

Investigating Person-Specific Profiles of Readiness-To-Exercise: Exploring Associations with
Hypothetical Experiential Outcomes and Perceived Relevance

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ABSTRACT

Autoregulation is a person-adaptive strategy wherein exercise workloads are adjusted to match one's *readiness* (e.g., acute mental, physical, perceptual state). Prior work demonstrated that structural features of readiness profiles (i.e., which factor(s) are most important) differ across individuals. As this work relied on mathematical modeling, research is needed to understand the informational utility of person-specific profiles (PSPs) of readiness. **Purpose:** Model heterogeneity in PSPs of readiness (Aim 1), explore associations between PSP factor scores and forecasted experiences to hypothetical muscle-strengthening exercise (Aim 2), and explore participants' perceptions of relevance and utility regarding their PSP (Aim 3). **Methods:** For Aim 1, a reference structure was created by applying R-technique factor analysis to cross-sectional readiness data from surveys taken by adults (N=326) preparing to engage in muscle-strengthening exercise. This reference was compared to PSPs created by applying P-technique factor analyses to time-series readiness data from resistance-trained adults (N=11; up to 84 time points per person) using ecological momentary assessment (EMA) procedures. For Aim 2, scatter plots were created using EMA data to visualize PSP first factor (i.e., most mathematically important) scores against ratings of affective valence forecasted in response to hypothetical exercise. For Aim 3, following EMA, individuals were interviewed to view and discuss their PSP; qualitative data underwent thematic analyses to explore participants' shared perceptions. **Results:** The reference readiness structure differed from PSPs in factor number (10 vs. mean=12), interpretation of the first factor ('activation', vs. 'mood/emotions' or 'physical states'), and the amount of variance in the dataset it explained (26.2% vs. 18.1 to 45.3%). No consistent pattern was observed regarding factor one scores and forecasted ratings of affect. Thematic analyses revealed that atypical circumstances during the EMA period and

incongruency between personal perceptions and data feedback fueled a general skepticism and reservations toward mathematically modeled PSPs. **Conclusion:** Results replicated previous observations of heterogeneity between nomothetic and idiographic models of readiness.

However, mathematically modeling PSPs based on a single period of observation appears to hold insufficient informational utility for resistance-trained adults. Further research is needed to optimize conceptualizations of readiness to refine practical implementation of autoregulatory strategies for muscle-strengthening exercise.

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Chapter I: Introduction

Muscle Strengthening Physical Activity and Exercise Participation

Regular participation in muscle-strengthening activities provides a number of health and fitness benefits, yet self-reported levels of consistent engagement is low among adults in the United States. Specifically, the American College of Sports Medicine (ACSM) recommends the performance of muscle-strengthening activities using moderate or vigorous intensities to target all major muscle groups – legs, hips, abdomen, chest, shoulders, arms, and back – at least two days per week (Byrne & Wilmore, 2001). This level of activity is associated with numerous health benefits, such as improved bone density and body composition (Lopez et al., 2018), increased insulin sensitivity/glucose metabolism (Ismail et al., 2019), positive effects on resting metabolic rate (Byrne & Wilmore, 2001), and improvements in depressive symptoms (Miller et al., 2019). However, just 30.2% of adults report meeting this recommendation (Bennie et al., 2018), suggesting the need for specific strategies to increase engagement in muscle strengthening activities. *Exercise*, which, according to Caspersen (1985), refers to planned and structured activity that is performed with the intent to improve or maintain at least one component of fitness (cardiovascular endurance, muscular strength, muscular endurance, flexibility, and body composition) is a common strategy used to increase total physical activity levels. For example, one could engage in resistance exercise (i.e., powerlifting, calisthenics, free weight training, weight-stack machines) during their leisure time to fulfill muscle-strengthening guidelines.

Behavioral interventions that have been developed with the goal of promoting exercise and physical activity have achieved limited success. A review of the literature found that exercise programs have reported dropout rates ranging from 9% to as much as 87% (Marcus et al., 2006). For those who do not drop out, researchers have often observed patterns of sufficient initial adherence followed by a consistent decrease in physical activity maintenance over time

(Middleton, Anton, & Perri, 2013). Noting that for health behaviors that possess a high degree of complexity (i.e., exercise), nonadherence is more of a standard than an outlier – occurring as much as 70% of the time (Martin, Williams, Haskard, & DiMatteo, 2005). As such, understanding the determinants of exercise adherence and behavioral maintenance has become a critical focus of contemporary research.

Early investigations into exercise behavior identified experiential outcomes as strong predictors of behavioral maintenance. Kimiciek and Harris (1996) defined *enjoyment* as an optimal psychological state that results in one performing an activity primarily for the sake of participation and the associated positive feelings states and, historically, enjoyment has been cited as a determinant of exercise adherence (Dishman & Chubb, 1990; Nigg, Borrelli, Maddock, & Dishman, 2008; Sallis, Prochaska, Taylor, Hill, & Geraci, 1999). However, a paradigmatic shift has resulted in research efforts that target *affective responses* to exercise, as affective attitudes have been noted as stronger predictors of one's intentions and behavior (Rhodes, Fiala, & Conner, 2009). Core affect – or simply *affect* – is defined as a neuro-physiological state that is always *accessible* by conscious thought, but is a primitive, nonreflective feeling that occurs automatically and serves as the underpinning of all mood states and emotions (Barrett & Russell, 1999). Indeed, early investigations revealed that exercise improved mood and emotional states (Hughes, 1984; Peluso & Andrade, 2005), leading to the dissemination of the idea that “exercise feels good.” This simplistic idea stood in stark contrast to the reality that exercise participation and adherence remains low. A critical examination of measurement procedures identified the common practice of measuring affective states before and after an exercise bout as capturing a *rebound effect*. The rebound effect describes improvements in affective states as a result of the exercise (i.e., a potentially negative or aversive stimulus) concluding (Backhouse, Ekkekakis,

Biddle, Foskett, & Williams, 2007). Further complicating matters, early research often used measurement tools that were biased towards reports of positive mood states (Ekkekakis & Petruzzello, 2000). Thus, methodological adjustments occurred, and it is now of standard expectation that researchers assess *in-task* affect (i.e., core affect while participants are actively under exertion) to better understand and predict exercise behavior.

Affective Responses to Exercise

Theoretical support exists that identifies affect as a relevant construct pertaining to behavioral decisions. In behavioral economics – a field whose focus pertains to explaining human decisions that depart from rationality – the *affective heuristic* suggests that people may avoid activities that are assumed to elicit unpleasant affect, even if they are aware that the activity provides benefits (Finucane, Alhakami, Slovic, & Johnson, 2000). Indeed, Kahneman (2003) highlighted the affective heuristic as being the most critical development with regards to judgment heuristics in the preceding few decades. Further supporting the behavioral implications of affect, the affective heuristic is in line with the widely acknowledged hedonic principle. That is, the notion that people seek pleasure while avoiding pain has governed the understanding of behavioral motivation for centuries (Higgins, 1997). In fact, affective responses to exercise and the centrality of affect with regards to behavior has helped to inform the development of a new theory pertaining specifically to exercise and inactivity.

The Affective-Reflective Theory (ART) of physical inactivity and exercise describes a dual-process interaction to explain why some individuals remain sedentary and inactive while others are successful at adopting and maintaining exercise behaviors (Brand & Ekkekakis, 2018). According to the ART, exposure to an exercise-related stimulus (i.e., the act of performing

exercise, a physician prescribing exercise as a means to improve health) triggers a type I process. A type I process is automatic and involves affective associations and tacit valuations of being pleasant or unpleasant. If an individual does not process these valuations any further, an unpleasant automatic response will likely propel one towards a sedentary behavior in order to avoid further displeasure. However, an alternative outcome is possible. If an individual possesses adequate self-control, type II processes – which are cognitive and deliberate – can overrule the type I impulse and lead, ultimately, to the formation of an action plan and the performance of exercise. Regardless of the outcome, the result of the dual-process interaction becomes encoded into one's affect and cognition, coloring the future automatic associations and valuations the next time an exercise-related stimulus is encountered. These theoretical suppositions are supported by empirical evidence that indicates more pleasant in-task affect during aerobic activities can predict future levels of activity, assessed via self-report (Williams et al., 2008; Williams, Dunsiger, Jennings, & Marcus, 2012) and objective methods (Schneider, Dunn, & Cooper, 2009). Such results may be explained by the predictive power of affective responses over exercise intentions and motivations (Focht, 2009; Kwan & Bryan, 2010; Schneider & Kwan, 2013)

Given the importance of affective responses during exercise, researchers have dedicated research efforts to understanding determinants of in-task affect. Exercise intensity is empirically supported as a primary determinant of affective responses. In the context of aerobic exercise, the Dual Mode Model (DMM) proposes that one's ventilatory threshold (VT; the onset of hyperventilation and an inability to maintain an aerobic steady state) serves as a “tipping point” for affect (Ekkekakis, 2009a). In short, intensities below one's VT tend to produce positive affective ratings, because of the ability to focus on cognitive factors (i.e., self-efficacy) or

external factors (i.e., music, environment), while surpassing VT increases the likelihood of experiencing unpleasant affect because one's attention is dominated by the saliency of interoceptive cues such as heart rate, muscular strain, and respiration rate. With respect to resistance exercise, similar claims have been made as they pertain to exercise intensity – and volume – and affective responses (Cavarretta, Hall, & Bixby, 2019). Namely, moderate intensity and low volume are said to produce more favorable ratings of affect, particularly in those just beginning a resistance-based exercise program.

Intensity cannot be the sole determinant, however, as evidenced by a high degree of interindividual variability when intensities are *near* VT, with noted interindividual variance in magnitude and direction at the high and low end of the intensity spectrum. “Think out loud” procedures (i.e., participants verbally explaining the reason for perceptual ratings) identified energy/perceptions of tiredness and mood states as impacting in-task affect in response to aerobic exercise (Rose & Parfitt, 2010). In a separate study, individuals were asked to recall their in-task affect and explain their scores, revealing the impact of energy, substrate availability, and physical condition on their exercise experience (Beaumont, Ferrara, & Strohacker, 2021). Research efforts have also revealed that anticipated affective responses (Conner, McEachan, Taylor, O'Hara, & Lawton, 2015; Dunton & Vaughan, 2008) and associations [“When I think of exercise, I feel...” (Kiviniemi, Voss-Humke, & Seifert, 2007)] are significantly associated with participation in physical activity and exercise. Taken together, in order to promote sufficient long-term behavioral adherence, it is critical that researchers identify approaches and strategies to optimally manage affective responses to exercise.

Management of Affective Responses Using Autoregulation

Implementing autoregulation holds promise for managing affective experiences with general exercise programming in health settings, but it is currently understudied. Greig et al. (2020) define autoregulation as the purposeful and frequent adjustment of volume and intensity that coincides with an individual's response to training- and non-training-related stressors. While numerous approaches for autoregulation exist, flexible nonlinear periodization (FNLP) is a strategy that may be most applicable for non-athlete populations. Under FNLP, a number of training workloads (1) are identified to achieve targeted physiological adaptations in a given time period, (2) are organized on a spectrum of low-to-high demand and (3) are selected at the onset of each session based on one's *readiness to train* (Kraemer & Fleck, 2007). Readiness to train was conceptualized as a variety of physical and mental states (e.g., energy level, coach/athlete interactions, fatigue, injury status, hydration) that purportedly yield insight into the in-the-moment capabilities of the individual undergoing training (Kraemer & Fleck, 2007). While these factors were likely identified through the practice and intuition of strength and conditioning specialists, empirical evidence to support factors underlying readiness to train was lacking in the original text that promoted the FNLP framework. More recent investigations into the dimensionality of exercise readiness in university students (Strohacker & Zakrajsek, 2016) and adults with obesity (Strohacker, Zakrajsek, Schaltegger, & Springer, 2019) have demonstrated overlap with previous conceptualizations of readiness, in that these sample populations cite that perceptions of affect, activation, bodily integrity, and food/hydration status contribute to readiness states. Such evidence has provided the necessary empirical support for readiness-to-exercise as a multidimensional construct to then progress towards refining FNLP for use in untrained and at-risk populations.

A current limiting factor in the refinement of FNLP prior to robust efficacy and social validity testing pertains to how assessments of readiness-to-exercise can be practically and effectively utilized within a training study or within a behavioral intervention. That is, readiness is a multidimensional construct, yet it is unknown which dimension is most important (i.e., upon which factor of readiness should one ultimately base their daily training decision?). To date, one approach has been that the researchers choose what they deem as the most important factor (i.e., energy; (McNamara & Stearne, 2010), thus requiring participants to provide ratings thereof each day to inform training decisions. However, no evidence was provided to demonstrate that participants did solely (or mostly) rely on energy level in this regard. In a subsequent study, McNamara and Stearne (2013) gave participants numerous constructs to consider (i.e., mood, preference, energy, sleep quality) before choosing which training bout to perform. Conversely, Colquhoun (2017) provided a bank of workloads and participants were instructed to choose their bout based on their motivation within that training day with no further instruction regarding any guiding indices of readiness-to-exercise.

This degree of imprecision with regards to implementing autoregulatory strategies using subjective indices of readiness-to-exercise poses a substantial limitation to testing the utility and acceptability of FNLP. It is possible that the most important indicator(s) of readiness could vary among individuals or even within an individual over time. The ability to leverage each individual's most important factors, which most strongly influence their readiness-to-exercise, represents a key step in refining FNLP as a person-adaptive model of exercise programming. This overall goal aligns with contemporary expert opinions supporting efforts to pursue precision behavioral medicine through developing interventions based on precisely measured participant

characteristics, contexts, moods, and behavior (Chevance, Perski, & Hekler, 2021; Conroy, Lagoa, Hekler, & Rivera, 2020; Nahum-Shani et al., 2018).

Determining the Most Relevant Factor(s) of Readiness-to-Exercise

Factor analysis provides a mathematically based means of identifying the most important factor(s) from multivariate datasets (Cattell, 1952), such as a collection of rated items that all may exert some influence on an individual's perceptions regarding their readiness-to-exercise. Specifically, the objective of factor analysis as a technique is to process and reduce multivariate datasets under the assumption that the covariation among the variables of interest can be explained with fewer latent constructs. In the most widely applied approach – the R-technique – a large number of individuals provide data on a single occasion and that data is modeled to create a population level factor structure or reference structure (Cattell, 1952). The results from an R-technique factor analysis shed light on the total number of factors, how much variance in the data is explained by each factor, correlations between factors, as well as the magnitude and direction of each item's factor loading. This approach operates under the assumption that the factor structure will be consistent at the individual level, thus sufficiently representing lower levels of data. Alternatively, time-series data can be processed using the same procedures described with the R-technique to investigate person-specific structures of multivariate data in a procedure known as the P-technique factor analysis (Cattell, 1963). Using both approaches may be warranted, as it is not appropriate to assume that structures created from R-technique can be extrapolated to structures produced using P-technique. Mathematically this assumption has been disproven (Molenaar & Nesselroade, 2009) and previous research from clinical psychologists has revealed that individual factor structures of psychometric data have the potential to be relatively

diverse when compared to results from the R-technique (Fournier, Moskowitz, & Zuroff, 2008, 2009; Wright et al., 2016). These individualized structures have been referred to as *interpersonal signatures* (Fournier et al., 2009) and may assist researchers who seek to individualize treatment plans (Wright et al., 2016).

Results from our research group demonstrated that person-specific structures using constructs underlying readiness-to-exercise can substantially deviate from the reference structure uncovered using R-technique factor analysis (Strohacker, Keegan, Beaumont, & Zakrajsek, 2021). Such results echo the aforementioned findings from clinical psychologists. Further, consistency in person-specific ‘factor one’ score (i.e., a composite score using items loading on the factor that explained the most variance in the dataset) was found to be moderate at best. This suggests that the most important variables for everyone’s dataset do fluctuate over time (potentially supporting the need for person-adaptive exercise programming). The overall results from Strohacker (2021) uncover a potentially useful means of modeling readiness-to-exercise data, which could be used, in turn, for person-specific autoregulatory programming in a more evidence-based fashion than previous designs (Colquhoun et al., 2017; McNamara & Stearne, 2010, 2013).

However, this preliminary study was conducted by implementing secondary analyses of previously collected data, which poses several important limitations. First, the design was exploratory without considering whether person-specific factor scores are associated with experiential outcomes (i.e., volitional exertion, affective responses). Second, only a limited number of items (12) were used to assess four constructs underlying readiness-to-exercise (e.g., ‘vitality,’ ‘fatigue,’ ‘physical discomfort,’ ‘health and fitness’). A more expansive set of items are likely necessary to better interpret interpersonal signatures (Wright et al., 2016). A third

consideration is whether individuals *perceive* their personalized model to adequately represent their readiness-to-exercise or that an exercise experience would be impacted by fluctuation in their interpersonal signatures. As a hypothetical scenario, one's interpersonal signature may identify stiffness as the most impactful structure of readiness, yet affective response or volitional exertion may only be statistically predicted by pre-exercise energy levels. In such an instance, autoregulating the prescription of workload based on stiffness would possess reduced utility rather than referring to what the individual considers to be more relevant for such outcomes. To date, empirical testing of the relationships between personalized readiness structures and relevant exercise outcomes, as well as exploration of individuals' perception of statistically determined interpersonal signatures represent critically important research aims that must be addressed to optimize FNLP as a strategy for managing affective responses to exercise.

Statement of the Problem

FNLP offers a potential means of tailoring individuals' training workloads to be congruent with their daily readiness-to-exercise (i.e., pre-exercise physical and mental status assessments). Although this approach was originally developed to provide sport-specific strength and conditioning practices, refining FNLP for the general adult population may serve in managing in-task affective responses, which are predictive of future exercise behavior. However, from a practical perspective, effective implementation of the FNLP form of autoregulation requires that the constructs that are assessed to gauge readiness-to-exercise are meaningful (i.e., predictive of key exercise outcomes and perceived by the individual as actually impacting their exercise experience). Further, because readiness-to-exercise is conceptualized as being multidimensional, it is possible that the most important underlying variables – which would

primarily guide training decisions – could differ between individuals (i.e., the existence of interpersonal signatures is possible). To date, the potential inter-individual differences in the most relevant readiness-to-exercise factor(s) has not been sufficiently explored. Thus, additional research is needed to understand the degree of heterogeneity in interpersonal signatures compared to a generalized reference structure of readiness-to-exercise. Additionally, the validity of these interpersonal signatures would need to be determined by examining relationships between the first factor (i.e., the cluster of items that explains the most variance in one's data) and experiential outcomes such as affective responses during exercise. Finally, it is further important to gauge individuals' perceptions of whether objectively constructed interpersonal signatures of readiness-to-exercise hold sufficient meaning to them regarding guiding exercise decisions. Gaining an understanding of these perceptions is warranted, as quantitative constructions of interpersonal signatures – and, in theory, using interpersonal signatures to autoregulate and manage affect – would be futile if an individual ultimately relies on *other* factors as a basis for their behavior and experience.

Statement of the Purpose

The current study has three specific aims.

Aim 1: Compare participants' interpersonal signatures of readiness-to-exercise to a reference structure.

Aim 2: Visually illustrate associations between person-specific first factor scores and anticipated experiential outcomes related to a hypothetical bouts of strength training exercise in adults who are recreationally trained in muscle-strength exercise.

Aim 3: Explore the participants' perceptions regarding the relevance and informational utility of their interpersonal signature of readiness-to-exercise as it pertains to strength training.

Significance of the Study

Addressing the proposed research aims represents a crucial step to allow the practical implementation of FNLP procedures, which could then be compared to standard exercise programming approaches to test effects pertaining to physiological and psychological efficacy, as well as social validity. Flexible, person-specific approaches to intervention are critical, as traditional approaches have yielded limited success in promoting long-term adherence to exercise behavior.

Chapter II: Review of the Literature

Chronic Diseases and Effects of Physical Activity

According to the National Center for Chronic Disease Prevention and Health Promotion, a chronic disease can be understood, broadly, as being a condition that requires medical attention, limits activities of daily living (or both), and lasts for at least one year (Prevention, 2021). Two of the most important chronic diseases that drive physical activity and exercise research are type 2 diabetes and cardiovascular disease.

Disease Etiology, Prevalence, and Physiological Risk Factors

Type 2 Diabetes Mellitus

Type 2 diabetes mellitus (T2DM) is a metabolic disease whose pathology includes apoptosis and dysfunction of pancreatic beta cells (Fu, R Gilbert, & Liu, 2013). Apoptosis, which is defined as the death of cells in the body, is a naturally occurring, normal phenomenon. However, excessive apoptosis is associated with diseases like Parkinson's and Alzheimer's, and insufficient apoptosis is associated with diseases as well, such as cancer (Lawen, 2003). With respect to T2DM, apoptosis is the primary cause of pancreatic beta cell death (Kahn, 2003). It is the beta cells of the pancreas that, under normal functioning, are responsible for secreting and processing newly synthesized insulin (Harding & Ron, 2002), which in turn is necessary for transporting glucose into a cell for metabolism and/or storage. Thus, the development of T2DM manifests through insulin resistance (i.e., reduced sensitivity of insulin receptors, necessitating increasingly more insulin secretion) and a resultant impaired glucose tolerance (Singh & Saxena, 2010), as well as the apoptosis of pancreatic beta cells.

T2DM is a relevant cause of public health concern, as 21 million adults in the United States are currently diagnosed with the disease (Bullard et al., 2018). This metabolic disease is

also a concern because of its association with co-morbidities and the lifestyle behaviors that can increase the likelihood of developing T2DM in the first place. For instance, individuals with obesity are 10-fold more likely to develop T2DM (Bellou, Belbasis, Tzoulaki, & Evangelou, 2018). Obesity has been identified as a primary disease risk factor that results from the accumulation of excess body fat has occurred to a degree that health may be adversely affected (Kopelman, 2000). The increased risk of developing T2DM for those with obesity is understandable, given the fact that obesity is characterized by – among other symptoms – elevated levels of fasted plasma insulin and an increased insulin-secretion response when ingesting glucose (Kolterman, Insel, Saekow, & Olefsky, 1980). Insufficient levels of activity also increase the risk of developing T2DM. Sedentary behaviors, which are behaviors (while awake) that produce energy expenditure ≤ 1.5 metabolic equivalent of task (METs) while an individual is sitting, reclining, or lying down (Tremblay et al., 2017), also increase the risk of developing T2DM. This is because physical inactivity and sedentary behavior reduce daily energy expenditure which, over time, can result in an individual's energy balance being positive (i.e., consuming more energy than expended). Over time, chronic positive energy balance can lead to unhealthy weight gain (i.e., obesity) which is a risk factor for T2DM, as discussed above.

Cardiovascular Disease

The risk of developing cardiovascular disease (CVD) – the leading cause of death in the United States (Benjamin et al., 2018) – is increased by 1-3-fold in women and 2-5-fold in men with T2DM. The physiological mechanisms that associate T2DM with CVD include elevated levels of circulating free fatty acids, dysfunction of the mitochondria, which result in endothelial dysfunction and inflammation (Low Wang, Hess, Hiatt, & Goldfine, 2016). Chronic and acute

overproduction of reactive oxygen species (ROS) has been identified as an important mechanism by which cardiovascular diseases are developed, including atherosclerosis (Singh & Jialal, 2006). Such overproduction – referred to as *oxidative stress* – can cause inflammation and the accumulation of plaque. Alongside T2DM, other risk factors for developing CVD include hypertension, hyperlipidemia, and smoking (Fryar, Chen, & Li, 2012). While the prevalence of adults with at least one of the three risk factors mentioned has been decreasing, approximately 102.5 million adults still possess at least one (Fryar et al., 2012).

Risk Management Using Physical Activity

Effects of Aerobic Activity

Although muscle-strengthening activity is traditionally considered to be relevant for managing and preventing T2DM, participating in aerobic activities has been shown to substantially reduce the risk of developing the disease in various populations (Hu et al., 1999; Medina et al., 2018). The reduction in risk is a result of favorable body composition and improved glucose metabolism due to increased energy expenditure (Hu et al., 1999). Perhaps the most widely disseminated relationship is that between aerobic activity and heart health. Specifically, physical activity has demonstrated substantial effects on the prevention and treatment of CVD with a clear dose-response such that the greater the increase in activity and energy expenditure, the greater the reduction in risk and prevalence (Berlin & Colditz, 1990; Leon, Connett, Jacobs, & Rauramaa, 1987; Sesso, Paffenbarger Jr, & Lee, 2000). The physiological explanation for the effects of aerobic activity pertaining to CVD are relatively simple: activity improves blood circulation, lowers blood pressure and heart rate, and improves

delivery of oxygenated blood to the heart and muscles where increased mitochondrial and capillary density allow for greater oxygen extraction (L. T. Braun, 1991).

