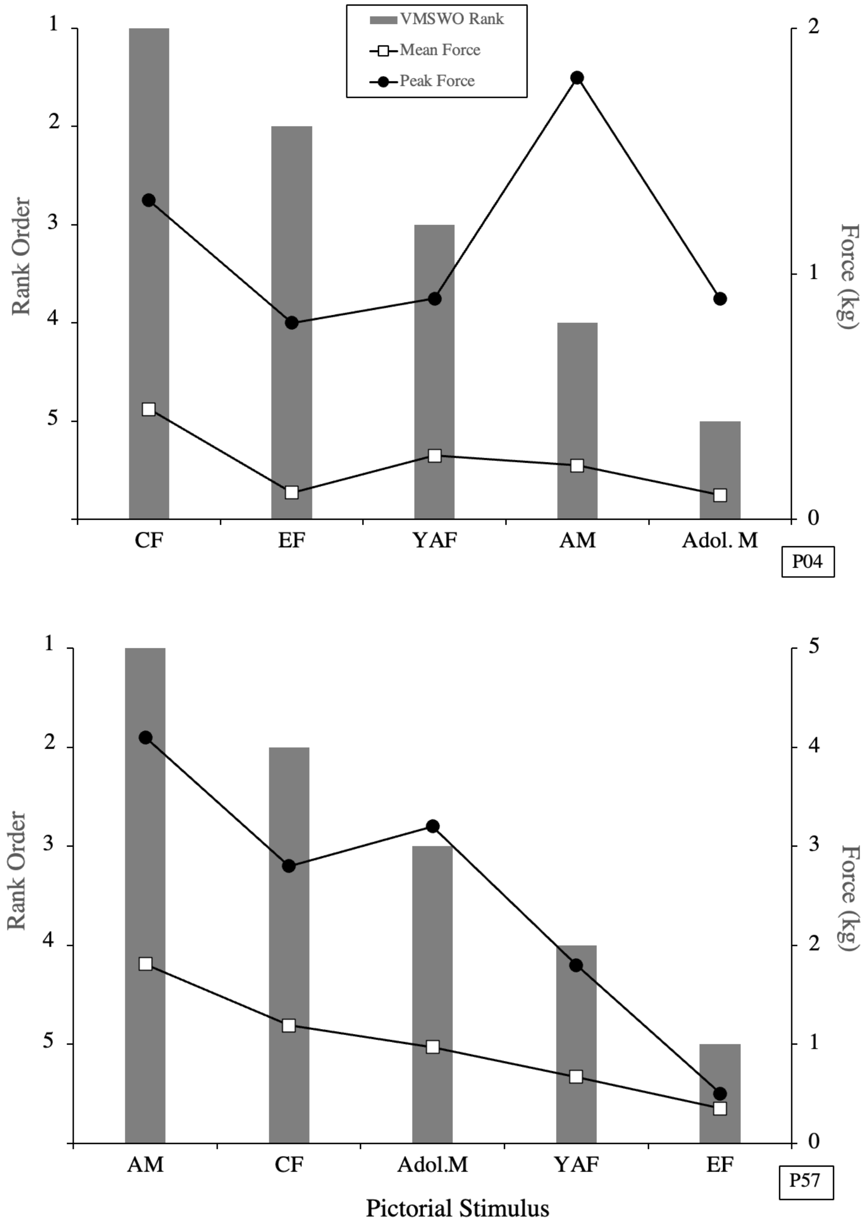
Box plot of Peak Force Across Pictorial Stimulus



Note. N=98. Stimulus presentation order varied across participants. Black dots depict outliers for each pictorial stimulus.

Figure 10

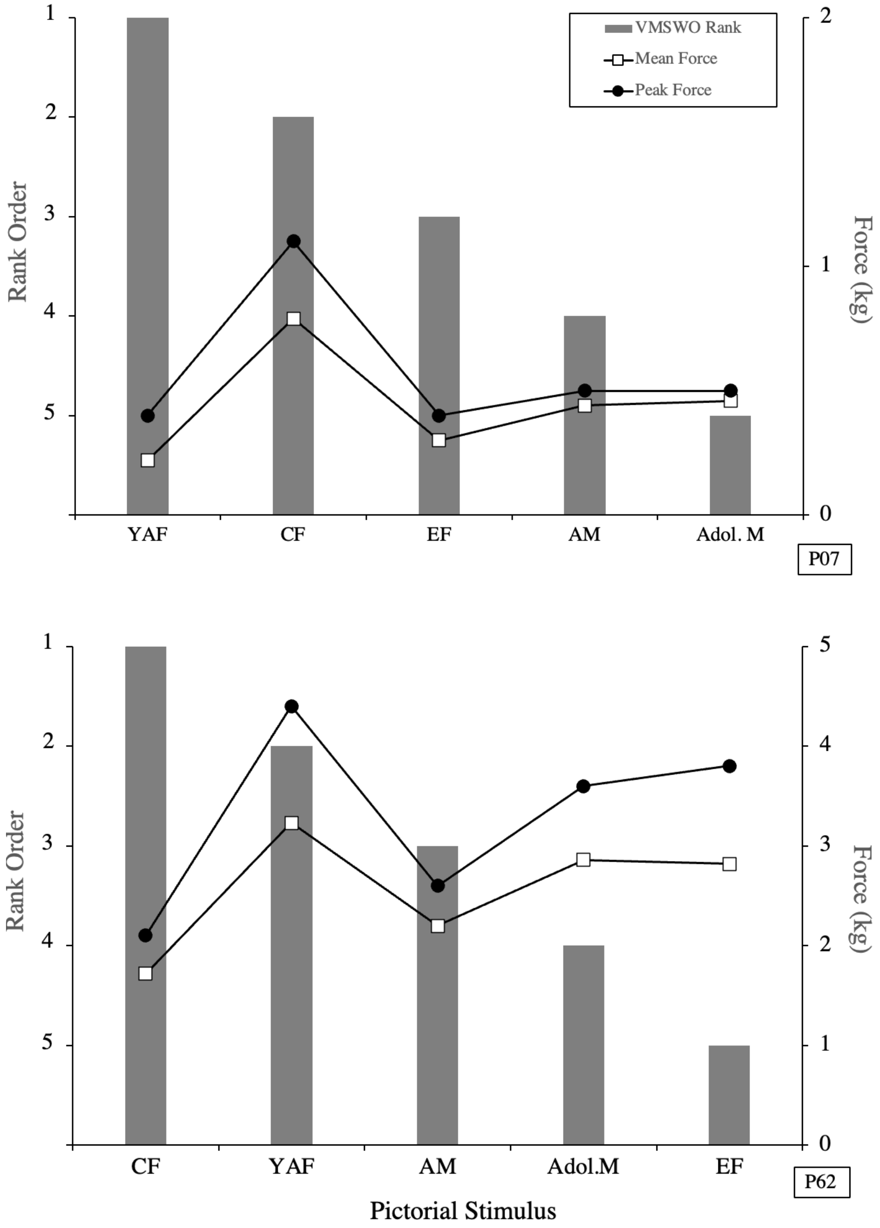
Representative Graphs Depicting HP and LP Correspondence



Note. VMSWO = verbal stimulus without replacement. AM = Adult Male. CF = Child Female. Adol.M = Adolescent Male. YAF = Young Adult Female. EF = Elderly Female.