Effects of Muscle-Strengthening Activity

Resistance exercise may be particularly beneficial in preventing and managing T2DM – and, by extension, the co-morbidities it is associated with. Regular participation in resistance exercise has been shown to increase lean body mass, bone mineral density, and insulin sensitivity, while also decreasing HbA1c levels (i.e., 3-month glucose control) and blood pressure in those with type 2 diabetes (Gordon, Benson, Bird, & Fraser, 2009). Additionally, an inverse association exists between skeletal muscle index (i.e., the ratio of skeletal muscle mass to total body mass) and development of insulin resistance (Srikanthan & Karlamangla, 2011). A recent review revealed that resistance exercise (i.e., a subset of muscle-strengthening activity) holds significant therapeutic effects for CVD as well, counteracting the loss of muscle strength and decreasing visceral fat (Cadore & Izquierdo, 2015). Resistance exercise can also prevent the development of CVD, reducing the risk in healthy adults by decreasing blood pressure and circulating triglyceride levels (Cornelissen, Fagard, Coeckelberghs, & Vanhees, 2011). Such protective benefits are the results of biological pathways that are not necessarily related to cardiorespiratory fitness (Fiuza-Luces et al., 2018).

Physical Activity Guidelines for Americans

Given the empirical evidence of positive effects on physical and mental health outcomes that regular participation in physical activity can have, experts have put forth public health recommendations regarding weekly volume and intensity for adults to achieve. Physical activity

refers to bodily movement that results in the expenditure of energy above one's resting metabolic levels. Adults should achieve at least 150 minutes per week of moderate aerobic activity (efforts equivalent to brisk walking), 75 minutes per week of vigorous aerobic activity (efforts equivalent to running or jogging), or an equal combination of the two intensities (Piercy et al., 2018). In conjunction with aerobic guidelines, adults are recommended to participate in muscle-strengthening activities such as resistance training or bodyweight training, at least twice per week, targeting all major muscle groups using moderate intensities (Piercy et al., 2018).

Public Health and Economic Burden

Premature Death and Co-morbidities

Adults with T2DM have a 50% greater rate of all-cause mortality than adults without (Rowley, Bezold, Arian, Byrne, & Krohe, 2017). Adults with T2DM are also at increased risk for developing co-morbidities that can be physiological, such as hypertension, dyslipidemia, and peripheral vascular disease (Pantalone et al., 2015), as well as psychological. Namely, T2DM can result in mild cognitive impairment and depression (Abd Elaaty, Ismail, Sheshtawy, Sultan, & Ebrahim, 2019), such that 31% of adults with T2DM have presented clinically relevant depression (Rustad, Musselman, & Nemeroff, 2011). CVD is the leading cause of mortality for most adults in the United States (Friede, Reid, & Ory, 1993), representing one in every four deaths (Virani et al., 2020). Those with CVD are also more likely to be obese (Koliaki, Liatis, & Kokkinos, 2019), have T2DM (Strain & Paldánius, 2018), and hypertension (Zhou, Xi, Zhao, Wang, & Veeranki, 2018).

Quality of Life and Physical Functioning

Health related quality of life (HRQoL) has been measured using five domains: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Ge et al. (2019) observed that the presence of one chronic disease had a deleterious effect on HRQoL in young adults (i.e., age 21-44 years) and the presence of multiple chronic disease reduced HRQoL in all adults regardless of age. In a more specific context, Wardoku et al. (2019) observed that physical inactivity compounded the effect of CVD on HRQoL. Independent of chronic diseases, physical activity has been shown to reduce the rate of recurrent falls, functional limitations, and cognitive impairments (i.e., Alzheimer's disease, depression, cognitive decline) in adults over the age of 60 years (Cunningham, O'Sullivan, Caserotti, & Tully, 2020).

Economic Burden

More than \$3 trillion USD in annual health expenses are for individuals with chronic mental and physical conditions (Buttorff, Ruder, & Bauman, 2017). In the year 2020, estimates for spending related to T2DM in the United States reached a staggering USD 294.6 billion – almost tripling expenses of China who spent the second most on the disease with estimates of USD 109 billion (R. Williams et al., 2020). Despite the exorbitant cost of health care dedicated to T2DM, the spending on CVD eclipses economic burden, requiring USD 316.6 billion in 2012 (Fan, 2017). As they pertain specifically to physical inactivity, Americans spend approximately USD 117 billion per year, which represents about 11% of total health care expenses (Carlson, Fulton, Pratt, Yang, & Adams, 2015). Given that healthcare spending has routinely surpassed the gross domestic product in the United States for over four decades (Poisal et al., 2007), paired with the therapeutic and preventative effects of physical activity, behavioral and lifestyle

interventions have represented a worthy opportunity for improving economic and public health for the country.

Lifestyle Modification

Need for Behavioral Intervention

Despite the positive effects on relevant chronic diseases, Americans are not participating in sufficient levels of physical activity. According to self-reported data, meeting the aerobic guidelines is substantially more prevalent in adults (53.3%) compared to only 23.2% who reported meeting recommendations for both aerobic *and* muscle-strengthening activity. This large disparity is clearly driven by the lower participation levels for muscle-strengthening activity. In fact, 30.2% of adults report meeting *only* the muscle-strengthening recommendations (Bennie et al., 2018).

Effects of Physical Activity Interventions

Rhodes et al. (2017) conducted a thorough review of interventions aimed at improving physical activity and their effectiveness. In total, the authors analyzed 30 meta-analyses and 56 narrative reviews that encompassed a wide range of adult and youth populations, including but not limited to college students, individuals with obesity, cancer survivors, pregnant or post-natal women, populations of low socioeconomic status, and cardiac patients. For interventions that included adult populations, the average effect size was $d = 0.27$ ($SD = 0.13$), which is considered a small effect. Interventions with youth populations had a similar effect size ($d = 0.30$, $SD = 0.05$). While interpretations of the effect size at face value suggest interventions are relatively unsuccessful at behavior change, Rhodes et al. (2017) advise to interpret the effect sizes with

baseline physical activity levels in mind. For instance, when Conn et al. (2011) translated their effect size of $d = 0.19$ into weekly minutes of physical activity, it was equivalent to roughly 15 minutes per week in healthy adults, while the effect size of $d = 0.18$ reported by Chase (2015) was equivalent to 73 minutes per week in older adults. In addition, both meta-analyses showed no effect on physical activity in control groups.

With regards to the effectiveness of physical activity interventions on clinical outcomes, caloric restriction combined with achieving 150-175 minutes per week of aerobic activity yielded a 40-70% reduction in the risk of developing T2DM in adults who had impaired glucose tolerance (Colberg et al., 2016). Exercise, which is a subset of physical activity commonly used to achieve sufficient activity levels, is distinct from physical activity in a number of ways. First, exercise is structured and repetitive, while physical activity is a broader construct that can encompass things like occupational activity (i.e., a postal worker delivering mail on foot) or transportation activity (i.e., walking to the grocery store) which are done for their own purpose. Secondly, exercise is performed for the sake of maintaining or improving at least one of the five components of health-related physical fitness (e.g., cardiovascular endurance, muscular strength, muscular endurance, flexibility, and body composition).

Poor Long-Term Adherence

While physical activity and exercise interventions have demonstrated effectiveness in terms of behavior and clinical outcomes, the problem of long-term adherence still persists. Marcus et al. (2006) reported that structured exercise programs have an average dropout rate of 45%. The authors speculate that although the nebulous operationalization of “exercise dropout” may add to the variance in results (i.e., dropout rates ranged from 9% to 87%), the need to

address adherence is clear. This is especially true given how long the problem of exercise adherence has persisted; in a series of studies within a sedentary adult population, Dubbert et al. (Dubbert et al., 1984) reported dropout rates as high as 70%. Adding to the complexity of maintaining exercise behavior, participation in structured programs may *create* additional barriers. For example, DeBusk et al. (1985) found that individuals who were enrolled in a gym-based training program spent more time in their vehicles traveling to and from the facility than the home-based group spent on their ergometers actually exercising. Middleton et al. (2013) provide another consideration in a review, that even if an intervention is completed in its entirety, the environmental challenges (i.e., neighborhood characteristics, accessibility/opportunities to exercise, calorically dense food availability) experienced afterwards creates a “cascade” of behavioral lapses, which the authors describe as initial lapses in behavioral maintenance subsequently undermine the self-confidence one has to employ self-management, thus abandoning the overall behavior change effort.

Commonly Implemented Theoretical Frameworks and Important Criticisms

It has been advised that physical activity interventions geared towards behavior change be theory based. In a review that compared the effectiveness of theory-based interventions to interventions that did not state a theoretical framework, there were 148 theory-based interventions compared to 77 without (McEwan et al., 2019), suggesting that many researchers have heeded this advice. Interestingly, there were no statistically significant differences in the effect sizes between theory-based and non-theory-based interventions ($d = 0.48$ and 0.37 , respectively). However, the authors speculate that while effects may not differ significantly, theory-based interventions seem to improve physical activity on a more *consistent* basis and

argue that – if faced with the decision of using a theoretical framework or not – researchers should continue to ground their interventions in theory. A variety of behavior change theories exist, but some of the most commonly used in health-related research include the Transtheoretical Model, Social Cognitive Theory, the Health Belief Model, and the Theory of Planned Behavior (Painter, Borba, Hynes, Mays, & Glanz, 2008). According to the Transtheoretical Model, individuals move across a number of behavior change stages (i.e., precontemplation, contemplation, preparation, action, and maintenance), and researchers are recommended to tailor intervention components to match their current stage (Prochaska & Velicer, 1997). The Social Cognitive Theory identifies self-efficacy, or one's confidence in their capacity to perform a behavior, as a primary factor for behavior change, and purports that self-efficacy is influenced by a complex interaction of a person's past experiences and outcome expectancies, their environment, and the behavior itself (Bandura, 2001). According to the Health Belief Model (Becker, 1974), a person's motivation to alter their behavior is driven primarily by their perceptions of disease susceptibility and the severity of the disease. And finally, the Theory of Planned Behavior identifies *intention* as the primary predictor of behavior, and purports that intention is influenced by the person's attitudes, subjective norms, and their perceived control related to the behavior itself (Ajzen, 1991).

One concern with classic health behavior models that has been raised (Kahneman, 2003) is the assumption that people make rational decisions to achieve goals, and that the more informed they are, the more likely they will be to behave rationally. This assumption has been proven untrue, explaining an entire field of study called behavioral economics, which is concerned with explaining *why* humans depart from rationality when making behavioral decisions. As a result of such research, constructs such as *heuristics* have emerged. Heuristics are

a mechanism employed by individuals for the purpose of reducing complex, deliberate thought processes into a more time-efficient process – which can lead to errors and acting against one's own best interest (Tversky & Kahneman, 1974). According to prominent researchers, the development of the *affect-judgment* heuristic (Finucane et al., 2000) has been labeled the most important development in judgment heuristics in the past several decades (Kahneman, 2003). The affect-judgment heuristic purports, rather simply, that one's affective state influences subsequent assessment of risk versus reward or the utility in making one decision over another.

Affective Responses to Exercise

Key Definitions

Affect has been defined as a neuro-physiological state which is always accessible by conscious thought, but is a simple and primitive, nonreflective feeling that underpins all mood and emotion (Russell & Barrett, 1999). Foundational research led to the creation of the Circumplex Model of Affect, a measurement conceptualization which suggests that affect itself is comprised of two factors: valence (pleasant/unpleasant qualities) and arousal (high/low activation states) (Russell, 1980). By contrast, moods and emotions are more salient psychological constructs, which are distinct from affect and from each other. For example, mood states are typically longer lasting than emotions are – lasting hours or even days compared to emotions which may last for mere seconds or minutes (Ekman & Davidson, 1994). And while affect underpins both moods and emotions, there appear to be interactions *between* moods and emotions. That is, while some debate exists, such that some theorize emotional episodes impact mood states (Frijda, 1994), while others suggest mood states lower the threshold to experience

particular emotions (Ekman & Davidson, 1994). In either case, moods and emotions appear separate yet related, while affect represents the basis of both.

Historical Importance of Affective Responses to Exercise

Early research conducted to examine the effects of exercise on affect, mood states, and emotions led to the general notion that exercise elicited improvements in such constructs (Biddle, 2000; Fox, 1999). Given the empirical support in a variety of fields like social psychology (Emmons & Diener, 1986), neuroscience (Bechara, Damasio, & Damasio, 2000), and behavioral economics (Kahneman, Diener, & Schwarz, 1999), researchers posit that affect impacts behavioral decisions, such that people gravitate towards behaviors and stimuli that make them feel good. And yet, exercise and physical activity participations continue to be insufficient (Guthold, Stevens, Riley, & Bull, 2018), resulting in what was referred to by some as the “feel-better paradox” (Backhouse et al., 2007).

Important Methodological Errors

Backhouse et al. (2007) sought to explain this paradox. The authors identified issues with the conceptualization of research, the interpretation of data, and the methodology involved as explanatory factors for the feel-better paradox.

With regard to conceptualization of historical research, instrumentation selected for use during studies lent to an inherent limitation. Until the mid-1990s, exercise-related affect was typically assessed by tapping in to select variables: state anxiety, which was obtained from the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970) and the six mood states (i.e., tension, depression, anger, vigor, fatigue, and confusion) from the Profile of Mood States

(McNair, Lorr, & Droppleman, 1971). Critics of these scales have suggested that their use may appear to demonstrate no effects of exercise even though there may have been effects in reality, because the instrumentation's ability to target the "psychometric domain of significance to the exerciser" had not been evaluated (Morgan, 1997). The field, broadly speaking, shifted in their choice of instrumentation to include the Exercise-Induced Feeling Inventory (Gauvin & Rejeski, 1993), the Subjective Exercise Experiences Scales (MeAuley & Courneya, 1994) and the Physical Activity Affect Scale (Lox, Jackson, Tuholski, Wasley, & Treasure, 2000), the latter of which was the result of merging the two formers. Nevertheless, the measurement limitation persisted, as many of the items selected were unipolar. This means that the results produced were limited such that inferences regarding which positive changes occurred could not be made solely based on the *lack* of negative changes to occur, and vice versa. Ultimately, a series of four articles made the strong case for assessing exercise-related affect using the Feeling Scale (Hardy & Rejeski, 1989) to capture changes in valence and using the Felt Arousal Scale to capture changes in arousal (Ekkekakis & Petruzzello, 2000).

In a substantial majority of studies conducted up through the 1990s – and in some cases beyond – researchers took measurements of affect only before and after the bout of exercise without assessing during the bout, while under the physical exertion ("in-task" affect). Backhouse et al. (2007) speculate that this methodological decision may have been as a result of participant burden; many of the instrumentation previously described consisted of several items and thus, would be logistically infeasible to use repeatedly or during the bout. They also speculate that researchers may simply have not been interested with the in-task affect, choosing instead to focus on post-exercise effects. The previous issue leads directly to the final factor that

yielded the historic “feel-better” paradox, which is *when* affective responses were typically assessed.

Fortunately, several research groups began assessing in-task affect despite previous convention (Bixby, Spalding, & Hatfield, 2001; Hall, Ekkekakis, & Petruzzello, 2002; Parfitt, Rose, & Burgess, 2006; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000). Findings from such studies uncovered an important phenomenon: the rebound effect. This phenomenon describes the tendency for in-task affect to become less positive in both moderate intensity and high intensity conditions, only to rapidly reverse after the bout is over, often exceeding pre-exercise levels. This decline of in-task affect has been observed even when exercise intensity is manipulated to preserve a steady-state during the bout (Acevedo, Gill, Goldfarb, & Boyer, 1996). The rebound effect suggests that perhaps the “feel-better” effect of exercise is more accurately describing that individuals feel better because they *stopped* exercising and the strain has been removed.

Contemporary Research Focus on Affect

Measurement Considerations

Although instrumentation concerns have been addressed by implementing the Feeling Scale and the Felt Arousal Scale, researchers were often prone to overlooking inter-individual variations in their participants’ affective responses. This posed a barrier to the development of exercise-related affect knowledge development, as exercise can produce positive affective responses in some individuals and negative affective responses in others even if the mode, duration, and intensity (i.e., “external load”) is uniform across participants. It is worth noting that affective responses tend to be relatively consistent across individuals when exercising at the

more extreme ends of the intensity spectrum (i.e., very low or very high), but in the rather substantial range between the two, the inter-individual variations are considerable (Ekkekakis, Hall, & Petruzzello, 2005). This variation was illustrated quite clearly by Van Landuyt et al. (2000) when an overwhelming proportion of participants (85.7%) experienced affective changes while cycling at 60% of VO_{2MAX} , and 14.3% experienced no change. The problem identified by the authors was that, of those participants who experienced changes in affect, an approximately equal proportion reported increases and decreases. So, if one were to only assess and report the aggregate results, it would appear the intensity elicited no changes in affect across the group while cycling. In conjunction with their findings that post-exercise affect at the group level trended towards the positive, one could erroneously conclude that the bout itself led to positive affect (i.e., “feeling better”) even though 41.3% of participants actually felt worse *during* the exercise.

Predictive Power of In-Task Affect

Williams et al. (2008) conducted a study with healthy, sedentary adults (i.e., achieving 90 minutes or less of moderate intensity activity per week, $n = 37$). Participants complete a Balke treadmill protocol, wherein speed was held constant at 4.83km/h and initial grade was 2.5% and progressively increased by 2.5% every two minutes. Ratings of affect were collected at baseline and every two minutes during the protocol using the Feeling Scale (Hardy & Rejeski, 1989), an 11-point bipolar scale commonly used in exercise-related affect research. Because the study was focused on promoting moderate intensity activity, the FS score when moderate intensity (i.e., 64% of age-predicted heart rate max) was reached was the score used in their model. For every one-point increase on the Feeling Scale, an additional 38 minutes of moderate activity per week

was associated in self-reports 6 months after the test when controlling for pre-exercise affect. At 12 months, a shift in one point on the FS was associated with an additional 41 minutes of physical activity per week when controlling for baseline activity level, 6-month activity level, and pre-exercise affect. Schneider et al. (2009) had adolescents ($n = 124$) complete two 30-minute exercise bouts on a cycle ergometer: one above ventilatory threshold and one below. In addition, participants were fitted with accelerometers for approximately 7 days. Again, the FS was used to assess affective ratings before the bout, at minutes 10 and 20 during exercise, and 10 and 20 minutes after completing the exercise. Those who reported increases in pleasure during exercise on a cycle ergometer at 80% of ventilatory threshold averaged approximately eight minutes per week more of moderate activity than those who reported no change, and approximately 15 minutes per week more than those who reported decreases in pleasure. The role of exercise intensity as a predictor of behavior stands in contrast to duration and frequency, which do not appear to be related with exercise adherence (Dishman & Buckworth, 2007; Perri et al., 2002).

The Affective-Reflective Theory of physical inactivity and exercise

The Affective-Reflective Theory (ART) of physical inactivity and exercise was established to explain why individuals do or do not initiate action to exercise (Brand & Ekkekakis, 2018). Rather than focus on the deliberate reflections that individuals may have regarding their thoughts and actions, the ART incorporates affect and the concept of automaticity – in part as a means to explain why people may sometimes *continue* being inactive without deliberately reflecting on that choice. That is not to say the ART disregards conscious reflection altogether. Rather, the theory is a dual-process theory, meaning there is an acknowledgement of

the interplay between automatic affective associations (a type-1 process) and conscious cognition (a type-2 process).

The ART builds upon early work from the field of social psychology, specifically Lewin's force field theory (Lewin, 1943). His theory suggests that behavior (and behavior change) should be viewed as the total result of forces that push us towards one action and pull us away from another. Further, this force-field is dynamic, meaning the forces are always changing in terms of magnitude and across contexts, and that this field is more influential on behavior than past experiences or future goals. Likewise, the ART focuses on the exact moment that an exercise-related stimulus occurs. Such a stimulus could be viewing an advertisement online for a fitness facility or even as simple as recalling that a physician prescribed an exercise program. As a result of that stimulus, an automatic affective association to that object occurs – assigning a pleasant or unpleasant connotation to the stimulus without intentional thought. The affective association (if pleasant) is then an action impulse that propels the individual to act, or conversely, if unpleasant, becomes a repulsion force away from the action of exercising. An individual is always able to reason through their automatic associations using type-2 processes. However, according to the ART, the availability of self-control resources determines whether the type-1 or type-2 processes are the primary determinant of behavior. Over time, the repeated process of being exposed to an exercise stimulus followed by type 1 and subsequent type 2 processes begins to encode future affect in a way that leaves an imprint on future affective associations. This encoded affect can be detrimental or conducive to exercise behavior, depending on the experienced valence. While the ART is comparatively new in relation to the classic behavior change theories that have been applied to exercise, it gives warranted

consideration to affect and specific affective constructs (i.e., forecasted, in-task, and recalled affect), which have demonstrated behavioral implications in empirical research.

Determinants of Affective Responses to Exercise

Research attention, in varying degrees, has been given to multiple ‘temporal’ aspects of affect. That is, scientists have dedicated efforts towards understanding forecasted affect (i.e., the affect one anticipates experiencing prior to an event or exposure to a stimulus), affect that is experienced while under exertion (“in-task affect”), and recalled affect or how one remembers the affective experience. While an individual does not necessarily experience these affective components in a linear fashion – one can anticipate affect, recall prior affect and not exercise, thus not experiencing in-task affect before once again anticipating affect at later time – the review of the literature herein will follow the sequence of forecasted, in-task, and recalled determinants.

Determinants of Forecasted Affect

A recent surge of research has begun to take into account forecasted affect and explore its determinants. Cox et al. (2020) had participants complete 20 minutes of treadmill walking at a self-selected speed and grade. Participants were able to adjust the speed and grade as frequently as desired, so long as they did not begin running. Three conditions were performed in a randomized order: control, music, and mindfulness. For the latter two conditions, participants identified the genre of music they would typically choose for an exercise session and listened during the 20-minute walk, and in the mindfulness condition they listened to a guided mindfulness audio track. In both experimental conditions, forecasted affect was significantly

greater than the control condition. Audio and visual stimuli were also compared to control conditions in treadmill exercise conducted by Pottratz et al. (2021) across two studies. In experimental conditions, participants listened to music, watched music videos, and watched music videos with affective primers (“PRIME” condition). Affective primers were music videos of songs that were rated positively when assessed with the Affect Grid (Russell, Weiss, & Mendelsohn, 1989). Effects were consistent with Cox et al. in that the experimental conditions produced significantly greater forecasted affect. Specifically, the PRIME condition elicited the greatest forecasted affect in both studies by Pottratz et al. The use of affective priming was also employed using written excerpts (Kwan, Stevens, & Bryan, 2017). Depending on assignment to positive or negative priming conditions, participants read descriptors of the subsequent bout of exercise that depicted the workload as being pleasant or unpleasant, and then performed the exercise under supervision at a laboratory. Interestingly, an effect by condition on forecasted affect was only observed in the laboratory exercise but not in the nonlaboratory exercise. They were then prescribed the same exercise to complete daily for a week, with forecasted affect measurements obtained each day.

Another approach has been used in order to potentially manipulate forecasted affect is altering the “slope of pleasure,” a within-session manipulation wherein the exercise bout begins at a higher intensity (i.e., less pleasant) and progressively becomes easier (i.e., more pleasant). This strategy is implemented by starting the bout with high intensity and gradually decreasing intensity as duration grows. Zenko (2016) separated participants into an increasing-intensity group (28 ± 5 y, 6 women) and a decreasing-intensity group (27 ± 4 y, 9 women). Those in the increasing-intensity group started a 15-minute cycling session at 0W, and power was increased until 120% of Watts that corresponded with the individual’s ventilatory threshold. Those in the

decreasing-intensity group started at 120% of Watts at their ventilatory threshold and decreased to 0W at minute 15. The decreasing-intensity group averaged significantly higher levels of forecasted pleasure (51.75 ± 22.67 vs. 31.47 ± 26.05), $t(44) = 2.82$, $p = .007$, $d = -0.83$).

While the previously mentioned studies have all taken quantitative approaches to investigate the relationship between exercise, forecasted affect, and a variety of independent variables, few research groups have taken a qualitative approach to first identify determinants of forecasted affect *before* manipulating such variables. However, one group subjected their participants to a 30-minute bout of moderate intensity treadmill walking, with a forecasted affect rating provided before the bout (Calder, Hargreaves, & Hodge, 2020). Fifteen minutes after the bout, participants provided a second forecasted affect for a future, hypothetical 30-minute bout of moderate intensity exercise. This second forecast was supplemented with a semi-structured interview aimed at exploring determinants of their forecasted affect. The content of the interview was subjected to thematic analyses, ultimately yielding four themes for determining forecasted affect: the intensity of exercise, the exercise environment, exercise outcomes, and anticipated enjoyment. These determinants share commonalities with determinants of in-task affect, which will be discussed in the next section.

As a final note, forecasted affect has been positively associated with subsequent in-task affective responses during exercise (Helfer, Elhai, & Geers, 2015; Kwan et al., 2017), though forecasted affect is prone to underestimate how positive one's in-task affect will be (Loehr & Baldwin, 2014; Ruby, Dunn, Perrino, Gillis, & Viel, 2011). Despite these associations forecasted affect has not demonstrated a predictive effect over future levels of activity in experimental work to the same degree that in-task affective responses have.

Determinants of In-Task Affect

Intensity. As a result of the measurement timing issues in classic studies, which were identified by Backhouse et al. (2007), a substantial shift in the research paradigm occurred. Broadly speaking, researchers began collecting ratings of in-task affect, often using aerobic modes of exercise. The rebound effect identified by multiple groups (Bixby et al., 2001; Hall et al., 2002; Van Landuyt et al., 2000), discussed previously, prompted researchers to contextualize the relationship between exercise intensity and exercise-related affect. In 2009, Ekkekakis published a framework for this very purpose (Ekkekakis, 2009a). The Dual Mode Theory (sometimes referred to also as the Dual Mode Model or DMM), brings together the intensity of exercise with the individual's attentional focus, with affective response being the result. The DMM emphasizes one's ventilatory threshold (VT; physiological event that marks the onset of hyperventilation and a subsequent inability to maintain an aerobic steady state) as a proxy for lactic acid accumulation, both of which signify important shifts in affective response. At low intensities, when one is below their VT, affective responses tend to be pleasant. Ekkekakis purports that this pleasant response is due to the individual's ability to keep their attention focused on cognitive processes such as self-efficacy and exercise-related goals. At high intensities, when one has exceeded their VT, affective responses tend to be rather uniformly unpleasant. According to the DMM this is because one's attention has shifted towards salient interoceptive cues such as elevated heart rate, respiration, elevated body temperature, and muscular strain. Indeed, the DMM was both informed by empirical evidence and garnered future support from later studies that suggested affective responses became less positive when intensities and ratings of perceived exertion (RPE) increased (Rose & Parfitt, 2007). However, there is considerable inter-individual variation when intensities are moderate or approximately equivalent to one's VT.

Additional Determinants. Intensity has been cited as a primary determinant for exercise-related affective responses, perhaps explaining why a substantial portion of research efforts have continued to focus on strategies for manipulating intensity. However, consideration has been given to other determinants of exercise-related affect. For example, Carraro (2018) compared affective responses from free weight exercises (i.e., barbell bench press, front military press, and squat) with their machine-based variations. Each exercise was performed by participants ($N = 30$, 23 ± 5 y, at least two years of lifting weights for 2-3 sessions per week) for three sets in a descending pyramid system. That is, the repetitions increased across the three sets (six, eight, and ten, respectively) while the intensity decreased across each set. Despite ambiguous application of the Feeling Scale (FS) and Physical Activity Enjoyment Scale (PACES) – authors report that questionnaires were “self-completed immediately after each session” without including the prompts used, making it difficult to comment whether recalled in-task affect was measured or if a rebound effect was captured – free weight exercises were perceived as more enjoyable. Additionally, they report significant associations between the PACES and FS ($r = 0.75$, $p < 0.01$).

Bellezza et al. (2009) investigated the impact of exercise order on affective responses. Eleven men (21 ± 2 years) and 18 women (21 ± 2 years) participated in the study. Both groups reported completing at least 2 sessions of strength training per week. Each group performed both sequences of exercise order, in a randomized and counterbalanced design. A large-to-small muscle group order consisted of chest press, leg press, rows, leg extension, overhead press, hamstring curl, biceps curl, calves raise, and triceps extension – the small-to-large muscle group order a complete inverse sequence. Authors reported using the FS and Felt Arousal Scale (FAS) to assess affective responses, though detailed application of the instrumentation was not

provided. Significant differences were only found for FS scores during exercise ($p = 0.002$) and 10 minutes after the exercise session ($p = 0.039$), with more favorable scores in the small-to-large exercise order.

Chmelo, Hall, Miller, and Sanders (2009) examined the influence of mirrors on affective responses to strength training. Thirty-two regularly active females (21 ± 1 y, 81% reporting at least three exercise session per week) completed two exercise conditions: one in front of mirrors and one without mirrors. Aside from the mirror, exercise sessions were similar; seven exercises were completed (i.e., chest press, rows, squats, lateral raises, bicep curls, tricep extensions, and deadlifts) for two sets (60% and 100% of 10-RM, respectively). Affective responses were measured prior to the exercise bout, during the exercise (i.e., after the lateral raises), immediately post-exercise, and 15-minutes post-exercise using FS and FAS. Repeated Measure General Linear Model for FS and FAS revealed a significant main effect for Time (Wilks $\lambda = 0.19$, $F(6,21) = 16.0$, $p < 0.001$), with no significant finding for condition or condition by time interaction. Fisher's LSD indicated that the FS scores increased from pre-exercise rating during exercise ($p = 0.001$). Overall, the presence of mirrors does not seem to impact affective response, which is in contrast to similar work conducted with aerobic exercise that found a negative impact from mirrors (Focht & Hausenblas, 2004; Martin Ginis, Burke, & Gauvin, 2007; Martin Ginis, Jung, & Gauvin, 2003).

Determinants of Recalled Affect

Compared to forecasted affect and in-task affect, the construct of recalled affect has garnered less specific research attention. That is, while some studies include remembered affect as a dependent variable in the design (Zenko et al., 2016), it is often a quantitatively assessed

outcome added into the design as a complement to forecasted affect. Thus, little is known regarding the underlying factors that individuals specifically consider when they revisit affective responses they experienced in a previous bout of exercise. Because of this gap in the literature, a recent study was conducted by our research group to explore determinants of recalled in-task affective response – specifically affective valence (Beaumont et al., 2021). After finishing a bout of volitional exercise at a university fitness facility, individuals were asked to complete a survey and provide a score for recalled in-task valence and a written response for the basis of the score. Thematic content analysis uncovered three major themes that determined recalled affective valence. The first, *readiness*, was composed of pre-exercise energy, substrate availability (i.e., adequate pre-exercise meal consumption, hydration status), and their physical condition. The second, *performance*, included levels of exertion, interpretations of interoceptive sensations, and the quality of execution. Finally, experienced and anticipated outcomes such as stress relief/mood improvement and enjoyment were factored into the evaluations made by respondents when recalling their in-task valence. With respect to the ART of physical inactivity and exercise, it is likely useful to measure recalled in-task affect, given the implication towards future behaviors and the manner in which affective responses can become encoded into one's subconscious.

Exercise Programming to Manage Affective Responses

Tripartite Model for Exercise Prescription

Traditionally, exercise program prescriptions are developed with two primary objectives: 1) to maximize health and fitness adaptations while 2) minimizing the risk of injury or overtraining. Based off of a review of 33 articles on the relationship between exercise intensity

and affective responses, a third consideration, dubbed the Tripartite Rationale, was proposed: whether a particular exercise intensity would likely yield increases or decreases in pleasure (Ekkekakis, Parfitt, & Petruzzello, 2011). As such, the Tripartite Rationale suggests a threshold-based prescription. In line with the Dual Mode Model, it has been recommended that exercise intensity be prescribed in a way that promotes or preserves pleasant affect, thus, prescribing intensities below one's VT. However, the authors highlight an intriguing consideration from their review. Ekkekakis and Petruzzello (1999) uncovered that, although more vigorous exercise intensities revealed a negative relationship between Feeling Scale scores and ratings of perceived exertion (RPE), the correlation was positive when the higher intensities were self-selected.

Self-Pacing and Ratings of Perceived Exertion (RPE)-Based Training

One explanation for more favorable affective responses during self-paced activity is the tendency for participants to choose intensities that approach their VT without surpassing it (Ekkekakis, Lind, & Joens-Matre, 2006; Lind, Joens-Matre, & Ekkekakis, 2005; Parfitt et al., 2006). In one study, a within-subjects design was implemented across three conditions of intensity: below lactate threshold (LT), above LT, and self-selected (Parfitt et al., 2006). In line with the Dual Mode Model and the threshold-based prescription of the Tripartite Rationale, intensities above LT produced consistent decrements in affect (approximately 83% of participants) and 58% of participants reported improved affect when intensity was below LT. However, the self-selected condition produced consistently positive changes in affect (i.e., 93% of participants improved) even though the results of blood lactate testing revealed that, on average, accumulation was between that of the two imposed conditions. Authors of the Tripartite Rationale speculate that this seeming paradox could be explained by a sense of autonomy and

control that is fostered by the self-selection of intensity. However, they also propose caution with respect to self-selected intensity, as different factors (i.e., inexperience, individual differences, environmental conditions) may still lead to exercising above VT, resulting in affective declines (Ekkekakis et al., 2006). It is also worth noting that a considerable limitation to the Tripartite Rationale and threshold-based recommendations is the review is entirely based on aerobic activity and is not transferable to resistance exercise.

Autoregulation

The rationale for applying self-selected intensities/RPE to determine exercise workload speaks to a broader strategy of programming referred to as *autoregulation*. Autoregulation is typically applied in the competitive sport context, rather than general exercise prescription, and refers to deliberate, frequent adjustments to programming (Greig et al., 2020). These programming adjustments are made in conjunction with the observable changes in the athlete's response to both training and non-training related stressors (i.e., sleep, nutrition, and illness). Proponents of autoregulatory training suggest that consistent assessment of these stressors can inform training prescription in a way that – as is the goal for all programming – minimizes the risk of overtraining while promoting optimal gains in performance and experiential outcomes (Thorpe, Atkinson, Drust, & Gregson, 2017).

Flexible Nonlinear Periodization and Operationalization of Readiness

Flexible nonlinear periodization (FNLP) is an autoregulatory strategy that assigns workloads based on the athlete's *readiness-to-train* (i.e., pre-exercise mental and physical states; (Kraemer & Fleck, 2007). The developers of FNLP suggested that readiness-to-train could be

measured using a six-item checklist comprised of indices that are intuitive and possess face validity, albeit lacking empirical support. These items include hydration status, interactions between coach and athlete, injury status, vertical jump performance, mental and physical fatigue, and initial performance of the prescribed workload. Further adding to the importance of a number of these items, Mann et al. (2014) have suggested that training status, sleep, stress, and habitual physical activity would impact readiness-to-train, as well as potentially explain individual variations in response to a standardized workload. Original identification of items that purportedly impact readiness-to-exercise relied on practitioner experience and face validity but were not empirically determined.

Only seven studies have been carried out in which authors attempt to implement an FNLP framework, and a considerable degree of heterogeneity is present in the methods. Two studies (da Silva, Vilaça-Alves, de Souza, dos Santos, & Figueiredo, 2016; Rodrigues, Santos, Medeiros, Gonçalves, & Júnior, 2021) referenced in the introduction of their manuscripts that they would employ flexible periodization strategies. However, authors in both studies did not describe any procedures, nor did they provide details in how such methods were executed. McNamara and Stearne (2010) attempted to implement flexible periodization with a group of beginners (age 18-23, 4 females, average of 1.4 years of “strength training experience”) in a collegiate weight training course. The participants were separated into either a flexible nonlinear group (FNL) or a nonlinear group (NL), with training volume equated between the two. The only difference between groups was the FNL group was instructed to monitor their energy levels (using a scale from 0 to 10) immediately prior to lifting, and they were given the option to choose whether they used their 10RM, 15RM, or 20RM that day depending on which was “the workout they felt most comfortable with on that particular day” (pg. 2014). Authors did not report measures of fidelity

that confirmed whether participants followed this system. In 2013, the same authors investigated the impact of concurrent training (i.e., combination of aerobic and strength training done on the same day) with and without max effort cycling using flexible programming for all participants (McNamara & Stearne, 2013). Like their earlier study, the authors instructed participants the flexibility to choose which training session they completed, this time instructing them to select “according to their mood, preference, and energy level” (pg. 1465). However, like their earlier study, the authors still did not provide process details in whether (or how) the participants carried out this process. Colquhoun et al. (2017) compared the effects of daily undulating periodization (DUP) with Flexible Daily Undulating Periodization (FDUP) in a sample of 32 recreationally trained individuals (32 ± 6 years old, self-reported at least six months of training at least three times per week). Each training session was color-coded depending on the goal of the workout such that ‘Green’ reflected a hypertrophy-focused bout, ‘Blue’ reflected a power-focused bout, and ‘Red’ reflected a strength-focused workout. The sequence of workouts each week was standardized for the DUP group (i.e., Green first, Blue second, and Red third). The FDUP group used a 5-point Likert scale to assess motivation and allowed to select the workout for the day, and once a workout was completed for the week, they could not repeat it. Although participants were instructed to assess motivation prior to the bout selection, it is unclear whether they directly used motivation as the primary determinant for choosing the bout. Flexible programming has also been applied, to some degree, in a sample of 58 post-menopausal women (aged 50-75 years) as part of a concurrent training programming (Medeiros, Sandbakk, Bertazzone, & Bueno Júnior, 2022). Participants were separated into three groups: a nonperiodized group, a nonlinear periodized group (NLP) and a flexible nonlinear periodized group (FNLP) for twelve weeks of training. The NLP group completed physical workloads in a fixed order completing two sets

using 5-7RM on Day 1, two sets using 10-12RM on Day 2, and two sets using 15-17RM on Day 3. The FNLP group had the same assigned workloads but were allowed the flexibility to choose which workout they preferred after taking into “consideration their daily variation in physiological and mental conditions.” Again, no further elaboration was made by the authors regarding process details. Only one study described their methods with replicable precision (Walts, Murphy, Stearne, Rieger, & Clark, 2021). Participants ($N = 32$, 19 ± 1 years) were intercollegiate lacrosse players, and the others were investigating whether flexible periodization (FP) would induce greater performance gains compared to a nonflexible periodized (NP) program. Each group completed three workouts per week for eight weeks. Workloads were color-coded (i.e., green, yellow, and red), with multiple workouts for each color. Participants in the FP assessed their “state of readiness” (SOR) prior to each workout, guided by the prompt “based on how your body feels and your current mindset, how ready are you for today’s training?” The answers to the SOR questionnaire were color-coded as well (Green = good feel and mindset, Yellow = fair feel or mindset, Red = poor feel or mindset). Thus, workouts were chosen to be congruent with the color-code of their readiness rating. If the participants in the FP group rated their readiness as Red, they skipped training that day.

With the goal of adapting FNLP for use in novice exercisers and inactive populations, researchers have uncovered similarities such that pre-exercise constructs like affective states, physical discomfort, and food intake/hydration impact perceived readiness in college students (Strohacker & Zakrajsek, 2016) and adults with obesity in reference to ambulatory exercise specifically (Strohacker et al., 2019). In turn, readiness factors have also been shown to impact in-task affect responses in laboratory settings (Rose & Parfitt, 2010) and recalled in-task affective valence in naturalistic settings (Beaumont et al., 2021). Affective responses can be

classified as *internal loads* of exercise – compared to external loads such as amount of weight being lifted – and these internal loads have been purportedly influenced by nutrition, health, and psychological factors as well (Impellizzeri, Marcora, & Coutts, 2019), reflecting an impact of readiness-to-exercise factors. And though some have proposed modifying exercise prescriptions to preserve or produce positive affective responses – with exercise being the main focus of such a recommendation (Ekkekakis et al., 2011) – in order to promote behavioral maintenance, the fact remains that these readiness factors fluctuate within an individual across time and context. As a possible result of such temporal fluctuations, the affective responses to the precise same external workload have shown to vary within an individual when they repeatedly perform the same bout of exercise (Unick et al., 2015).

In a secondary analysis of an existing database of items impacting readiness-to-exercise collected through EMA, Strohacker et al. (2021) were able to create *interpersonal signatures* of readiness-to-exercise for 29 adults who provided “right now” ratings of four categories purported to impact readiness-to-exercise (i.e., vitality, physical discomfort, fatigue, and health/fitness) across 14 days. Specifically, through P-technique factor analysis, ratings of the 12 separate readiness items were reduced into structures of readiness ranging from two to four factors and showed considerable variations between participants. The interpersonal signatures encompassed a diverse collection of physiological (i.e., pain, stiffness, exhausted) and psychological (i.e., happy, lively) factors while also showing substantial variation from a reference structure of readiness-to-exercise that was constructed using R-technique factor analysis in the same study. The reference structure of readiness-to-exercise was composed of four factors that explained 60% of the variance in a sample of 572 participants who provided “right now” assessments of

readiness items before exercising: 1) health and fitness, 2) fatigue, 3) vitality, and 4) physical discomfort.

There is noticeable overlap between factors impacting readiness-to-exercise, factors that influence response to training, and determinants of affective response to exercise. Because of this overlap, there is potential utility in measuring common variables and using that data for autoregulatory, flexible program design. Specifically, the assessment of one's readiness state can inform session-by-session adjustments to external workloads with the goal of optimizing physiological *and* affective responses while also minimizing risk of overtraining. Before such an involved process can be tested, further work needs to be conducted. Specifically, one limitation from Strohacker et al. (2021) that both factor analysis approaches were conducted using pre-existing sets of data and may not encompass all constructs related to readiness-to-exercise.

Chapter III: Methodology

Overall Methodological Overview

Two related studies (referred to herein as Study 1 and Study 2) were conducted to address the three specific aims of the current project. For Study 1, adults completed a one-time, anonymous survey prior to engaging in a bout of muscle strengthening exercise. Surveys contained items pertaining to readiness-to-exercise, in line with previous literature. These data were subjected via R-Technique factor analysis to model a reference structure of readiness-to-exercise using integral data. For Study 2, resistance-trained individuals underwent ecological momentary assessment (EMA) procedures over 21 consecutive days. All EMA surveys contained the same readiness-related items as the survey in Study 1. Each individual's time-series data were subjected to P-Technique factor analyses to create person-specific models of readiness to exercise. *Aim 1 of the dissertation was addressed by comparing the structural features of readiness-to-exercise when using R- vs. P-technique factor analyses.* Each EMA survey also contained a hypothetical exercise scenario, wherein respondents were asked to provide forecasted experiences (e.g., affective valence), should he or she engage in that training scenario, in the moment of the survey. *Aim 2 of the dissertation was addressed by plotting forecasted experiences against first factor scores from personalized readiness profiles.* Following the EMA portion of Study 2, participants completed a one-on-one interview with the researcher to discuss perceptions of their personal readiness models. *Aim 3 of the dissertation was addressed by analyzing the resultant themes emerging from qualitative data.*

Research Design – Study 1

All methods described herein were approved by the university's Institutional Review Board prior to any data collection and all participants provided voluntary consent to participate

in research activities. The purpose of Study 1 was to explore and create the factor structure of constructs that are hypothesized to underlie readiness-to-exercise using integral data (i.e., specifically pre-exercise).

Individuals were approached as they entered a fitness facility and, if interested, were asked to complete a one-time, anonymous survey meant to gather momentary data regarding constructs purportedly underlying readiness-to-exercise. These multivariate data were analyzed using R-technique factor analysis to take the single-observation data from a large sample and reduce the dataset into fewer constructs. Results from this nomothetic technique provided insight into the proportion of variance in the data that were explained by each factor, the item content of each factor, identified any correlations between factors, and identified the magnitude and direction of each item's factor loading. Ultimately, the methods from Study 1 created the reference structure of readiness-to-exercise that was used to address Specific Aim 1.

Participants

We sought to recruit at least 300 adults for Study 1. Given the nature of the study (i.e., a one-time, anonymous survey) prospective participants did not need to fulfill specific training history criteria. Participants simply needed to be attending the fitness facility on a given day preparing to participate in muscle-strengthening exercise. Participants were screened to recruit adults over the age of 18 years. Similarly, precautions were taken to ensure the same individual did not complete the survey on more than one occasion. To this end, we verbally questioned each person as to whether they completed the survey at any other time. The online survey, which could be accessed via QR code, contained a question at the end asking whether the individual

had already completed the survey. If a respondent answered *yes* or *I don't know*, their data were discarded.

Procedures

Recruitment. Participants for the Study 1 were recruited by convenience sampling in-person at local fitness facilities as well as recruitment flyers posted with a QR code for instances where research team members were not present on-site. A recruitment table was established at three fitness facilities to ensure a diverse sample: Orangetheory Fitness, Armor Gym, and the Tennessee Recreation Center for Students (i.e., the university's fitness facility). To ensure variety in the sample, fitness facilities were visited at different times of day (e.g. mornings, afternoons, and evenings) and on different days (i.e., both weekdays and weekends).

Screening and Informed Consent. Respondents were screened to ensure they were about to engage in resistance exercise (i.e., not solely aerobic exercise). Prior to providing any data for the study, a member of the research team reviewed the survey itself with each prospective respondent. During this review, prospective respondents were informed that completing the anonymous survey qualified as providing informed consent. They were also given the option to review the document alone and ask questions before providing any answers. The research team member stated that questions could be asked during completion of the survey.

Instrumentation

Demographics and Anthropometrics. The survey contained a section to collect demographic information from the respondents. Such demographics included self-reported height and weight, age, sex, gender identity, race, and ethnicity. Items were multiple choice and

included at least one option of “Other” with a blank space to indicate selections which may not be included in the bank of answers, as well as an option indicating ‘I do not wish to answer.’

Habitual Exercise Behavior. Habitual exercise behavior was collected using several multiple-choice questions. Respondents were asked how many days per week, on average, they performed strength training exercise and how long they had maintained such frequency.

Readiness-to-Exercise. The constructs that we hypothesized impact one’s readiness-to-exercise were collected using a conglomeration of previously used instrumentation that have been obtained from multiple sources. Overall, 51 items were used as possible indices of readiness-to-exercise in the R-technique factor analysis procedures. The comprehensive list of items, along with the entire Qualtrics survey, is in Appendix D. In the current project, items pertaining to readiness-to-exercise consisted of items related to three larger constructs: 1) affective states, 2) pain and discomfort, and 3) thirst and hunger.

Affective States. The Mood Adjective Checklist, developed by researchers at the University of Wales Institute of Science and Technology, and subsequently validated (Matthews, Jones, & Chamberlain, 1990), considers the four dimensions of mood to be hedonic tone, energetic arousal, tense arousal, and anger. Pulling from all four categories, sixteen items were selected to represent overall mood with regards to readiness to exercise in the current study. Each item was ranked on a six-point scale (1= definitely not, 2= not, 3= not really, 4= a little, 5= very much, 6= extremely) as to whether the adjective applies to participants’ current mood.

Pain and Discomfort. The McGill Pain Questionnaire (Short Form) contains 11 and 4 descriptors of sensory and affective pain, respectively. The current study selected four sensory and one affective descriptor of pain for assessment via six-point intensity scale, such that 1= definitely not, 2= not, 3= not really, 4= a little, 5= very much, 6= extremely.

Thirst and Hunger. The same six-point scale described above for Affective States and Pain and Discomfort was used to assess three items of thirst and four items of hunger. These items were selected because of their relevance in original conceptualizations of readiness-to-exercise (Kraemer & Fleck, 2007), as well as their previous impact on affective responses to exercise (Beaumont et al., 2021)

Statistical Analyses

Descriptive Statistics. Descriptive statistics and frequency scores were calculated for participant demographics, self-reported anthropometric data, and item scores using IBM's Statistical Package for the Social Sciences (SPSS; IBM, Armonk NY).