Figure 11

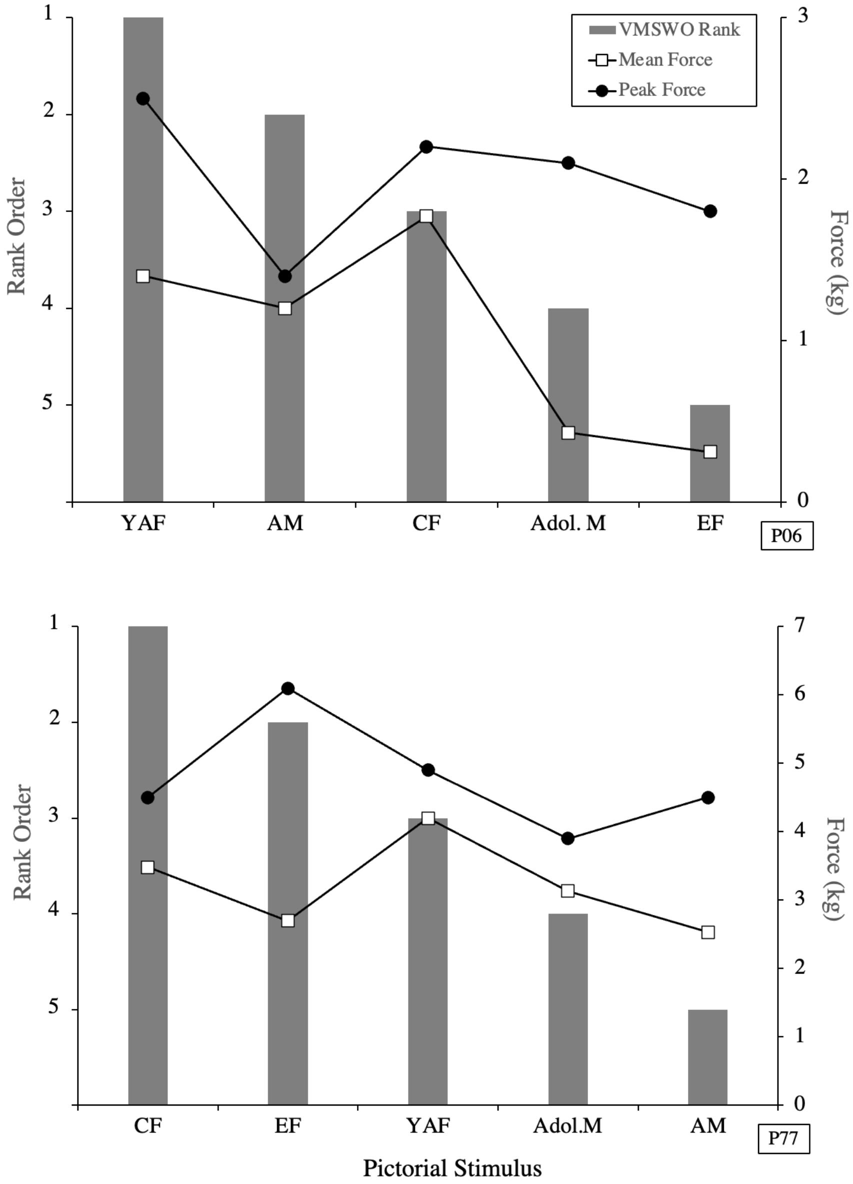
Representative Graphs Depicting HP only Correspondence



Note. VMSWO = verbal stimulus without replacement. AM = Adult Male. CF = Child Female. Adol.M = Adolescent Male. YAF = Young Adult Female. EF = Elderly Female.