Suitability of Factor Analysis. Broadly speaking, there are varying guides for determining the suitability of data for factor analysis. Some recommend referring to sample size, although some have recommended samples sizes of at least 100 (Hair, Anderson, Tatham, & William, 1998) and others suggest a spectrum of sample size quality ranging from 100 as “poor,” 300 as “good” and 500 as “very good,” with a sample size of 1000+ as being “excellent” (Comrey & Lee, 2013). Another set of guidelines refers to ratios between cases and variables rather than overall sample size as the determinant of suitability for factor analysis. This ratio, represented as $N:p$ compares the number of participants with the number of variables measured. Again, the suggested ratios are highly varied with some suggesting anywhere from 3:1 on the lower end of the spectrum, increasing to an upper ratio of 20:1 (Everitt, 1975; Tabachnick, Fidell, & Ullman, 2007). Given the work by Hogarty et al. (2005), who determined there was not a minimum level of sample size of $N:p$ ratio to achieve a good factor recovery, we selected the 300-participant rule of thumb as our target for data collection pertaining to the R-technique procedure (i.e.,

constructing the population level reference structure of readiness-to-exercise). Before the factors could be extracted for further analysis, two tests were used to determine the suitability of the data to ensure factor analysis was appropriate: the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (Kaiser, 1970) and Bartlett's Test of Sphericity (Bartlett, 1950). The KMO test is suggested when the ratio between cases and variables are less than 1:5, and the KMO index ranges from 0 to 1, with a score of 0.50 considered suitable for factor analysis (Hair et al., 1998; Tabachnick et al., 2007). For a factor analysis to be suitable according to the Bartlett's test, a p value of <0.05 reflects suitability (Hair et al., 1998; Tabachnick et al., 2007).

Statistically Determining Factor Retention. Traditionally for factor analysis procedures, the number of meaningful factors to retain is based on the number of eigenvalue scores greater than or equal to 1.0. An eigenvalue indicates the amount of variance a single factor explains. When a factor's eigenvalue is ≥ 1 , the factor explains more variance than a single variable in the analysis. However, this approach has been criticized for being too liberal, necessitating researchers to conduct additional statistical analyses to determine how many factors to retain in the final model. Raw data eigenvalues were considered significant and retained as factors if they were larger than the 95th percentile eigenvalues and larger than the mean random data eigenvalues.

A parallel analysis was used to determine the number of factors to retain during the R-technique factor analysis for Study 1. The objective of parallel analysis is focused on determining the components that are responsible for more variance than the components from random data. As an example, if 300 single observations are collected for Study 1, and each observation contains 30 variables, a random matrix of 300 x 30 would be constructed and eigenvalues would be calculated for the random matrix *and* for the Study 1 data. Then the

eigenvalues from each matrix would be compared. If the eigenvalue from the actual data set is greater than the eigenvalue from the random set, the factor or component would be retained. The parallel analysis for Study 1 was conducted using SPSS with the application of syntax written by O'Connor (2000). The number of components is decided using eigenvalues from a random dataset that is parallel – in terms of the number of cases and variables – to the actual study's data set.

R-Technique. Statistical procedures were conducted using IBM's Statistical Package for the Social Sciences (SPSS; IBM, Armonk, NY). Oblique rotation was applied because of a general expectation for a degree of correlations between some factors when modeling psychological constructs. A pattern matrix was used to determine the model structure. The pattern matrix contained every factor retained from the analysis and indicated the amount of loading each of the 51 items had on every factor. An item was considered to sufficiently load onto a factor if the absolute loading magnitude was ≥ 0.4 . If an item sufficiently cross-loaded onto multiple factors (for example, if "sleepy" had a loading magnitude ≥ 0.4 for factor 2 and factor 4), the item was discarded from the factor based on comparison of the absolute value, such that only the factor receiving the highest loading magnitude retained that item in its structure. Structural features of the resultant model (i.e., the number of factors, proportion of variance explained, between-factor correlation, item loading) was examined. To supplement the factor structures, a communality plot was generated. A communality is the proportion of each item's variance that can be explained by the factor. Initial communalities are generated in SPSS as part of the factor analysis. Thus, a line graph was created using the communality for each item that sufficiently loaded onto each factor that was retained from the analysis. Finally, a factor analysis

is an exploratory approach that requires researchers to ultimately interpret the meaning and theme connecting the items that load upon it.

Research Design – Study 2

Overview

Study 2 required participants to be enrolled for at least 25 days. The total duration of enrollment was determined, in part, by the scheduling availability of both the participants and the research team members. Given public health concerns around mutations to the COVID-19 virus, all procedures for Study 2 (e.g., consent, familiarization, data collection, and qualitative interviews) were conducted remotely. Once enrolled, participants were asked to complete four web-based surveys per day for 21 consecutive days. Surveys were distributed via SMS messages to participants' smartphones to capture incidental measures of items purportedly underlying readiness-to-exercise (i.e., the same items utilized in Study 1).

Each survey contained the 51 items that were used in Study 1 and an additional block, which was randomly chosen from a bank of five. Four of the five additional blocks contained questions pertaining to hypothetical strength training scenarios – referred to herein as 'Hypotheticals.' These Hypotheticals were used to provide a context that participants could provide forecasted ratings for experiential outcomes based on how they felt physically and mentally at that moment. A complete description of the Hypotheticals can be found in the "EMA" section below. The fifth block contained a simple message thanking the participants for their continued time and effort in completing the study. Inclusion of the fifth block was to reduce daily burden of the participants. Following the 21st day of survey distribution, participants had their unique profile of readiness-to-exercise constructed and, within three days (when possible),

they completed a qualitative interview with the principal investigator. The purpose of the interview was to present participants with their unique profile and explore their perceptions of utility and relevance therein.

Participants

We recruited adults who reported being recreationally trained in resistance exercise to participate in this study. The term ‘recreationally trained’ in resistance exercise was operationally defined as completing at least two sessions of resistance exercise per week for the past 12 months, in line with definitions used in previous studies (Cotter, Garver, Dinyer, Fairman, & Focht, 2017; Focht et al., 2015). Any mode of resistance exercise (i.e., bodyweight, machines, free weights, circuit training, etc.) was permissible and participants needed to own a smartphone with access to the internet and texting capability. Eligibility was determined with the following inclusion criteria: 1) must have been 18 years of age or older, 2) must have completed at least two days per week of muscle-strengthening activity for at least one year, and 3) owned a smartphone with the ability to receive text messages and access the Internet.

Procedures

Recruitment. Participants were recruited several ways. First, a recruitment flyer was digitally circulated through social media platforms such as Facebook and Instagram. Informational PowerPoint slides (consisting of a recruitment flyer) and announcements were made in university classrooms after obtaining permission from the instructors of record. Recruitment did not take place in classes where members of the research team were instructors of record or graduate teaching associates. Interested persons contacted a member of the research

team to schedule the initial meeting via Zoom, which consisted of screening, provision of consent, and familiarization with study procedure and expectations.

Screening and Informed Consent. Participants were screened during the initial Zoom meeting. If participants met the eligibility criteria and were still interested, they were taken through the consent process. Given that participants were not asked to participate in any exercise, there was minimal risk involved in the study. Additionally, all procedures were conducted remotely. Thus, the university's institutional review board granted the use of a waiver of consent. However, participants were still provided with an electronic copy of an informed consent document. This document contained information pertaining to the study duration, study expectations, the risks and benefits to participating in the study, etc. During the initial meeting, the research team member reviewed the document with the participant by sharing their screen and verbally explaining each section.

EMA. Across 21 days, participants were asked to complete four semi-randomly timed surveys per day using their smartphone. A random-time generator was used to determine the distribution for each survey received by participants. First, four time-blocks (5:30am-9:30am, 9:31am-1:30pm, 1:31-5:30pm, and 5:31-9:59pm) were established to create boundaries of survey distribution. For each participant, 21 times were randomly generated within each of the four bounded time blocks using the online time generator. The surveys each contained one identical block of questions asking for “right now” ratings of 51 different physical and mental states that purportedly impact their readiness to perform exercise. Items were rated on a 6-point Likert scale from 1 (‘definitely not’) to 6 (‘extremely’). The variables are described above in the Study 1 procedures, and the full list of items – along the other elements of the survey – are in Appendix

E. In addition to this block of readiness items, participants randomly received questions from one of five possible blocks (referred to herein as *Hypothetical Blocks*).

If participants received Hypothetical Block 1, participants were given a hypothetical strength training scenario based on the American College of Sports Medicine (ACSM) recommendations for adults (i.e., a workout comprised of exercises that target the major muscle groups for two sets of 8-12 repetitions with a moderate intensity). Participants were asked to consider their current physical and mental states and then rate how ready they would be to complete the hypothetical workout using a single item scale from 0-10 (0= not ready at all, 10 = as ready as possible).

If participants received Hypothetical Block 2, participants were asked to consider their current physical and mental states before choosing which body region(s) they would be willing to train (e.g., upper, lower, and/or core) if they were to perform strength training exercise at that moment, as well as how much exertion they would put into the workout. Three options were provided, and participants were able to select all body regions that applied. A follow-up question asked participants to identify how challenging they would make the hypothetical workout they constructed. Borg's Category-Ratio 10 (CR-10) scale was used for this assessment of exertion (Borg, 1998). The CR-10 ranges from 0-10 with accompanying descriptors of exertion levels associated with numerical ratings (i.e., 0 = rest, 4 = somewhat hard, 7 = very hard, 10 = maximal). A CR-10 Scale is located in Appendix E.

If participants received Hypothetical Block 3, participants were presented with the same hypothetical workout from the ACSM described above in Hypothetical Block 1, and then provided ratings for how much physical and mental effort they would be willing to invest in the workout, as well as how confident they were that they could complete the hypothetical session.

A 6-point scale was used to assess all three variables, ranging from 0 (“no physical/mental effort,” or “not confident at all”) to 6 (“maximum possible physical/mental effort” or “extremely confident”).

If participants received Hypothetical Block 4, participants were presented with the hypothetical ACSM workout and asked to rate anticipated in-task affect (i.e., how pleasant or unpleasant they would feel) during said hypothetical workout. Participants were provided with an electronic version of the Feeling Scale (Hardy & Rejeski, 1989) for this assessment of anticipated in-task affect. The Feeling Scale is an 11-point, bipolar scale used to assess the valence dimension of affect. Scores range from -5 (Very Bad) to 5 (Very Good), with the midpoint of 0, corresponding to neutral valence. A Feeling Scale is located in Appendix E.

Finally, if participants received Hypothetical Block 5, participants were thanked for their time and effort in the study. The purpose of this final block was to provide a “low burden” option for surveys, given that during the study participants were sent a total of 84 surveys across a 21-day timeframe.

Statistical Analyses

Descriptive statistics were calculated for participant demographics and anthropometric data. Multivariate data from the 51 daily items were used to create a person-specific of readiness-to-exercise (i.e., a person-specific model generated through factor analysis). Through factor analysis, the 51 items were clustered into factors (i.e., reduced in number to create a more latent set of variables. Each factor explained a given percentage of the variance in the participant’s dataset.

P-Technique. Each participant's EMA data were isolated, using SPSS, to describe item characteristics (i.e., mean, standard deviation, range) and the procedures described above for the R-technique analysis were repeated, such that we (1) conducted preliminary factor analyses (principle axis method with promax rotation; factors retained based on eigenvalues ≥ 1.0) to determine the adequacy of our initial sampling based on Kaiser-Meyer-Olkin and Bartlett's test values, (2) conducted parallel analyses to statistically determine the number of factors to retain; and (3) conducted final factor analyses with the number of factors based on each individuals' parallel analysis. The use of parallel analysis has been previously determined to be an acceptable approach for P-technique factor analysis, as serial dependency of data does not negatively impact performance of the test (Lo 2016).

After a person-specific profile of readiness-to-exercise was generated with P-technique factor analysis, an individual's Factor 1 scores were determined for every survey completed. To calculate Factor 1 scores, the items that sufficiently loaded onto Factor 1 were isolated. The scores for every Factor 1 item were then summed at each time point (i.e., every survey that was recorded). In the event that an item negatively loaded onto a factor, the raw score for that item was converted to a negative number (i.e., the number was essentially subtracted from the sum of all item ratings) (DiStefano, Zhu, & Mindrila, 2009). The Factor 1 scores were then used to address Specific Aim 3, such that visual illustrations were created of the relationship between Factor 1 scores and anticipated experiential outcomes to a hypothetical bout of strength training exercise.

Qualitative Analyses

Qualitative Interview. After participants complete 21 days of survey completion, a Zoom meeting was held to conduct the qualitative interview. The purpose of the interview was to address Specific Aim 2: exploring the perceived utility of their person-specific profile of readiness-to-exercise. Prior to any interviews with participants, an interview guide was constructed and piloted via collaboration among the research team. The interview guide can be found in Appendix F. Before the interview officially began (i.e., before recording began), participants chose a pseudonym to protect their anonymity. Participants were asked about their strength training background, preferred mode of strength training, identified items from the survey that they believed were most important to their exercise experience and decision making, and presented with their person-specific profile, with an emphasis on the first factor of their profiles. During the one-on-one interview, each participant was presented with their person-specific profile of readiness-to-exercise. Prior to being presented with the profile, participants chose any of the survey items that they identified as being important to their exercise decision making (i.e., whether they engaged in exercise, modifications to their exercise session, etc.). The self-selected items were then presented side-by-side with the items that loaded onto their first factor from the factor analysis to explore their perceptions of differences, similarities, and relevance to garner context to their selections. The semi-structured interview also included open-ended questions pertaining to multiple topics such as possible factors impacting their experience that were *not* captured in the construction of their person-specific profile, their perceptions of relevance pertaining to their person-specific profile, and how best to approach autoregulating exercise sessions given their experience with self-monitoring readiness-to-exercise during the 21 days of survey completion. The interviews recorded via Zoom.

Audio recording of the interviews were used to create transcripts. Transcripts were sent to respective participants for member-checking (i.e., to confirm accuracy). The transcripts were assessed by the research team using basic content analysis guided by Castleberry and Nolen (2018). First, the principal investigator conducted multiple readings of every transcript in order to become immersed and familiar with participant responses. This familiarization process allows for an enhanced understanding of the data when viewing the responses as a whole, rather than individual phrasing (V. Braun & Clarke, 2006). The next step involved deconstructing the responses into smaller pieces in a process commonly referred to as *coding*. This process allowed for the conversion of raw data into a more usable format by identifying themes, concepts, or ideas that relate to one another (Austin & Sutton, 2014). Because the transcripts were transferred into an electronic spreadsheet, coding was made easier, such that codes for responses were entered into cells that are adjacent to participant answers. Once coding had been completed, they were used to *reassemble* the data by transforming codes into themes. Themes are essentially the common denominator shared between several codes that are related to the same concept or idea. The principal investigator then defined each theme that emerged from the data and created a thematic coding guide. Next, the thematic guide, complete with theme definitions, was distributed to members of the research team – along with uncoded transcripts of the interviews – for independent analyses following the same step-by-step process. Once all members of the research team completed the content analysis, results were compared until a consensus was reached pertaining to themes contained in participant responses.

Chapter IV: Results

Results – Study 1

Demographic Characteristics

Respondents ($N = 326$) were, on average (mean $\pm$ standard deviation), adults (29 ± 11.6 years of age, 48.8% women) who reported regularly performing strength training (4 ± 1 days per week) for over one year. Based on respondents' average self-reported height (172.9 ± 10.4 cm) and weight (75.9 ± 15.5 kg) the mean body mass index (BMI) of the sample was 25.4 kg/m^2 . The racial composition of the current sample was 89.3% non-Hispanic White/Caucasian, 3.7% Asian, and 2.1% Black or African American.

Data Suitability for Factor Analysis and Number of Factors to Retain

Data from the one-time survey were deemed suitable for performing factor analysis, as KMO = 0.89 and Bartlett's test of sphericity was statistically significant [chi square = 7891.558, (df = 1257), $p < .001$]. The parallel analysis indicated that ten factors be retained in the final model.

Variability in Item Scores

In the current sample, variability was revealed when assessing pre-exercise ratings of the 51 items purportedly impacting readiness-to-exercise. Participants used the entire range of ratings for every item – the minimum score provided for every item was 1 and the maximum score for every item was 6, except for 'Uncomfortable' which had a maximum score of 5. Across all respondents, the minimum average score for an item was 1.5 ['Uncomfortable Full (from Eating)] and the maximum average score for an item was 4.6 ('Good').

R-Technique Factor Analysis

Ten factors explained 54.3% of the total variance in the data set, with the first three explaining most of the 54.3% (26.2%, 7.3%, and 5.0%, respectively). Through the interpretation of item composition and loading, the first three factors were deemed representative of *Activation*, *Tension*, and *Calmness*. The remaining seven factors each explained, on average $2.12\% \pm 0.69\%$ of the variance (min = 1.37%, max = 3.11%) and were representative of the following: *Vitality*, *Hunger*, *Hydration*, *Sickness*, *Positive Mood*, *Mobility*, and *Overfed*. Items in all ten factors demonstrated sufficient loading magnitudes (0.408 – 0.991). A pattern matrix containing all the items with their loading scores on each retained factor can be found in Appendix F. A communality plot (Figure 1) was constructed using the initial communality value of each item on its related factor to demonstrate the ‘signature’ of the reference structure for subsequent comparison with interpersonal signatures in Study 2 and can be found in Appendix F. A communality represents an estimation of variance in each item that is accounted for by all components. The closer a communality score is to 1.0, the better the item is explained by the factor. Finally, a correlation matrix is displayed in Figure 2 (Appendix F), which indicates the correlation between each factor retained in the analysis.

Results – Study 2

Demographic Characteristics

Thirteen participants (32 ± 7 y, 171 ± 3 cm, 74 ± 5 kg, 54% women) completed screening, informed consent, and were enrolled into the study. Two participants did not complete the requisite 50 surveys to participate in the qualitative interview, completing 48 and 47 surveys, respectively. Their demographic data were retained, and none of their survey data were used in

further analyses. Thus, reporting of results below pertains to the eleven interview-eligible participants (32 ± 8 y, 169 ± 11 cm, 72 ± 19 kg, 7 women, 9 ± 6 years with muscle-strengthening experience). The eleven eligible participants completed 73 ± 9 surveys out of 84 possible surveys (min=52, max=84). A complete view of individualized participant demographics (i.e., age, height, exercise behavior, etc.) can be found in Table 2, located in Appendix F.

Ecological Momentary Assessment: Descriptives and Temporal Variance

Within-person variance pertaining to item ratings over time was assessed to determine temporal variability in readiness-related items. Participants responded to daily surveys using most of the 1-6 range. For the entire sample, the average minimum score was 1.62 ± 0.51 and the average maximum score was 4.96 ± 0.50 , indicating variance in item ratings across the data collection period. However, a variance in the degree of discrimination between items was observed across individuals. *VP*, for instance, demonstrated the smallest difference between their highest and lowest mean item score (“tired” = 3.84 and “flexible” = 2.91, respectively), suggesting more consistency in their ratings across items. On the other hand, *Nancy Drew* showed the greatest difference between their highest mean item score (“strong” = 5.41) and lowest mean item score (“uncomfortably full [from eating]” = 1.06), reflecting comparatively more variability in perceptual ratings over time.

P-Technique Factor Analyses

Sampling was determined to be adequate for all 11 factor analyses based on values pertaining to KMO (0.662 ± 0.093 , min=0.508, max=0.792) and Bartlett’s chi square (3238.436 ± 486.204 , min=3210.123, max=3859.812, all p ’s<0.001). On average, person-specific profiles of readiness-

to-exercise contained 12 factors (minimum: 9, maximum:16) based on separate parallel analyses for each participant. In Study 2, the average number of items that loaded onto participants' first factor score was 14 (min = 8, max =16). One participant (Gabby) had 35 items loading onto their first factor score; with this value removed, the average number of items loading onto factor one was 12. Across all eleven participants, the first factor explained 30.36% (min =18.1%, max = 45.3%) of the variance in the individual datasets.

Heterogeneity Between Person-Specific Profiles and Reference Structure

Person-specific profiles of readiness-to-exercise revealed heterogeneity when compared to the reference structure from Study 1. Not only were the number of factors different, as described above, but the composition of items that comprised Factor 1 scores in person-specific profiles were different than the reference structure. Items loading onto Factor 1 in the reference structure include *tired, sleepy, wide awake, drained, drowsy, well-rested, groggy, exhausted, alert, and vigorous*. While some participants person-specific profiles show similar items loading onto Factor 1 (i.e., *Sullivan Strange, June, and Oliver*), others revealed differences (i.e., *Nancy Drew, Dawson, Lizzy, Gabby, Toby, Jean, Doom, and VP*). Figures 3 through 13 contain the communality plots for each participant.

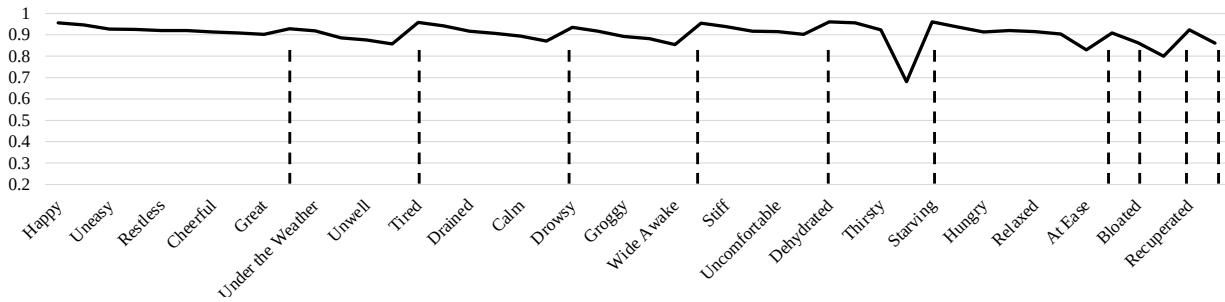


Figure 3. Communality plot for Nancy Drew's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

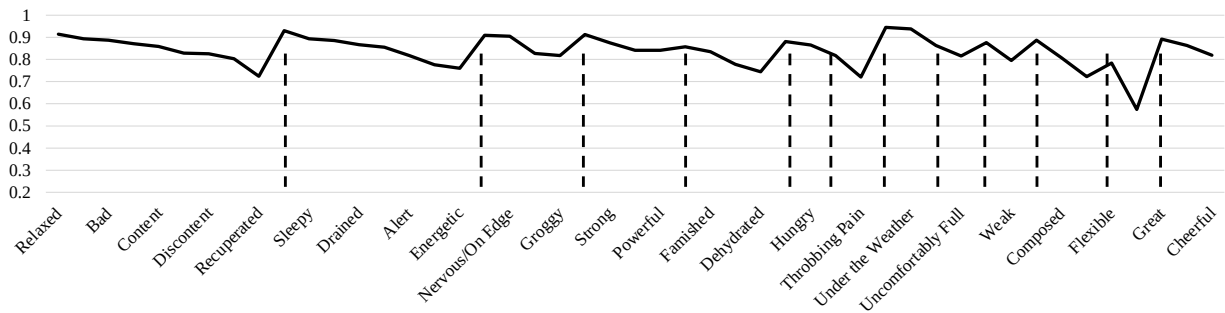


Figure 4. Communality plot for Dawson's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

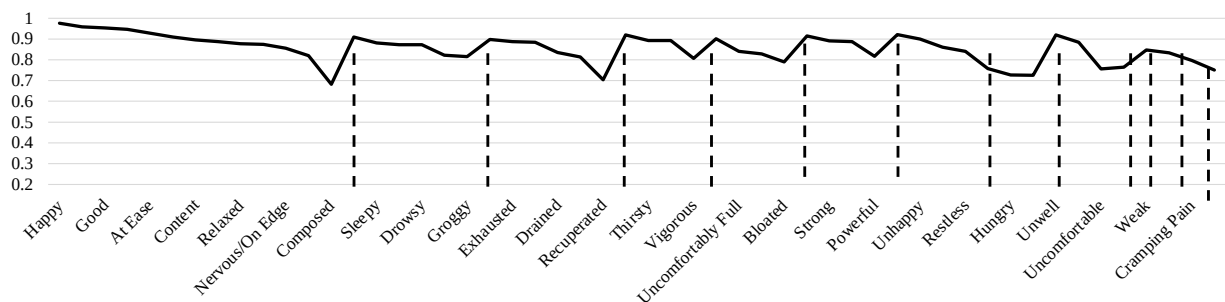


Figure 5. Communality plot for Lizzy's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

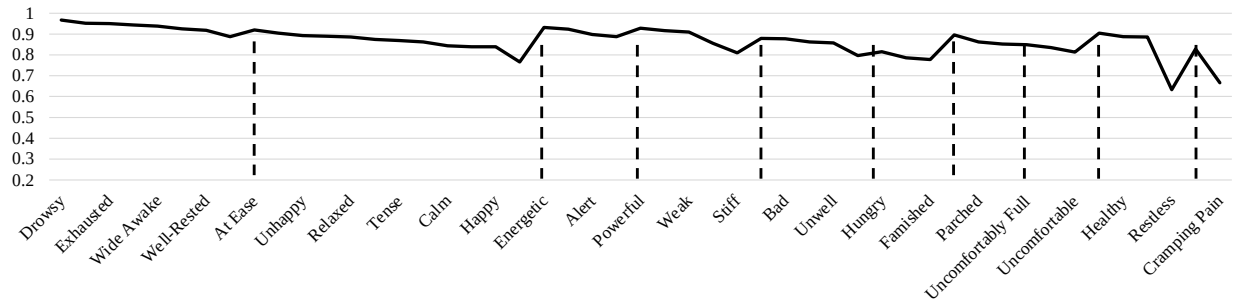


Figure 6. Community plot for Sullivan Strange’s person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

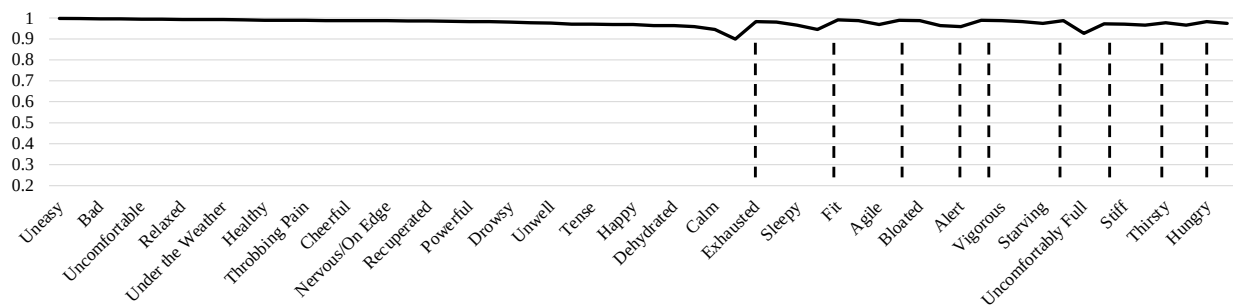


Figure 7. Community plot for Gabby’s person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

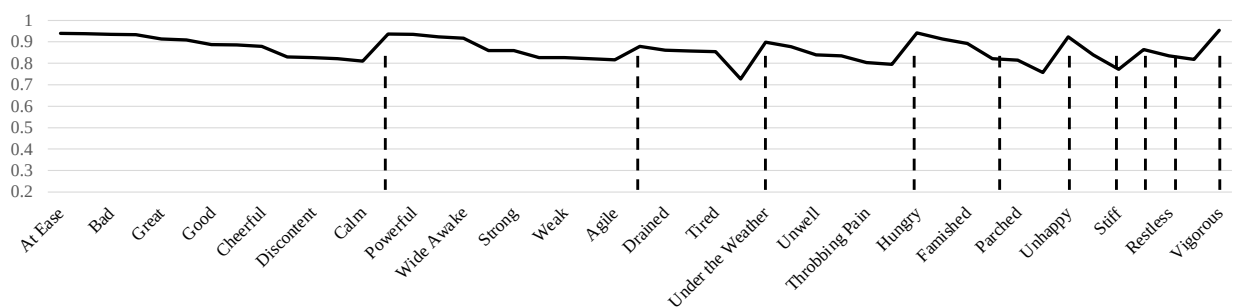


Figure 8. Community plot for Toby’s person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

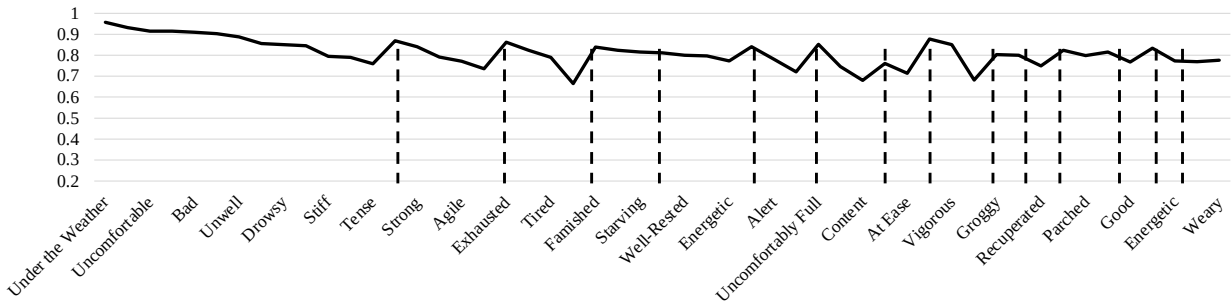


Figure 9. Communalities plot for Jean's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

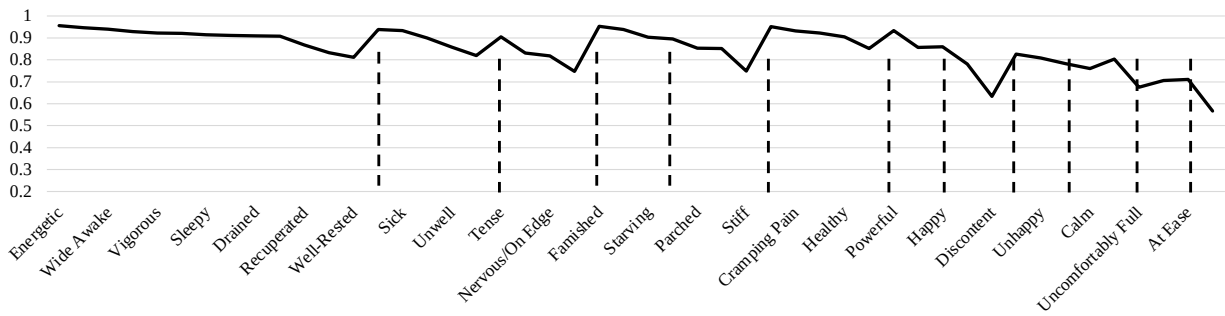


Figure 10. Communalities plot for June's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

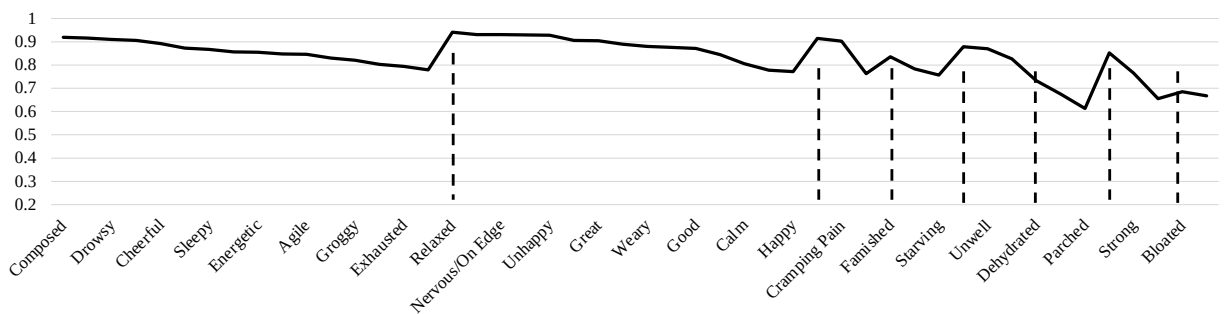


Figure 11. Communalities plot for Doom's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

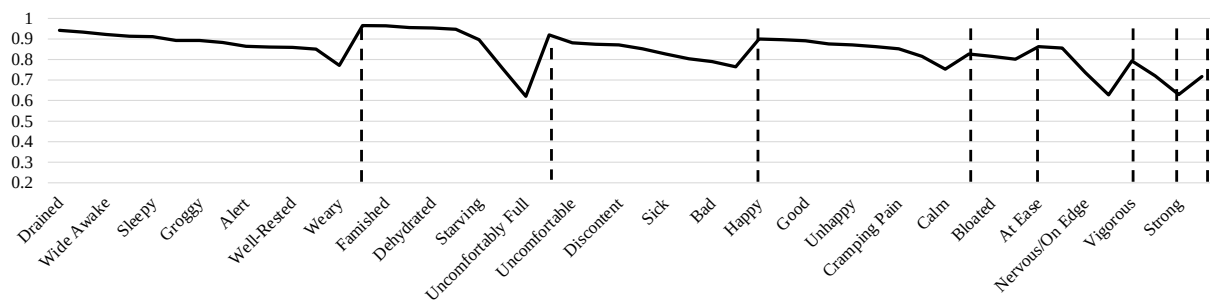


Figure 12. Communalities plot for Oliver's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

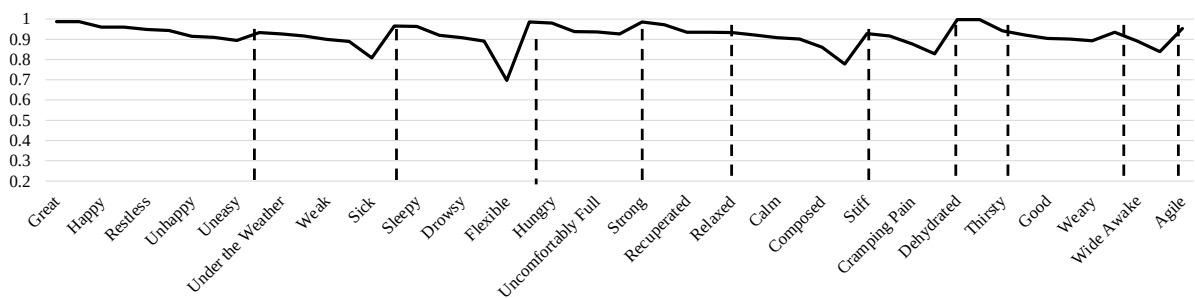


Figure 13. Communalities plot for VP's person-specific profile. Dashed, vertical lines indicate the beginning of a new factor.

First Factor Scores and Forecasted Experiential Outcomes

Scatter plots were generated to visually map the relationship between participants' first factor scores with forecasted experiential outcomes (i.e., affective response) or with perceived readiness-to-exercise. Exploratory graphical representation of these associations showed a mixed relationship between such variables, precluding further statistical analyses. Scatter plots make up panels B and C in each participants' visual profile (Figures 14-24).

Data Presentation

In order to demonstrate idiographic outcomes, figures 14 through 24 contain 3-panel figures that show: 1) temporal variance in Factor 1 (F1) scores, 2) the relationship between F1 scores and forecasted in-task affective response to muscle-strengthening exercise, and 3) the relationship between F1 scores and in-the-moment ratings of perceived readiness provided by each of the eleven participants. For eight participants (*Nancy Drew, Dawson, Lizzy, Toby, Jean, Doom, Oliver, and VP*), a higher Factor 1 score was indicative of a more favorable state, whereas for three participants (*Sullivan Strange, Gabby, and June*), a higher Factor 1 score was indicative of a more unfavorable state based on individualized item loading patterns.

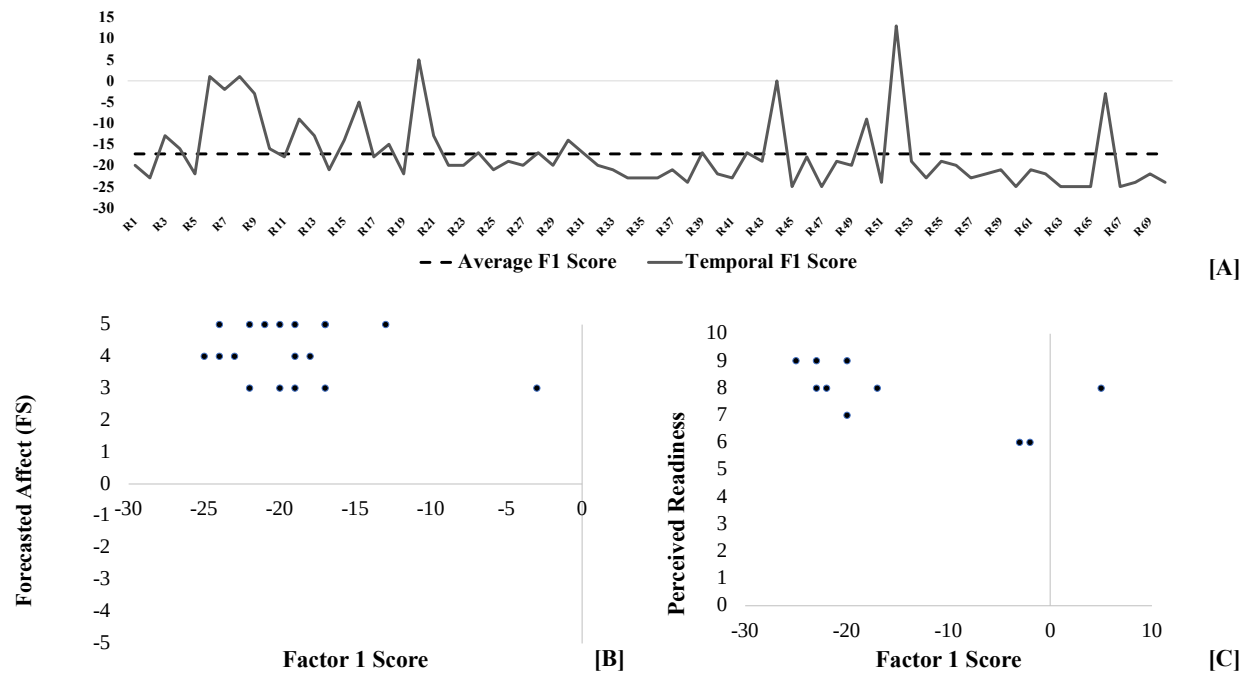


Figure 14. Nancy Drew’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

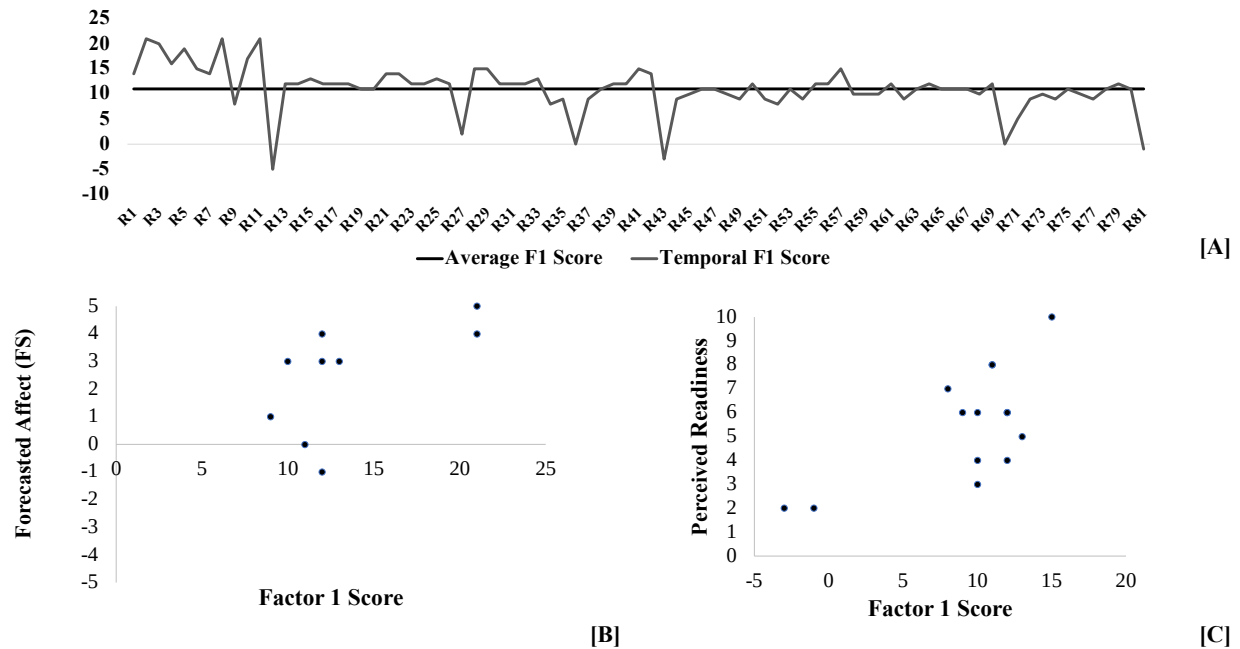


Figure 15. Dawson’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

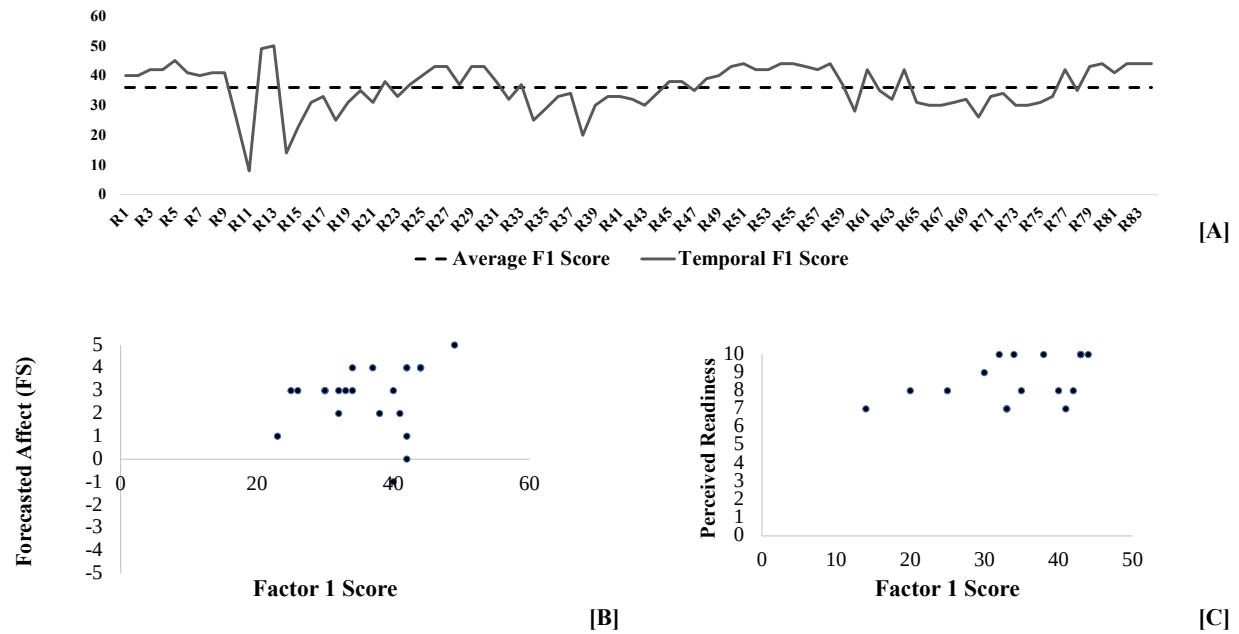


Figure 16. Lizzy’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

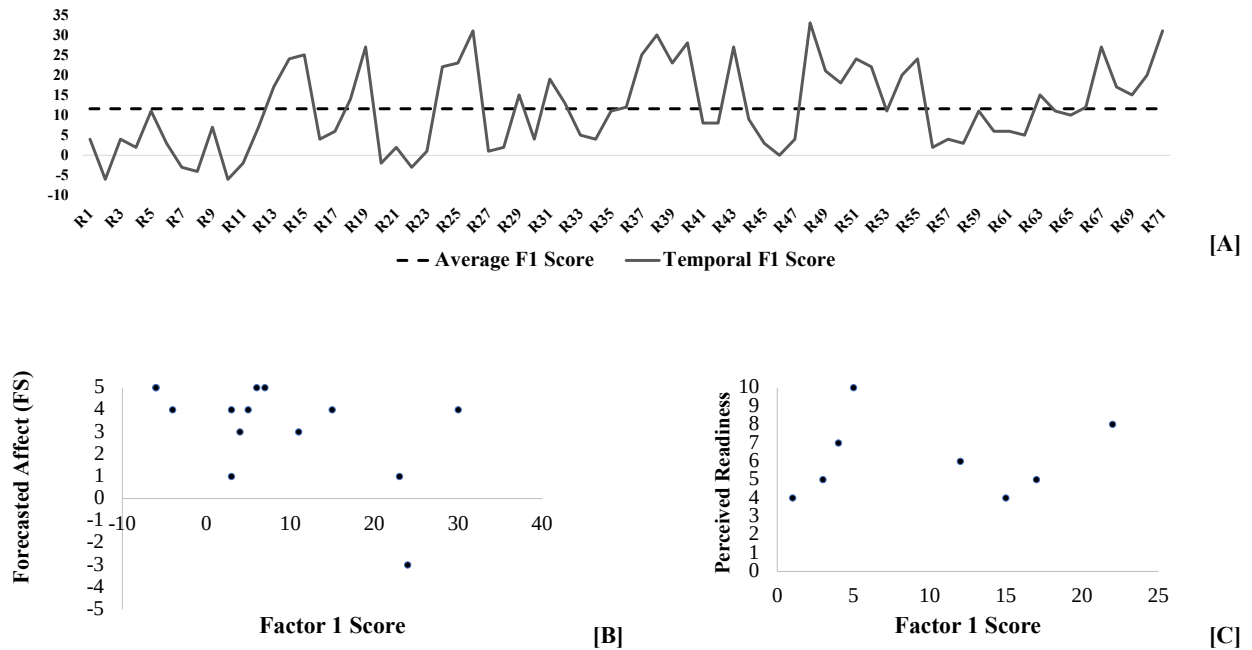


Figure 17. Sullivan’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more unfavorable readiness state based on P-technique factor composition and loading.

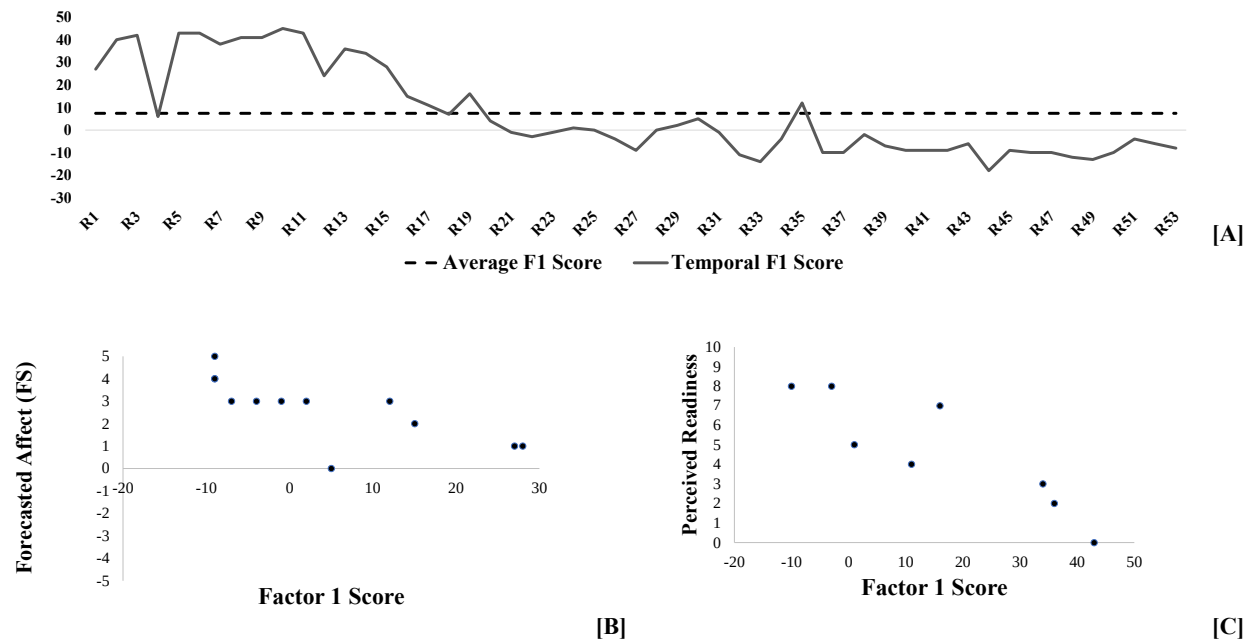


Figure 18. Gabby’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more unfavorable readiness state based on P-technique factor composition and loading.