Figure 12

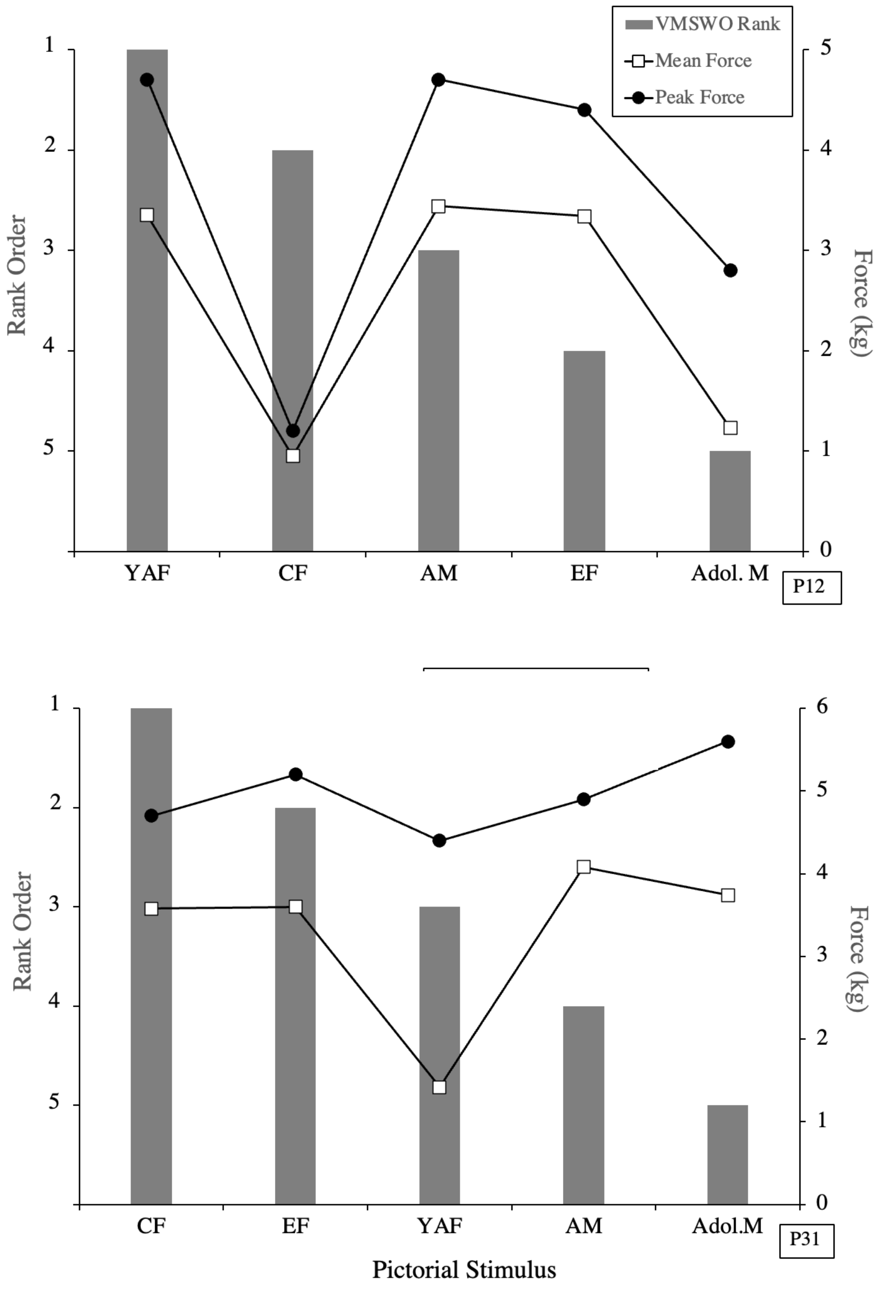
Representative Graphs Depicting LP only Correspondence



Note. VMSWO = verbal stimulus without replacement. AM = Adult Male. CF = Child Female. Adol.M = Adolescent Male. YAF = Young Adult Female. EF = Elderly Female.