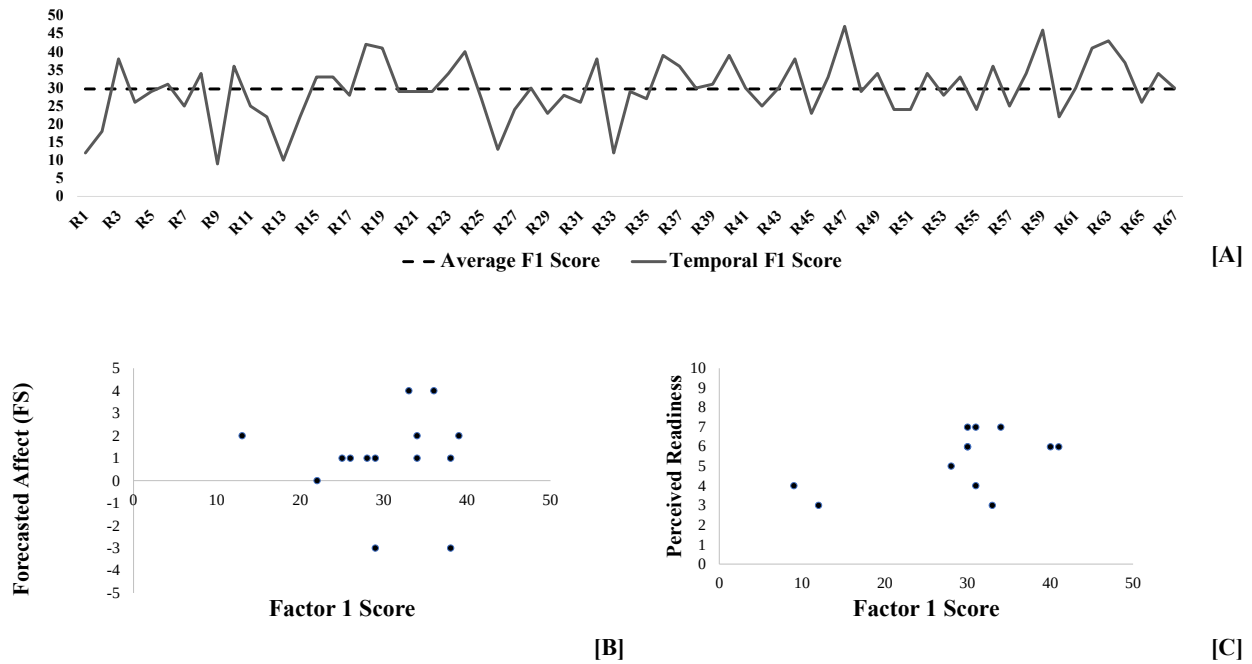


Figure 19. Toby’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

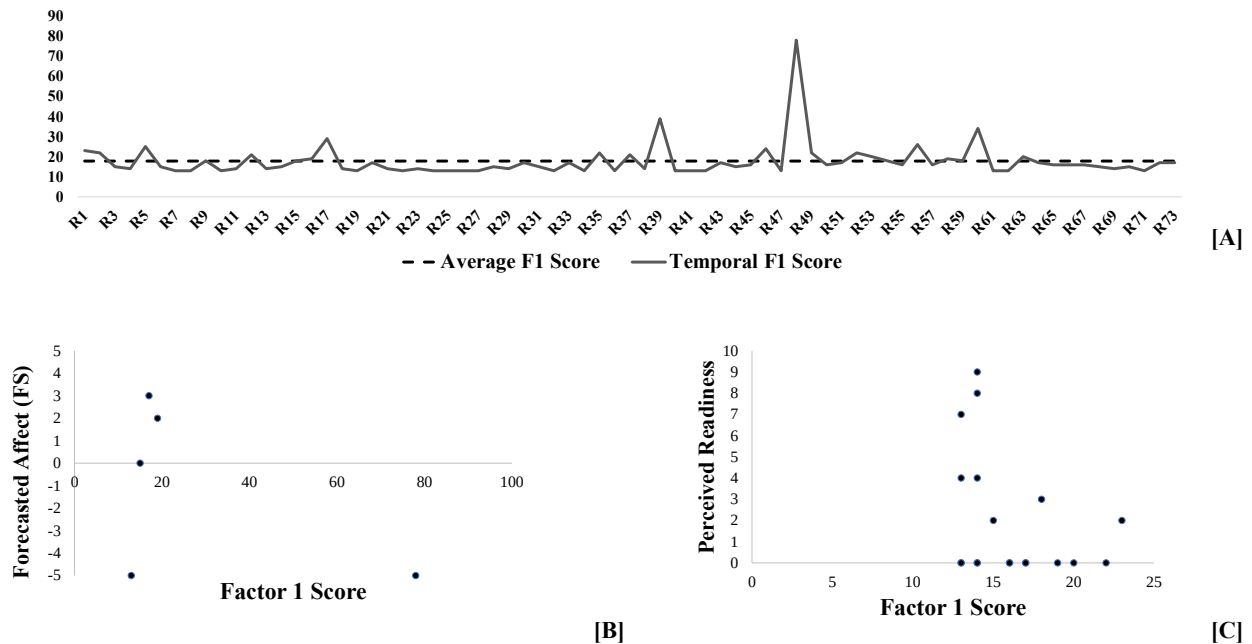


Figure 20. Jean’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

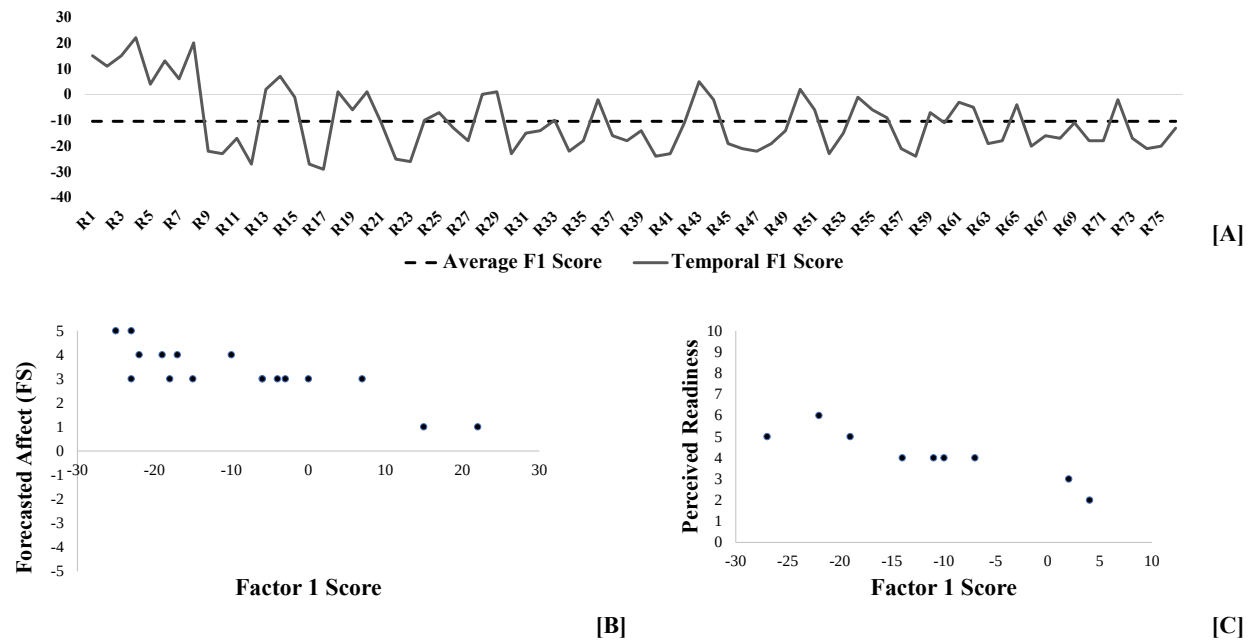


Figure 21. June’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

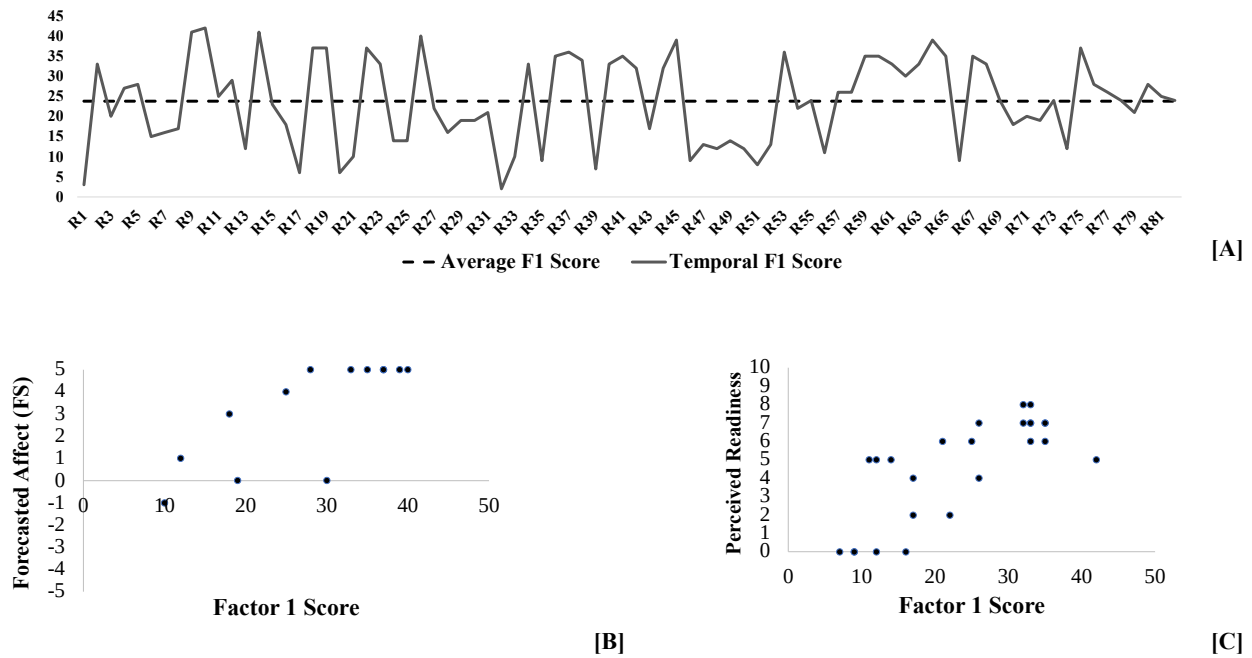


Figure 22. Doom’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

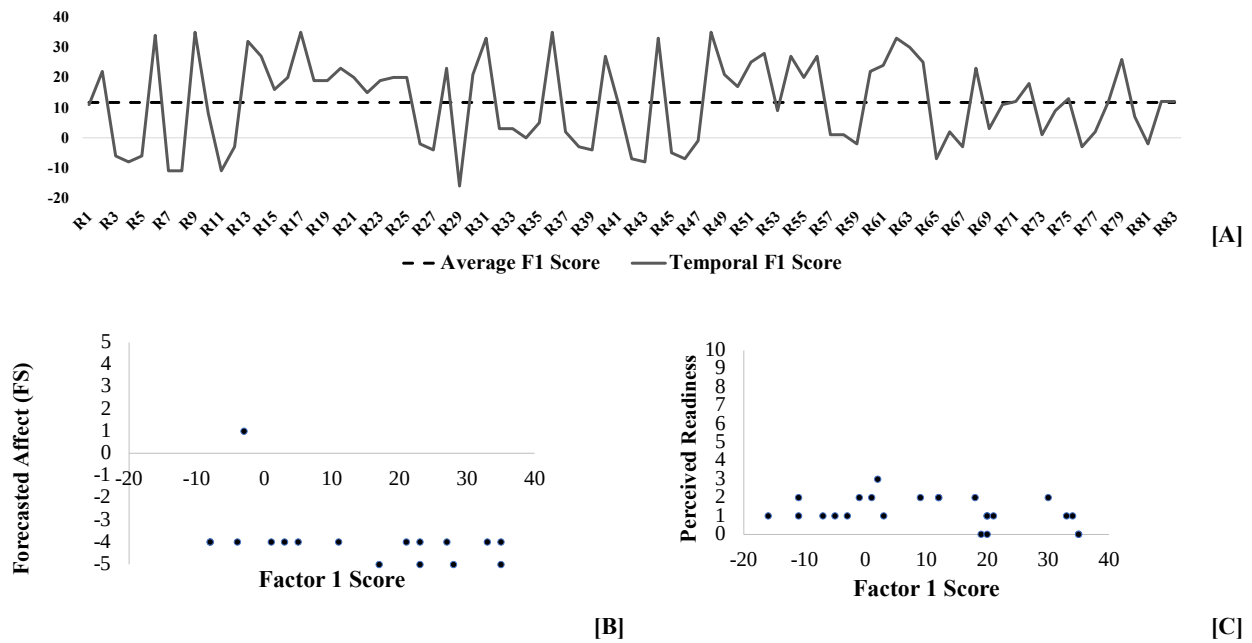


Figure 23. Oliver’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

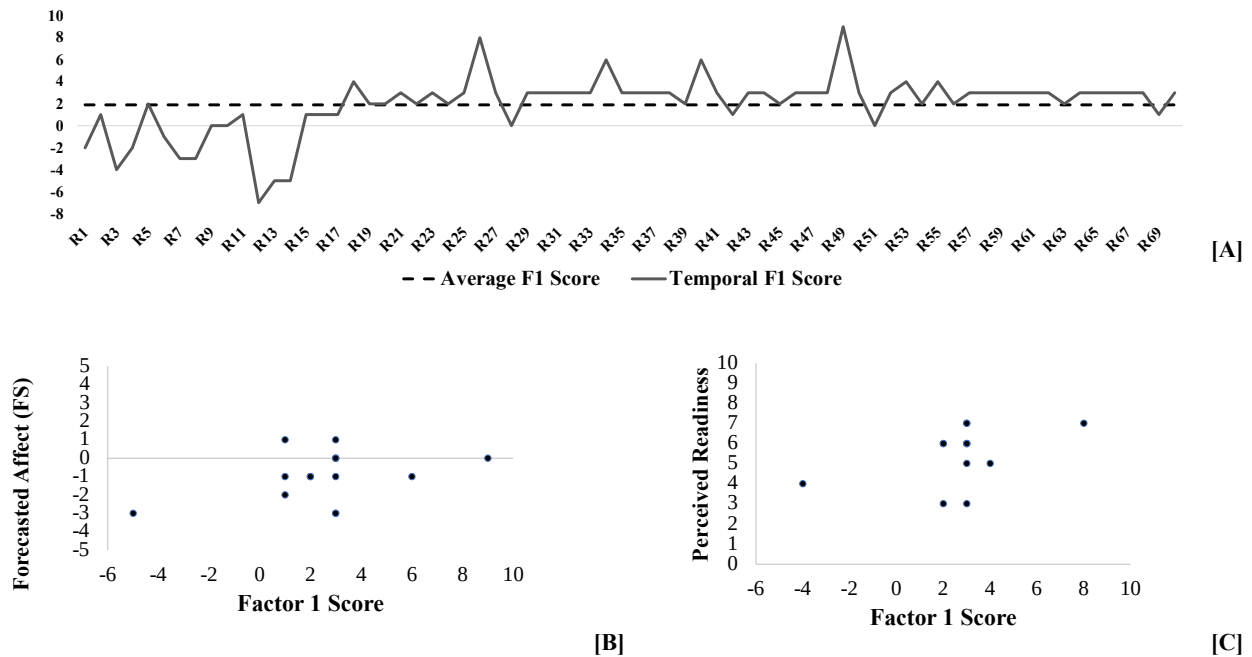


Figure 24. VP’s temporal variance of Factor 1 (F1) scores [Panel A], the relationship between F1 scores and forecasted in-task affect to a bout of muscle-strengthening exercise [Panel B], and relationship between F1 scores and perceived readiness [Panel C]. (Note: “R” in Panel A represents Response). In this individual, a higher F1 score indicates a more favorable readiness state based on P-technique factor composition and loading.

Qualitative Analyses

Three major themes emerged regarding the participants' perceptions of their person-specific profiles of readiness-to-exercise: 'Accuracy,' 'Facilitators of Skepticism,' and 'Resilience Overruling Readiness.'

Theme 1: Accuracy. The first theme to emerge related to the participants' acknowledgment of their first factor's relevance to their exercise experience and/or decision-making process. The accuracy of participants' person-specific profile is explained by the two subthemes below.

Strong Relevance. The first subtheme discussed within Theme 1 was related to the participants' indication that their profile accurately reflecting their readiness-to-exercise. The degree of perceived relevancy appeared to exist on a spectrum. For instance, *Gabby* mentions their profile was "kind of accurate," Other participants expressed a stronger degree of recognition. For example, *Toby* reported that their profile did "align pretty closely with how I feel." *Lizzy* had a similar reaction when presented with their profile, stating that it was a "general description of my personality." *June* spoke in more concrete terms, indicating that their profile was "definitely appropriate."

Reservations Regarding Accuracy. The second subtheme discussed within Theme 1 was related to reservations regarding relevance of Factor 1 items. Participants expressed a degree of uncertainty regarding the mathematically determined items impacting readiness-to-exercise but expressed an understanding of their inclusion in their person-specific profile. When presented with the items comprising their first factor scores, *Sullivan Strange* remarked that they "weren't that important," but admitted they "may impact me more than I thought," revealing an interesting

paradox in the profile's reception. *VP* echoed a similar paradox, indicating they “don’t think they (the items in factor 1) pop out,” because “rational me would pick most of the variables that make more sense physiologically” compared to a predominantly mood-centered first factor list of items (i.e., happy, discontent, uneasy, cheerful, great). However, *VP* did recognize that “looking at the whole picture, I could basically expect that,” because in their opinion, “readiness, it’s mostly subjective.”

Theme 2: Facilitators of Skepticism. The second theme to emerge related to personally identified caveats for why the person-specific profile may not have been perceived as relevant to the participant. Theme 2 was comprised of two subthemes: Atypical Circumstances and Interaction Between Perceptions and Data Feedback.

Atypical Circumstances. Fluctuations in personal circumstances and the contextual factors when participants completed the daily surveys compared to the context of the interview comprised one subtheme of Theme 2. *Oliver* mentions unusual circumstances very clearly when presented with their first factor items, stating it had “not been a typical three weeks” because they “spent a week of it in the hospital, heavily medicated.” By their estimation, then, “I see groggy and exhausted, it doesn’t surprise me” despite they “don’t think that’s normal per se.” *Sullivan Strange* also admits that they were “really tired a lot,” which was congruent with their first factor items, but that they “went through a wild phase,” without getting much rest. The context in which participants completed the surveys also influenced their perceptions of the resultant person-specific profiles, especially when compared to the items they had selected as being important prior to being presented with their profiles. *Doom* admits that items in their first factor is a “good list, but I still feel like my list is better,” in part because “you (the principal

investigator) talking to me is so different than me just punching a survey too.” *Nancy Drew* shared a similar sentiment, explaining some discrepancy between their person-specific items and self-selected items may be the difference between completing “four surveys a day vs. on the spot (in the interview),” and that when selecting items, they would “naturally pick both sides” (i.e., physical and mental aspects). *Lizzy* mentions the context of survey completion as well, because as a first-grade teacher, they “completed a lot of these during the day at school,” where they were “more likely to be tense, more likely to be on edge” even though “part of my job is to be cheerful and happy and calm.”

Interaction Between Perceptions and Data Feedback. The second subtheme to be discussed within Theme 2 pertains to the potential interaction between personal perceptions of readiness and mathematically or physiological indices of readiness-to-exercise. In some instances, participants mentioned a scenario where numerical feedback regarding readiness-to-exercise may bias their decisions or experiences. *Toby* mentioned that feedback from their Whoop™ influenced their decision to engage in exercise at all, recalling times that they “talked myself out of going to the gym because it says I’m not ready.” *June* reported a similar experience with the Whoop™ feedback, such that “just wearing this Whoop, when I look and see my recovery was only like 30%, then I’m probably gonna feel like crap.” *VP* expands on this potential for experiential bias, suggesting that even if one exercises despite negative feedback from the wearables: “(if) that machine says I’m feeling like [expletive], like I am going to feel like [expletive]. I don’t want to know that.” With regards to the interaction between personal perceptions and data feedback, there are scenarios where participants report an incongruence between physiological feedback and subjective experience. *Toby* recalled that their Whoop

device “says I’m 20% recovered and I feel great... Sometimes it’ll say I’m like 90 (percent recovered) and I feel like I’ve been hit by a truck.”

Theme 3: Resilience Overruling Readiness. The third and final theme to be discussed is the importance of resilience when participants do not necessarily feel ready to engage in exercise. Participants mentioned the importance of mentality with respect to overcoming unfavorable states. *Dawson* commented that there is utility in “taking into account how your body is feeling” but that there’s benefit in “overcoming the mental side of things,” suggesting “you got to suck it up,” because of the “value in not wanting to do this (exercise), but I have to if I want to get stronger.” *Jean* mentions the importance of mentality in a slightly different context, stating that they prefer to “know what I’m walking into, I can tend to get my mindset right.” In a unique articulation, *VP* acknowledges the importance of mentality, commenting that “emotional stuff kind of effects behavior responses, and behavior responses are the ones that affect recovery both physically and psychologically,” but that they “wouldn’t want to put too much kind of weight on their emotional or subjective feelings.” *VP* expands on this interesting paradox: “maybe the objective stuff would be better used in autoregulation in the sense that feelings don’t correlate too much with actual fatigue when measured in the lab.”

Chapter V: Discussion

The primary purpose of this research was to compare person-specific profiles of readiness-to-exercise, as it pertains to muscle-strengthening exercise, with a reference structure. An additional purpose of the study was to explore the participants' perceptions regarding relevance and informational utility of their person-specific first factor score, as well as exploring the associations between the first factor scores of their profiles and forecasted experiential outcomes in response to a hypothetical exercise bout. To our knowledge, this is the first study to create a reference structure of readiness-to-exercise using integral (i.e., pre-exercise) data. It is also the first study to explore individuals' perceptions to their own mathematically generated person-specific profiles of readiness-to-exercise. Results from nomothetic and idiographic comparisons reveal a degree of heterogeneity. Overall, themes that emerged from participants' interviews indicate recognition that person-specific first factor items have a degree of relevancy, but that participants have unique ideas regarding their own perceptions of readiness-to-exercise.

Interpersonal signatures via P-technique depart from R-technique reference structure

Results from comparisons between the reference structure of readiness-to-exercise from Study 1 with the person-specific profiles from Study 2 reflect findings from Strohacker et al. (2021), who also found noteworthy differences between a reference structure derived from R-technique factor analysis and person-specific profiles derived from P-technique factor analyses. In the current study, the reference structure was comprised of 10 factors that collectively explained 54.3% of the variance. By contrast, person-specific profiles were comprised, on average, by 12 factors that collectively explained 70.3% of the variance in each participant's dataset. Additionally, first factor scores varied in terms of item composition, similarly suggesting that, mathematically speaking, different constructs hold a different degree of importance

depending on the person. Recognizing that person-specific profiles of readiness-to-exercise vary across individuals is important given prior researchers choosing indices of readiness and applying them uniformly to their entire sample (Colquhoun et al., 2017; McNamara & Stearne, 2010, 2013). Based on the current results, it may be inappropriate to broadly assign importance to constructs that purportedly represent readiness-to-exercise. Our findings, while relating specifically to exercise behavior, align with prior research suggesting that psychometric profiles of borderline personality disorder (derived from P-technique factor analyses) differ when assessing within-person data compared to a standardized reference structure (Wright et al., 2016). This emerging body of literature, which highlights the utility of P-technique factor analysis, adds support to a growing recognition that nomothetic methods and reporting often obscures idiographic responses (Unick et al., 2015; Van Landuyt, Ekkekakis, Hall, & Petruzzello, 2000), which limits the practical impact and application of the research.

In light of these findings, we must also consider a key speculation put forth by Borkenau and Ostendorf (1998) in that differences that arise from P-technique analyses may be explained as an artifact of simply having fewer measurement points to analyze compared to the reference structure. That is, despite *mathematical simulations* predicting differences between within-person and between-person factor structures, it remains unclear whether different structural features regarding readiness-to-exercise would emerge if both P-technique and R-technique analyses were conducted with more than 300 data points. However, the same authors rightfully acknowledge the logistical difficulty in obtaining sufficient time-series data for such robust comparisons. For example, obtaining equal measurement points in Study 2, as compared to Study 1, would require each participant to complete at least 300 surveys. More specifically, to compare integral (i.e., pre-exercise) data in both instances for the most conservative

comparisons, participants would be required to complete one survey per exercise bout (unlikely to exceed more than 1 bout per day). Thus, if we asked participants to perform exercise 5x per week and they were 100% compliant, the study duration would be 60 weeks (i.e., over 1 year). If muscle-strengthening frequency were to be reduced to at least 2x per week – in line with current recommendations – the study duration would increase to almost 3 years. The logistical concerns are apparent, especially when we consider that 13 participants were originally enrolled in Study 2, and 15% were not compliant with the requisite ≥ 50 surveys to conduct the one-on-one survey. It is simply not realistic to expect more compliance with a greater burden. Thus, we argue that it is more efficient to subject within-person profiles, ascertained by lower-burden approaches, to more robust experimental testing to determine their potential utility as indices of a subsequent or anticipated exercise experience.