Figure 13

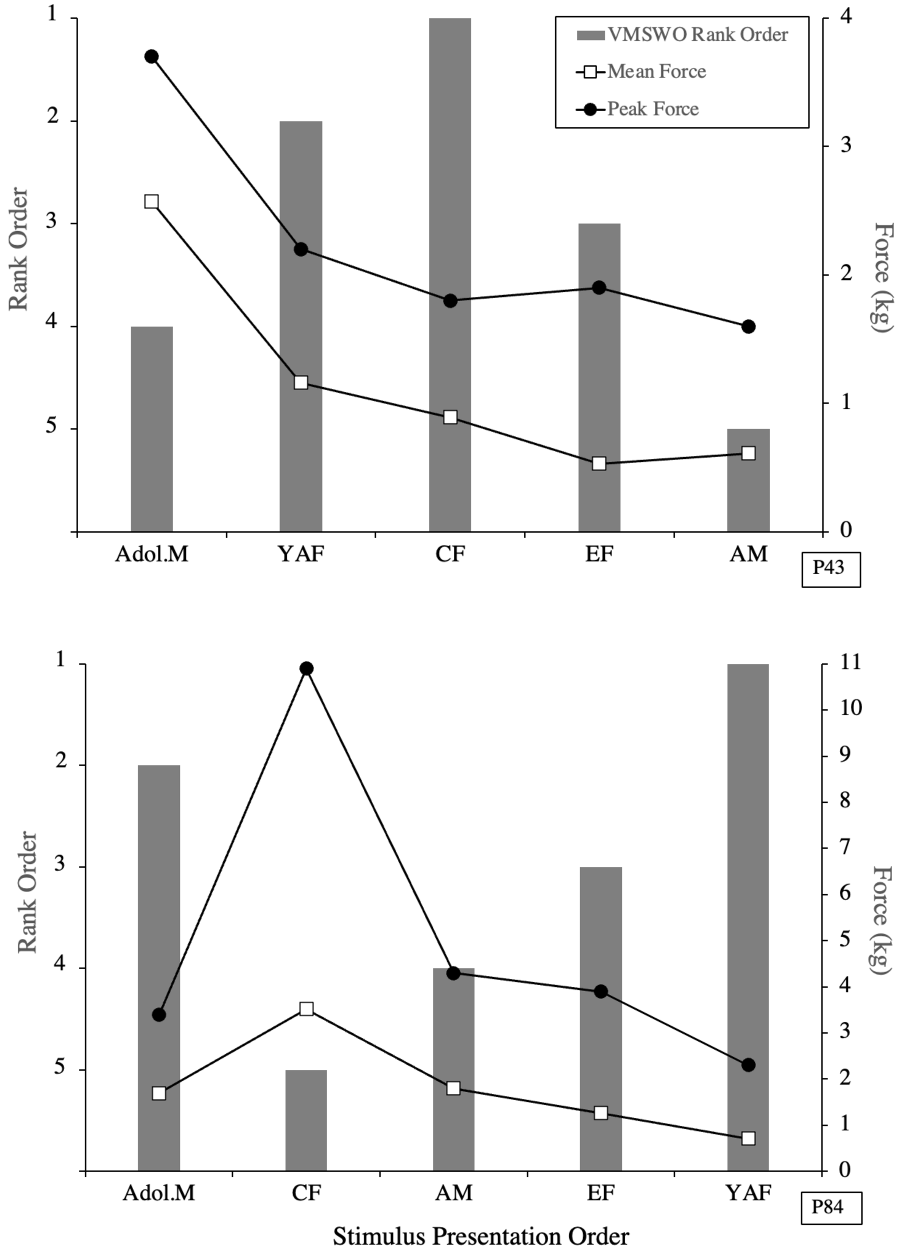
Representative Graphs Depicting Undifferentiated Responding



Note. VMSWO = verbal stimulus without replacement. AM = Adult Male. CF = Child Female. Adol.M = Adolescent Male. YAF = Young Adult Female. EF = Elderly Female.

Figure 14

Representative Graphs Depicting Decreasing Trend



Note. VMSWO = verbal stimulus without replacement. AM = Adult Male. CF = Child Female. Adol.M = Adolescent Male. YAF = Young Adult Female. EF = Elderly Female.