Visually speaking, we observed a degree of temporal variance in factor 1 scores (i.e., the factor explaining the most variance in an individual's dataset) over the 21-day study. While we could not statistically summarize the consistency in factor 1 scores, due to the heterogeneity in compliance in a relatively small sample size, prior research (Strohacker et al., 2021) similarly demonstrated that intraclass correlation coefficients of factor 1 scores, composed from items underlying readiness-to-exercise were moderate, at best. Together, these findings support the notion that important physical and psychological states fluctuate over even relatively short periods of time (i.e., 2-3 weeks), in line with Kramer and Fleck's (2007) rationale for developing FNLP. Thus, the demonstration of variance over time represents a key foundational attribute of an index of readiness-to-exercise. Such temporal variance in factor 1 scores also bolsters evidence from prior research that emphasizes the dynamic nature of mental, physical, and perceptual states (Dunton, 2017; Dunton & Atienza, 2009). While these authors did not

necessarily relate physical and mental states with readiness to exercise, they did explicitly indicate a role for such factors as both antecedents and consequences to physical activity-related behavior. Fluctuations in first factor scores observed across these research studies support the recent calls from experts to account for and adapt to such changes in personal circumstance when implementing behavior change interventions, particularly for physical activity (Chevance et al., 2021; Conroy et al., 2020; Nahum-Shani et al., 2018).

Relationships between first factor scores and hypothetical forecasted outcomes.

Broadly speaking, most participants' data did not demonstrate clear patterns between first factor scores and experiential outcomes. However, data from select participants (Dawson, Gabby, and June) demonstrated a relationship between factor 1 scores and forecasted in-task affect, such that more favorable F1 scores were accompanied by more pleasant forecasted in-task affect (i.e., higher Feeling Scale scores). A similar number of participants' data (Dawson, Gabby, Toby, June, and Doom) showed a comparable relationship between factor 1 scores and perceived readiness – greater factor 1 scores were accompanied by a greater perceived state of readiness. Interestingly, several of these individuals (Gabby, Toby, and June) represented the small number of individuals who, within their qualitative interview, ascribed high relevance to their factor 1 score.

The lack of strong relationships between factor 1 scores and experiential outcomes consistently across participants may be due to the context in which surveys were completed. Despite survey prompts instructing participants to consider hypothetical exercise scenarios, multiple participants mentioned where they were or what they were doing at the time of survey completion during the interview exploring perceptions of their person-specific profiles. Such

salient experiences may be difficult to disregard for the sake of the hypothetical scenarios. Further, assuming individuals did provide ratings as though they might perform exercise, results may be artificially exacerbated based on prior findings that anticipated exercise experiences are often rated more negatively than actual exercise experiences (Loehr & Baldwin, 2014; Ruby, Dunn, Perrino, Gillis, & Viel, 2011). Thus, it is critical for future research to assess relationships between mathematically derived factor 1 scores and actual experiential outcomes to performed exercise.

Continued refinement in conceptualizing readiness and subsequent exploration of the association between readiness-to-exercise and experiential outcomes are important because of the implication for behavioral consistency. When considered through the lens of the Affective-Reflective Theory of physical inactivity and exercise (Brand & Ekkekakis, 2018), if personalized indices of readiness can be leveraged for more favorable exercise-related in-task affective responses, long-term behavioral maintenance can be fostered. Evidence is emerging that determinants of affect reflect similar constructs that underpin readiness, such as energy/perceptions of tiredness and mood states (Rose & Parfitt, 2010) and determinants of recalled in-task affective valence like energy, substrate availability, and physical condition (Beaumont et al., 2021). Further, pre-exercise energy index scores have been shown to predict mean in-task affect during moderate walking exercise (Strohacker, Boyer, Smitherman, Cornelius, & Fazzino, 2017), demonstrating proof-of-concept that the pre-exercise state is associated with relevant markers of the exercise experience. However, these prior studies had only examined these relationships from a nomothetic view. Pending larger sample sizes and time-series data collected under integral contexts (pre-exercise readiness and in-task measures of affective responses), stronger estimates of association could be calculated using repeated

measures correlation (Bakdash & Marusich, 2017). Alternatively, as further detailed below, mathematical and statistical modeling may not provide a sufficient or holistic account regarding what individual's consider important when considering readiness-to-exercise.

The level of perceived relevance varied regarding mathematically modeled first factor scores.

Study 2 revealed mixed perceptions from the individuals regarding the degree of relevance their own person-specific profiles possessed. There is inherent value to understanding these perceptions, despite the potential for statistically meaningful relationships between personal profiles of readiness and key experiential outcomes. In regard to health care, individuals must find strategies, treatments, and interventions to be acceptable, which refers to related affective attitudes, burden, perceived effectiveness, ethicality, intervention coherence, opportunity costs, and self-efficacy (Sekhon, Cartwright, & Francis, 2017). Taken together, individuals must 'buy-in' to what practitioners are 'selling.' Perceived acceptability from patients is related to adherence in clinical and healthcare contexts and should be examined in early stages of behavioral intervention development (Czajkowski et al., 2015; MRC, 2008) particularly using qualitative approaches (Leko, 2014).

One factor that contributed to mixed perceptions of relevance to participants' person-specific profile was an incongruency between physiological measures and their own perceptions (i.e., a Whoop™ device indicates participants are 'recovered' based on heart rate variability, sleep quality, etc. but participants feel under-recovered). Such incongruencies have been noted in the medical field – somatic symptom disorder is characterized by patients manifesting symptoms despite no biological cause (Kurlansik & Maffei, 2016). Patients with somatic symptom disorder can experience physiological symptoms (i.e., pain in various body regions, fatigue, perceived

disturbances in cardiovascular and/or gastrointestinal function) or psychological and behavioral aspects such as high health anxiety (Henningsen, 2022). Not only can physiological or data-driven feedback be incongruent with participant perceptions, but responses in Study 2 suggested that such data can potentially bias exercise decisions (i.e., low-readiness feedback deterring participants from exercising) or bias the exercise experience itself (i.e., low-readiness feedback suggests it, a negative affective response will occur). Research in the field of psychology has long been aware of *affective priming*, a tendency for a stimulus to either facilitate or inhibit the affective response to a subsequent target (Fazio, Sanbonmatsu, Powell, & Kardes, 1986). Affective responses to a target are important, because people with more positive affective evaluations of exercise and physical activity are more active – and automatic evaluations to exercise and PA are modifiable (Conroy & Berry, 2017). Thus, as researchers pursue the optimization of assessing readiness and implementing FNLP, one must still consider potential limitations and unfavorable outcomes associated with presenting and interpreting statistically modeled data. Indeed, to improve perceived social validity of an intervention or treatment, consumers must be satisfied with all potential effects, both intended and *unintended* (Wolff, 1979). Thus, based on the current findings, more preliminary (and likely qualitative or mixed-methods) research is needed to determine whether or not to pursue purely numerically data-driven indices of readiness. Other approaches may be warranted.

Potential approaches for monitoring and leveraging data pertaining to readiness-to-exercise.

One opportunity for optimizing indices of readiness and their utility (determined by the individual, by mathematical determinants, or a combination) is to collaborate with a coach or fitness professional. This possibility was mentioned by individuals during the qualitative

interview when suggesting that their personalized profile of readiness may not be sufficiently meaningful when used alone. The Disconnected Values Model (DVM) is a recently developed approach for inducing behavior change (Anshel, 2008). The DVM has been used in several contexts, such as university staff members seeking to improve exercise habits (Brinthaup, Kang, & Anshel, 2010), employee wellness programs (Anshel, Brinthaup, & Kang, 2010), and developers of the model have illustrated implementation plans for the model in religious institutions (Anshel, 2010). The DVM contains two major tenets that are executed sequentially. First, an individual will identify deeply held values (i.e., core beliefs that influence behavior) as a means of identifying *unhealthy* habits that compromise their overall goals of health, happiness, performance, and/or quality of life. Second, following the DVM framework, the individual agrees to collaborate with a professional to generate action plans with the goal of replacing one or more negative habits with positive routines that facilitate behaviors consistent with their deeply held values. Based on interview responses in Study 2, it is possible to adapt the DVM and apply its tenets to monitoring and leveraging readiness-to-exercise data to implement flexible exercise programming. The first step of the DVM can be equated to the gathering of real-time data and generating person-specific profiles as an equivalent to deeply held beliefs, in that individuals can identify relevant constructs. After the relevant constructs have been identified and confirmed between the individual and a health professional, continued monitoring of the data on a session-by-session basis could be viewed as a parallel approach to the second step of the DVM. Indeed, participants in Study 2 made mention of using their person-specific profiles to troubleshoot low-motivation states or stalled/suboptimal performance quality. Similarly, if collaboration is unfeasible due to cost, accessibility, or lack of desire, it may be useful in future research to apply the concept of self-experimentation (Karkar et al., 2016). Within this

framework, individuals leverage their own knowledge combined with tracking technology (wearable devices, smartphone applications) to first identify relevant questions to be tested (does my pre-exercise emotional state impact *how* I experience exercise?) and then systematically test sequential hypotheses to narrow down information that can lead to health behavior change (“should I exercise despite feeling residual muscle soreness?”). This approach is considered a more personalized and self-directed derivative of small-case designs / ‘N-of-1’ studies (Dallery & Raiff, 2014), which hold enormous potential to guide precision behavioral medicine (Lillie et al., 2011). Based on the results of the current study, the complexity of readiness-to-exercise likely required further testing and optimization using such methodologies.

Finally, we must consider whether or not readiness-to-exercise can and should be the sole determinant of subsequent physical workloads. A key theme emerging from the current work is that, while acknowledgement and tracking of readiness states can yield important information, that there are cases where one must simply ‘do the work’. That is, participants acknowledged the need to exercise despite instances of low readiness if they want to achieve their self-determined goals. We liken this notion to the concept of ‘psychological grit’, which is defined as a perseverance and passion for long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007). Differing from those who score high on general achievement motivation – who tend to set short term manageable goals to elicit immediate feedback – those who score high regarding grit deliberately set long term goals with deliberate awareness of setbacks and plateaus (Duckworth et al., 2007). Higher ratings of grit have been shown to predict higher levels of moderate and vigorous exercise behavior (Reed, Pritschet, & Cutton, 2013). Thus, while the pursuit of an optimized index of readiness still holds tremendous value for novice exercisers and regular exercisers experiencing behavioral difficulties, it is reasonable to consider an alternative strategy

to FNLP (i.e., adjusting exercise demand to readiness) by way of enhancing readiness states in order to perform more demanding and previously scheduled exercise sessions. Overcoming the barrier of a low-readiness state could be achieved, for example, through self-talk – a strategy used in sports psychology that hinges on evidence that *what* people think will influence their actions and behaviors (Hatzigeorgiadis, Zourbanos, Galanis, & Theodorakis, 2011; Miechenbaum, 1977). Self-talk seems particularly appropriate in a sample of trained individuals, as was the case in Study 2; in one-on-one interviews, participants acknowledged the need to exercise despite instances of low readiness if they want to achieve their self-determined goals.

Limitations.

The current research study is not without limitations. First, the participants in both Study 1 and Study 2 reported a higher-than-average level of experience with strength training. The mean strength training age (i.e., how long participants engaged in at least two days per week of strength training) for the sample in Study 2 was 9 ± 6.7 years (min = 1.5, max = 22), though these data were self-reported and may be susceptible to recall bias such that behavioral lapses were omitted. Nevertheless, the perceptions of readiness-to-exercise and the meaningfulness of person-specific profiles may differ if compared to a sample of novice or untrained individuals. The survey design may also have posed barriers to data interpretation. Previous approaches using factor analysis to generate structures of readiness-to-exercise comprised of 12 items that were hypothesized to represent the same construct, resulting in 4 factors. The current study utilized 51 items, which predisposes the analysis to generate a greater number of factors, and naturally reduces the amount of variance in the dataset that each factor explains. Finally, Study 2 relied on anticipated experiential outcomes to hypothetical bouts of exercise because in-person exercise

testing was contraindicated due to public health concerns regarding the COVID-19 virus. It is reasonable to speculate that experiential outcomes to a performed bout of strength exercises may differ from anticipated effects of hypothetical exercise.

Conclusion/Future Directions.

Across Study 1 and Study 2, readiness-to-exercise pertaining to strength training was supported as a multidimensional construct comprised of both physical and mental states. Factor analysis was used to generate a population-level profile of readiness-to-exercise (Study 1) and person-specific profiles in Study 2. In line with previous research, comparisons between nomothetic and idiographic profiles of readiness-to-exercise reveal meaningful heterogeneity. Novel findings from Study 2 include the inter-individual perceptions that participants had regarding the meaning and utility of their person-specific profiles. Future research should consider an adaptive approach to implementing FNLP and exploring the relationship between readiness-to-exercise and experiential outcomes (i.e., ratings of perceived exertion, anticipated/in-task/recalled affective responses) to exercise that are directly measured, as opposed to anticipated outcomes related to hypothetical bouts of exercise.

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Appendices

APPENDIX A

Study information sheet – study 1

Consent for Research Participation

Research Study Title: Exploring the Physical and Mental States of Adults Before Performing Muscle-Strengthening Exercise

Researcher(s): [Cory Beaumont], Department of Kinesiology, Recreation, and Sport Studies University of Tennessee, Knoxville. [Dr. Kelley Strohacker], Department of Kinesiology, Recreation, and Sport Studies University of Tennessee, Knoxville

We are asking you to be in this research study because you are about to engage in muscle-strengthening activity. You must be age 18 or older to participate in the study. The information in this consent form is to help you decide if you want to be in this research study. Please take your time reading this form and contact the researcher(s) to ask questions if there is anything you do not understand.

Why is the research being done?

The purpose of the research study is to understand how adults feel mentally and physically right before starting a muscle-strengthening workout.

What will I do in this study?

If you agree to be in this study, we will ask you to complete your choice of a paper or online survey. The survey includes questions about your demographic information, habitual activity, as well as your current physical and mental states and planned exercise behavior for today.

Can I say “No”?

Being in this study is up to you. You can stop up until you submit the survey. After you submit the survey, we cannot remove your responses because we will not know which responses came from you.

Either way, your decision won't affect your grades, your relationship with your instructors, or standing with the University of Tennessee, Knoxville if you are a student.

Your decision also won't affect your relationship with the University of Tennessee, Knoxville, or the services/health care/benefits that you and/or your family receive.

Finally, if you are an employee, your decision won't affect your employment at the University of Tennessee, Knoxville.

Are there any risks to me?

We don't know of any risks to you from being in the study.

Are there any benefits to me?

We do not expect you to benefit from being in this study. Your participation may help us to better understand how differently individuals may feel right before exercising. We hope the knowledge gained from this study will benefit others in the future.

What will happen with the information collected for this study?

Please do not include your name or other information that could be used to identify you in your survey responses. Information provided in this survey can only be kept as secure as any other online communication.

Information collected for this study will be published and possibly presented at scientific meetings.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the researchers, [Cory Beaumont, cbeaumo1@vols.utk.edu, (865) 974-3340], or faculty advisor Dr. Strohacker [kstrohac@utk.edu] (865)-974-7667].

For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

Statement of Consent

I have read this form, been given the chance to ask questions and have my questions answered. If I have more questions, I have been told who to contact. **By completing and returning the survey, I understand that I am agreeing to be in this study.** I can keep a copy of this consent information for future reference. If I do not want to be in this study, I do not need to do anything else

APPENDIX B

Consent document – study 2

Consent for Research Participation

Research Study Title: Exploring the Unique Profile of Readiness-to-Exercise in Strength-Trained Adults.

Researcher(s): Cory Beaumont, M.S., CSCS, Department of Kinesiology, Recreation, and Sport Studies, University of Tennessee, Knoxville

Kelley Strohacker, Ph.D., FACSM, Department of Kinesiology, Recreation, and Sport Studies, University of Tennessee, Knoxville

Why am I being asked to be in this research study?

We are asking you to be in this research study because [you are an adult who regularly performs strength-training exercise](#).

What is this research study about?

The purpose of the current study is to model individual profiles of mental and physical states relate to understand 1) how the models differ across people, 2) how the model components relate to reactions to hypothetical exercise scenarios, and 3) how meaningful and useful each individual finds his or her constructed profile. How long will I be in the research study?

How long will I be in the research study?

If you agree to be in the study, your participation will last **approximately 25 days**, depending on scheduling. During this time, you will:

- Fill out **4 surveys per day for 21 consecutive days** using your smartphone (each survey takes ~3 minutes to complete). The timing of surveys per day will be randomized
- Attend **2 meetings via Zoom. Meetings will be recorded and transcribed. Recording will begin *after* your Zoom profile name is changed to a pseudonym to help protect your anonymity**
 - **Meeting 1** will last approximately **45 minutes** and will include confirmation of eligibility, informed consent procedures and familiarization with survey content and procedures
 - **Meeting 2** will last approximately **45 minutes** and will include a one-on-one, audio recorded interview with the researcher. The interview will involve questions related to your strength training background and your perceptions of your unique profile regarding mental and physical states. In order to

- complete this interview, you will be expected to complete at least 50 of the 84 surveys sent in the 21-day timespan.

What will happen if I say “Yes, I want to be in this research study”?

If you agree to be in this study, you will be providing consent for three overarching processes: 1) to complete 4 daily surveys via smartphone for 21 days, 2) attend two Zoom meetings, each lasting approximately 45 minutes, and 3) as part of your second Zoom meeting, complete a brief audio recorded interview to be conducted after your 21st day of survey completion.

If you are eligible and enrolled in the study, you will be asked to do the following:

- Attend a meeting via Zoom to provide informed consent and demographic information, as well as ensuring your smartphone is set up to receive and complete the daily surveys
 - This meeting will be audio and video recorded. You will choose a pseudonym to protect your anonymity.
 - The recording will begin **after** you have been instructed to change your profile name. This will protect your anonymity in the transcription of the meeting.
- Complete four daily surveys using your personal smartphone for 21 consecutive days (3-min per survey)
 - Survey links will be sent in text messages
 - The timing of surveys per day will be randomized. Four surveys per day will be sent for 21 consecutive days
 - The first survey will be sent to you via text message the day after your Zoom meeting where informed consent is obtained
- Attend an exit interview via Zoom following your 21 days of survey completion. You will be asked to engage in a one-on-one interview with the researcher to discuss your perceptions regarding the results of your daily surveys.
 - Electronic transcripts of the interview will be stored securely on a password protected device. Video and audio will be stored securely on the University's cloud network, though there will not be any video footage, as the camera will be turned away from you. Files will be destroyed after you confirmed the accuracy of the written transcripts.

What happens if I say “No, I do not want to be in this research study”?

Being in this study is up to you. You can say no now or leave the study later. If you are a student, your decision won't affect your grades, your relationship with your instructors, or standing with the University of Tennessee, Knoxville. If you are an employee at the University of Tennessee, Knoxville, your decision won't affect your employment. For any

interested individuals, your decision won't affect your relationship with the researchers or the University of Tennessee, Knoxville.

What happens if I say "Yes" but change my mind later?

Even if you decide to be in the study now, you can change your mind and stop at any time.

If you decide to stop before the study is completed, you must provide a statement in writing (in print or through email) **OR** verbally (via telephone) to the principal investigator (Cory Beaumont).

If you withdraw from the study after any information has been collected (baseline demographics, surveys), your de-identified data will be kept and used in the final write up so that we can compare study completers and non-completers. If you withdraw before any information is collected, all information pertaining to you (name, contact information) will be destroyed.

Are there any possible risks to me?

During this study, we will collect several pieces of identifiable information (name, phone number, email address), so it is possible that someone could find out you were in this study or see your study information. But we believe this risk is small because of the procedures we use to protect your information. These procedures are described later in this form.

Are there any benefits to being in this research study?

We do not expect you to benefit from being in this study. Primarily, your participation may help us to learn more about how physical and mental states may impact the exercise experience, and the information collected represents an important step to refining how we design and implement exercise programs. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your information by use of the following procedures:

We will give you a unique study identification code. This code will be used to identify your data for all study procedures.

Consent forms containing your printed name will be kept in a locked file cabinet in the locked office of the principal investigator. Other paper data sheets identified only by your unique code will be kept in a locked file cabinet in Dr. Strohacker's laboratory space in the HPER building.

Only approved research team members will have access to your data files.

If information from this study is published or presented at scientific meetings, your name and other personal information will not be used.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information or what information came from you. Although it is unlikely, there are times when others may need to see the information that we collect about you. These include:

- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.

What will happen to my information after this study is over?

We will keep your information to use for future research. Your name and other information that can directly identify you will be kept secure and stored separately from your research data collected as part of the study

We may share your research data with other researchers without asking for your consent again, but it will not contain information that could directly identify you.

Will it cost me anything to be in this research study?

If you agree to be in this study, standard texting and data use charges to your smartphone will be applied during this study

What else do I need to know?

Number of research participants. Up to 40 adults will take part in this study. Because of the small number of participants in this study, it is possible that someone could identify you based on information we collected from you.

We may need to stop your participation in the study without your consent if:

- You become ineligible for any reason (lose your smartphone or its internet/email capabilities)
- The study is stopped for any reason unrelated to your participation.
- Participants will need to complete at least 80% of the electronic surveys via smartphone. Compliance will be assessed every 7 days, and participants who do not meet these criteria will be removed from the study.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact Cory Beaumont, cbeaumo1@vols.utk.edu, 814-823-2353). You may also contact the faculty advisor, Dr. Kelley Strohacker, kstrohac@utk.edu, 865-974-7667

For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

APPENDIX C

Recruitment flyers – study 1 and study 2

Do you plan on strength training today using free weights, machines, or your body weight?

If so, please consider participating research study '*Exploring the Physical and Mental States of Adults Before Performing Muscle-Strengthening Exercise*'

Research Contact: Cory Beaumont (cbeaumo1@vols.utk.edu)

Study Purpose

To investigate the pre-exercise physical and mental states of adults over the age of 18 years who intend to perform muscle-strengthening exercise for today's workout

Study Details and Inclusion Criteria

- One-time, **anonymous** survey, which can be completed online (scan QR code below using a smartphone or follow the link posted below)
- Survey must be completed **before** you workout
- You will NOT be asked to alter your workout in any capacity
- You will be asked for basic demographic information
- Must be at least 18 years old

Study Duration and Time Commitment

- Online versions of the survey take about 5 minutes to complete
- Please take the survey **only once**

Instructions for Accessing the Online Survey

- Open the Camera app on your smartphone
- Center the QR code below in the camera's view; a hyperlink will appear on your smartphone
- Tap on the hyperlink and follow the instructions provided in the online survey
- **OR click the following link:** https://utk.co1.qualtrics.com/jfe/form/SV_3mvTNVr2jDDIgom



UTK IRB-21-06497-XM

RESEARCH PARTICIPANTS NEEDED

Inclusion Criteria

- Adults over the age of 18 years
- Willingness to provide demographic information
- Regularly perform strength exercises (≥ 2 days per week) for at least one year
 - Bodyweight exercises, machine-based, free weights, etc.
- Possession of a smartphone with internet access and text message capabilities
- Have access to the Zoom application for 2 meetings

Study Details

- **Purpose:** investigate daily physical and mental states related to the exercise experience
- **Duration:** approximately 25 days
- **Commitment:**
 - Baseline Zoom meeting (approximately 45 minutes total) to provide informed consent and become familiar with survey process
 - Four daily surveys completed via your smartphone for 21 days
 - Timing of surveys will be randomized
 - One-on-one interview with a researcher after the 21st day of survey completion (approximately 45 minutes)
 - Each participant will be asked to read through their transcribed interview to confirm accuracy
 - Zoom interview will be recorded after pseudonyms are provided to ensure anonymity

If you are interested in participating or have further questions, please contact Cory Beaumont [cbeaumo1@vols.utk.edu] or Dr. Kelley Strohacker [kstrohac@utk.edu]

IRB NUMBER: UTK IRB-22-06809-XP
IRB APPROVAL DATE: 03/23/2022

APPENDIX D

Survey used in Study 1

Pre-Exercise Survey

Survey Overview

There are two parts to this survey. **For the first part**, we want to know how you are feeling physically and mentally right before starting your workout. **For the second part**, we want to know more about you and your exercise habits. Please read the specific instructions at the start of each section.

Part 1

For each item listed below, **circle the number** that best represents how strongly you are or are not experiencing each feeling right now, at this very moment. Please be honest in your ratings – there are no right or wrong answers. Finally, please be sure you do not skip any items.

Right now, I am feeling...	1 Definitely not	2 Not	3 Not really	4 A little	5 Very much	6 Extremely
Agile	1	2	3	4	5	6
Groggy	1	2	3	4	5	6
Strong	1	2	3	4	5	6
Tense	1	2	3	4	5	6
Dehydrated	1	2	3	4	5	6
Happy	1	2	3	4	5	6
Exhausted	1	2	3	4	5	6
Good	1	2	3	4	5	6
Fit	1	2	3	4	5	6
Parched	1	2	3	4	5	6
Sick	1	2	3	4	5	6
Calm	1	2	3	4	5	6
Starving	1	2	3	4	5	6
Unwell	1	2	3	4	5	6
Powerful	1	2	3	4	5	6
Recuperated	1	2	3	4	5	6
Bad	1	2	3	4	5	6
Discontent	1	2	3	4	5	6
Sleepy	1	2	3	4	5	6
Throbbing Pain	1	2	3	4	5	6
Energetic	1	2	3	4	5	6
Uneasy	1	2	3	4	5	6

Right now, I am feeling...	1 Definitely not	2 Not	3 Not really	4 A little	5 Very much	6 Extremely
Wide Awake	1	2	3	4	5	6
Weak	1	2	3	4	5	6
Cheerful	1	2	3	4	5	6
At Ease	1	2	3	4	5	6
Flexible	1	2	3	4	5	6
Drained	1	2	3	4	5	6
Bloated	1	2	3	4	5	6
Great	1	2	3	4	5	6
Restless	1	2	3	4	5	6
Healthy	1	2	3	4	5	6
Uncomfortable	1	2	3	4	5	6
Famished	1	2	3	4	5	6
Tired	1	2	3	4	5	6
Thirsty	1	2	3	4	5	6
Content	1	2	3	4	5	6
Nervous / On Edge	1	2	3	4	5	6
Weary	1	2	3	4	5	6
Stiff	1	2	3	4	5	6
Well-Rested	1	2	3	4	5	6
Vigorous	1	2	3	4	5	6
Cramping Pain	1	2	3	4	5	6
Hungry	1	2	3	4	5	6
Unhappy	1	2	3	4	5	6
Alert	1	2	3	4	5	6
Drowsy	1	2	3	4	5	6
Composed	1	2	3	4	5	6
Under The Weather	1	2	3	4	5	6
Relaxed	1	2	3	4	5	6
Uncomfortably Full (from eating)	1	2	3	4	5	6

Part 2

The following questions are meant to collect your demographic information and habitual exercise behavior, as well as information about your planned exercise session today. Please answer as honestly as possible.

Part 2a. Describe Today's Muscle-Strengthening Workout

1. What types of muscle-strengthening exercise do you intend to perform today?
Circle all options that apply.
 - a. Weight-lifting (machines)
 - b. Weight-lifting (free weights)
 - c. Bodyweight exercises / calisthenics
 - d. Plyometrics (jump training)
 - e. A group fitness class (Please describe _____).
 - f. Other (Please describe _____).
2. How hard or easy do you think the muscle-strengthening portion of your workout will feel today? Circle only one option.
 - a. 0 - Rest
 - b. 1 - Very, very easy
 - c. 2 - Easy
 - d. 3 - Moderate
 - e. 4 - Somewhat hard
 - f. 5 - Hard
 - g. 6
 - h. 7 - Very hard
 - i. 8
 - j. 9
 - k. 10 - Maximal

Part 2b. Describe Your Typical Exercise Behavior

3. What type(s) of muscle-strengthening exercise do you perform regularly?
Circle all options that apply.
 - a. Weight-lifting (machines)
 - b. Weight-lifting (free weights)
 - c. Bodyweight exercises / calisthenics
 - d. Plyometrics (jump training)
 - e. Group fitness classes (Please describe _____).
 - f. Other (Please describe _____).
4. On average, how many days per week do you perform *muscle-strengthening* exercise of any kind (i.e., bodyweight, free weights, machines, etc.)
 - a. 0
 - b. 1
 - c. 2
 - d. 3
 - e. 4

- f. 5
- g. 6
- h. 7

5. Think about your answer to Question 4 – how long have you maintained this frequency of muscle-strengthening exercise?

- a. Less than 30 days
- b. 1 to 3 months
- c. 3 to 6 months
- d. 6 to 12 months
- e. 1 year
- f. 2 years
- g. 3 or more years

6. In general, how easy or hard do your typical muscle-strengthening workouts feel?

- a. 0 – Rest
- b. 1 - Very, very easy
- c. 2 - Easy
- d. 3 - Moderate
- e. 4 - Somewhat hard
- f. 5 – Hard
- g. 6
- h. 7 - Very hard
- i. 8
- j. 9
- k. 10 – Maximal

7. On average, how many days per week do you perform moderate-to-strenuous aerobic exercise of any kind (running, walking for fitness, cycling, swimming etc.)?

- a. 0
- b. 1
- c. 2
- d. 3
- e. 4
- f. 5
- g. 6
- h. 7

8. On average, how many minutes per session do you spend performing aerobic exercises? Circle the most appropriate option.

- a. 0
- b. 10
- c. 20

- d. 30
- e. 40
- f. 50
- g. 60
- h. 70
- i. 80
- j. 90
- k. 120
- l. 150

9. In general, how easy or hard do your typical *aerobic* workouts feel?

- a. 0 – Rest
- b. 1 - Very, very easy
- c. 2 - Easy
- d. 3 - Moderate
- e. 4 - Somewhat hard
- f. 5 – Hard
- g. 6
- h. 7 - Very hard
- i. 8
- j. 9
- k. 10 – Maximal

Part 2c. Describe Yourself

10. How old are you? Please fill in the blank.

_____ years old

11. What gender do you identify with? Please mark with a circle

- a. Man
- b. Woman
- c. Transgender Man
- d. Transgender Woman
- e. Other (please describe) _____
- f. I do not wish to answer

12. Do you identify as Hispanic or Latino?

- a. Yes
- b. No
- c. I do not wish to answer

13. What is your racial identity? Please mark with a circle

- a. American Indian or Alaskan Native
- b. Asian
- c. Black or African-American
- d. Native Hawaiian or Native Pacific Islander

- e. White
- f. Other (please describe) _____
- g. I do not wish to answer

14. How tall are you? (Estimate if necessary)

_____ ft. _____ inches

15. How much do you weigh? (Estimate if necessary)

_____ lbs.

16. Have you completed this survey before?

- a. Yes
- b. No
- c. I'm not sure

APPENDIX E

Survey used in Study 2

For each item listed, select the number that best represents how strongly you are or are not experiencing each feeling **right now**, at this very moment. Please be honest in your ratings – there are no right or wrong answers. Do not skip any items.

Right now, I am feeling...

	Definitely Not (1)	Not (2)	Not Really (3)	A little (4)	Very Much (5)	Extremely (6)
Agile (1)	☐	☐	☐	☐	☐	☐
Groggy (2)	☐	☐	☐	☐	☐	☐
Strong (3)	☐	☐	☐	☐	☐	☐
Tense (4)	☐	☐	☐	☐	☐	☐
Dehydrated (5)	☐	☐	☐	☐	☐	☐
Happy (6)	☐	☐	☐	☐	☐	☐
Exhausted (7)	☐	☐	☐	☐	☐	☐
Good (8)	☐	☐	☐	☐	☐	☐
Fit (9)	☐	☐	☐	☐	☐	☐
Parched (10)	☐	☐	☐	☐	☐	☐

Right now, I am feeling...

	Definitely Not (1)	Not (2)	Not Really (3)	A little (4)	Very Much (5)	Extremely (6)
Sick (1)	☐	☐	☐	☐	☐	☐
Calm (2)	☐	☐	☐	☐	☐	☐
Starving (3)	☐	☐	☐	☐	☐	☐
Unwell (4)	☐	☐	☐	☐	☐	☐
Powerful (5)	☐	☐	☐	☐	☐	☐
Recuperated (6)	☐	☐	☐	☐	☐	☐
Bad (7)	☐	☐	☐	☐	☐	☐
Discontent (8)	☐	☐	☐	☐	☐	☐
Sleepy (9)	☐	☐	☐	☐	☐	☐
Throbbing Pain (10)	☐	☐	☐	☐	☐	☐

Right now, I am feeling...

	Definitely Not (1)	Not (2)	Not Really (3)	A little (4)	Very Much (5)	Extremely (6)
Energetic (1)	☐	☐	☐	☐	☐	☐
Uneasy (2)	☐	☐	☐	☐	☐	☐
Wide Awake (3)	☐	☐	☐	☐	☐	☐
Weak (4)	☐	☐	☐	☐	☐	☐
Cheerful (5)	☐	☐	☐	☐	☐	☐
At ease (6)	☐	☐	☐	☐	☐	☐
Flexible (7)	☐	☐	☐	☐	☐	☐
Drained (8)	☐	☐	☐	☐	☐	☐
Bloated (9)	☐	☐	☐	☐	☐	☐
Great (10)	☐	☐	☐	☐	☐	☐

Right now, I am feeling...

	Definitely Not (1)	Not (2)	Not Really (3)	A little (4)	Very Much (5)	Extremely (6)
Restless (1)	☐	☐	☐	☐	☐	☐
Healthy (2)	☐	☐	☐	☐	☐	☐
Uncomfortable (3)	☐	☐	☐	☐	☐	☐
Famished (4)	☐	☐	☐	☐	☐	☐
Tired (5)	☐	☐	☐	☐	☐	☐
Thirsty (6)	☐	☐	☐	☐	☐	☐
Content (7)	☐	☐	☐	☐	☐	☐
Nervous/On Edge (8)	☐	☐	☐	☐	☐	☐
Weary (9)	☐	☐	☐	☐	☐	☐
Stiff (10)	☐	☐	☐	☐	☐	☐

Right now, I am feeling...

	Definitely Not (1)	Not (2)	Not Really (3)	A little (4)	Very Much (5)	Extremely (6)
Well-Rested (1)	☐	☐	☐	☐	☐	☐
Vigorous (2)	☐	☐	☐	☐	☐	☐
Cramping Pain (3)	☐	☐	☐	☐	☐	☐
Hungry (4)	☐	☐	☐	☐	☐	☐
Unhappy (5)	☐	☐	☐	☐	☐	☐
Alert (6)	☐	☐	☐	☐	☐	☐
Drowsy (7)	☐	☐	☐	☐	☐	☐
Composed (8)	☐	☐	☐	☐	☐	☐
Under the Weather (9)	☐	☐	☐	☐	☐	☐
Relaxed (10)	☐	☐	☐	☐	☐	☐
Uncomfortably Full (from eating) (11)	☐	☐	☐	☐	☐	☐

What were you doing immediately prior to completing this survey?

- ☐ A) Lying down or sleeping (4)
- ☐ B) a seated activity (reading a book, working at the computer, scrolling on your phone, etc.) (5)
- ☐ C) actively commuting (walking or biking) from one place to another (6)
- ☐ D) Doing household chores or yardwork (7)
- ☐ E) Exercising (8)

Where are you at the time of completing this survey?

- ☐ A) at home (4)
- ☐ B) at work (5)
- ☐ C) at school (6)
- ☐ D) outside (7)
- ☐ E) the gym (8)
- ☐ F) in the community (coffee shop, grocery store, etc.) (9)

Start of Block: Hypothetical 1 - Readiness

Hypothetically, consider that you had both the time and the resources to exercise right now, with how you are currently feeling physically and mentally,

How ready would you be to do a strength training workout that involved all major muscle groups (back, chest, legs, shoulders, core, arms) for 2 sets of 8-12 repetitions using a moderate intensity? (Moderate intensity = approximately 70% of your 1 repetition maximum).

- ☐ 0 - Not ready at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 (6)
- ☐ 6 (7)
- ☐ 7 (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - As ready as possible (11)

End of Block: Hypothetical 1 - Readiness

Start of Block: Hypothetical 2 - Construction

Assume you have the opportunity to work out right now, with adequate time and resources.

Consider your physical and mental states *at this very moment*. Based on your current physical and mental states, what muscle groups would you be willing to target in a strength training workout? Please select all that apply.

☐

Upper Body (1)

☐

Lower Body (2)

☐

Core (3)

Think back to your answer from the previous question (which muscle groups you would target in a workout).

Based on your current physical and mental states, how challenging would you make your hypothetical workout? Please select the most appropriate number (Note: Numbers without descriptive words are intentionally blank).

- ☐ 0 - Rest (1)
- ☐ 1 - Very, very easy (2)
- ☐ 2 - Easy (3)
- ☐ 3 - Moderate (4)
- ☐ 4 - Somewhat hard (5)
- ☐ 5 - Hard (6)
- ☐ 6 (7)
- ☐ 7 - Very hard (8)
- ☐ 8 (9)
- ☐ 9 (10)
- ☐ 10 - Maximal effort (11)

Start of Block: Hypothetical 3 - Investment

Consider your current physical and mental states. Based on these, how much **physical effort** would you be willing to invest into a total body strength training session (back, chest, legs, core, arms) for 2 sets of 8-12 reps using a moderate intensity (approximately 70% of your 1 repetition maximum)? Please select the most appropriate option.

- ☐ 0 - No physical effort at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 - Maximum possible physical effort (6)

Consider your current physical and mental states. Based on these, how much **mental effort** would you be ready to invest into a total body strength training session (back, chest, legs, core, arms) for 2 sets of 8-12 reps using a moderate intensity (approximately 70% of your 1 repetition maximum)? Please select the most appropriate option.

- ☐ 0 - No mental effort at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 - Maximum possible mental effort (6)

Consider the following hypothetical:

You are challenged with completing a total body strength training session (back, chest, legs, core, arms) for 2 sets of 8-12 reps using a moderate intensity (approximately 70% of your 1 repetition maximum).

Based on how you are feeling, right now, physically and mentally, how **confident are you** that you could tolerate the hypothetical exertion and discomfort that would accompany this workout? Please select the most appropriate option.

- ☐ 0 - Not confident at all (1)
- ☐ 1 (2)
- ☐ 2 (3)
- ☐ 3 (4)
- ☐ 4 (5)
- ☐ 5 - Extremely confident (6)

End of Block: Hypothetical 3 - Investment

Start of Block: Hypothetical 4 - Affective

Consider the following hypothetical:

Right now, in this very moment, you are made to complete a total body strength training session (back, chest, legs, core, arms) for 2 sets of 8-12 reps using a moderate intensity (approximately 70% of your 1 repetition maximum).

Given your current mental and physical states, how ***pleasant or unpleasant*** do you think it would feel while you were physically performing the repetitions?

Choose the most appropriate option (Note: numbers without descriptive words are intentionally blank).

- ☐ +5 [Very Good] (1)
- ☐ +4 (2)
- ☐ +3 [Good] (3)
- ☐ +2 (4)
- ☐ +1 [Fairly Good] (5)
- ☐ 0 [Neutral] (6)
- ☐ -1 [Fairly Bad] (7)
- ☐ -2 (8)
- ☐ -3 [Bad] (9)
- ☐ -4 (10)
- ☐ -5 [Very Bad] (11)

End of Block: Hypothetical 4 - Affective

Start of Block: Hypothetical 5 - Thank you

We appreciate your continued effort and participation in the study. Click to complete this survey.

- ☐ Okay! (1)

End of Block: Hypothetical 5 - Thank you

Feeling Scale (Hardy and Rejeski 1989). In-Task Affect. Participants used the Feeling Scale to provide anticipated in-task affective ratings to a hypothetical bout of strength training in any surveys that contained Hypothetical Block 4. Specifically, participants were provided the following prompt: “Consider the following hypothetical:

Right now, in this very moment, you are made to complete a total body strength training session (back, chest, legs, core, arms) for 2 sets of 8-12 reps using a moderate intensity (approximately 70% of your 1 repetition maximum).

Given your current mental and physical states, how pleasant or unpleasant do you think it would feel while you were physically performing the repetitions?

Choose the most appropriate option (Note: numbers without descriptive words are intentionally blank).

FEELING SCALE	
+5	Very Good
+4	
+3	Good
+2	
+1	Fairly Good
0	Neutral
-1	Fairly Bad
-2	
-3	Bad
-4	
-5	Very Bad

Category-Ratio 10 (CR-10; Borg 1998). Session Exertion. Participants used the following scale to provide levels of anticipated overall exertion to a hypothetical bout of strength training that they designed themselves. Specifically, participants were provided the following prompt:

“Based on your current physical and mental states, how challenging would you make your hypothetical workout? Please select the most appropriate number (Note: Numbers without descriptive words are intentionally blank).”

Rating	Descriptor
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat hard
5	Hard
6	
7	Very hard
8	
9	
10	Maximal

APPENDIX F

Interview guide

INTERVIEW GUIDE

Exploring the Unique Profile of Readiness-to-Exercise in Strength-Trained Adults.

Introduction:

- Greetings
- Reminder of recording audio/obtain permission

Questions:

First, we'd like to know a little about your background with resistance training.

1. Describe your history with strength training. (Provide prompts regarding how long they have been participating in resistance exercise, where do they typically lift, etc.)
2. When you do strength training, how do you plan or structure your workouts? (Prompt: do you follow a program, use whatever equipment is available, make your own program?)
3. When you do strength training, what is the primary/preferred mode? (Free weights, dumbbells, bodyweight, circuit training)

We'd like to learn a little more about the results from the surveys you've completed the previous 3 weeks. Before we go further, here is a paper version of that same survey. [SHARE SCREEN WITH SURVEY SHOWING READINESS ITEMS]

1. First, we'd like you to identify the items that you think are most important for you to consider when you're making exercise/training decisions. [*Prompt if needed that we mean decisions related to whether you exercise, how intense the exercise is, if you change sets/reps, add or subtract exercises, etc.*] INTERVIEWER CIRCLES ITEMS
2. Next, please also verbally indicate whether feeling these items enhances or worsens your overall experience. [INTERVIEWER MARKS + or – SIGNS ACCORDINGLY]
3. Finally, please rank the items you circled from most relevant (1) to least relevant (the highest number based on how many items were circled). INTERVIEWER MAKES LIST

(**Make clear that the participant does NOT need to circle/rank all 51 items, just any that they deem relevant**).

1. These are your most important items ... how would/do they influence you/your training?
2. What impact would you experience (on performance, feeling states, etc.) if you scored these items high vs. scoring them low?
3. Consider the items listed throughout the surveys. Are there any items **not** listed that you would consider for modifying your exercise experience?
4. Think about your typical strength training sessions in terms of the intensity (how heavy the weights are) and volume (how many sets and repetitions you do) ... describe how you make decisions regarding intensity and volume. (Prompt if needed: How do you guide/modify these variables?)

We've calculated your profile of readiness-to-exercise. This profile is specific to you and was calculated based off of the scores you provided on your electronic surveys over the previous weeks. We would like to get your opinion on your profile.

[PRESENT PARTICIPANT WITH THEIR INTERPERSONAL SIGNATURE;
EXPLAIN/DEFINE FACTORS THAT STATISTICALLY WERE THE MOST RELEVANT
FROM THEIR RESPONSES]

1. The first factor of your profile is ____, which is comprised of ____ [the items loading onto that factor]. Compared to the items you just circled and what we've discussed, how do you feel about this mathematically important factor in terms of its relevance or meaning to you personally?
2. We are trying to create programs that involve adjusting the physical work based on pre-exercise physical and mental states. So, consider your experience now monitoring those pre-exercise states, as well as our discussion today. What would be a more useful approach in your opinion: someone mathematically determining the most important factor and suggesting you adjust exercise sessions based off of that factor or having a conversation about it, a combination of the two? A different option altogether? Explain why.

Is there anything you would like to add before we conclude the interview?

Appendix G
Tables and figures

Table 1. Ten factors from R-technique factor analysis and pattern matrix of items with sufficient loading (Study 1: N = 326).

Item Name	Factor 1 <i>Activation</i>	Factor 2 <i>Tension</i>	Factor 3 <i>Calmness</i>	Factor 4 <i>Vitality</i>	Factor 5 <i>Hunger</i>	Factor 6 <i>Hydration</i>	Factor 7 <i>Sick</i>	Factor 8 <i>Positive Mood</i>	Factor 9 <i>Mobility</i>	Factor 10 <i>Overfed</i>
Sleepy	0.991									
Tired	0.863									
Wide Awake	-0.847									
Drowsy	0.789									
Well-Rested	-0.671									
Exhausted	0.659									
Groggy	0.599									
Drained	0.544									
Alert	-0.510									
Vigorous	-0.408									
Recuperated										
Discontent		0.714								
Nervous/On Edge		0.605								
Uneasy		0.602								
Unhappy		0.594								
Bad		0.564								
Weary		0.431								
Uncomfortable		0.405								
Restless										
Weak										
Calm			0.820							
Relaxed			0.782							
At Ease			0.723							
Composed			0.450							
Content										
Tense										
Fit				0.856						
Strong				0.665						
Healthy				0.547						
Agile				0.497						
Starving					0.940					
Hungry					0.849					
Famished					0.706					
Deyhydrated						0.895				
Parched						0.756				
Thirsty						0.733				
Sick							0.929			
Under the Weather							0.735			
Unwell							0.651			
Happy								0.744		
Cheerful								0.692		
Energetic								0.501		
Great								0.498		
Good								0.474		
Stiff									0.864	
Flexible									-0.441	
Bloated										0.502
Uncomfortably Full										0.446
Cramping Pain										
Powerful										
Throbbing Pain										

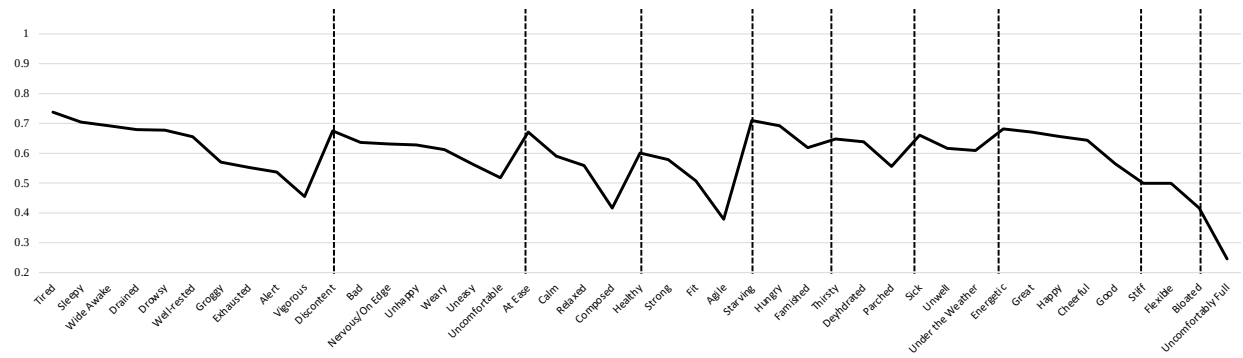


Figure 1. Community plot from R-technique ten-factor structure of readiness-to-exercise.

Factor Correlation Matrix											
Factor	1	2	3	4	5	6	7	8	9	10	11
1	1.000	0.402	-0.423	-0.429	0.306	0.335	0.466	-0.528	0.429	0.288	-0.005
2	0.402	1.000	-0.335	-0.179	0.403	0.340	0.409	-0.338	0.438	0.208	-0.060
3	-0.423	-0.335	1.000	0.515	-0.078	-0.054	-0.301	0.545	-0.181	-0.117	-0.140
4	-0.429	-0.179	0.515	1.000	-0.011	-0.114	-0.318	0.565	-0.241	0.033	-0.116
5	0.306	0.403	-0.078	-0.011	1.000	0.373	0.337	-0.116	0.434	0.260	0.019
6	0.335	0.340	-0.054	-0.114	0.373	1.000	0.264	-0.093	0.348	0.149	-0.080
7	0.466	0.409	-0.301	-0.318	0.337	0.264	1.000	-0.375	0.382	0.185	0.203
8	-0.528	-0.338	0.545	0.565	-0.116	-0.093	-0.375	1.000	-0.307	-0.136	0.040
9	0.429	0.438	-0.181	-0.241	0.434	0.348	0.382	-0.307	1.000	0.350	0.115
10	0.288	0.208	-0.117	0.033	0.260	0.149	0.185	-0.136	0.350	1.000	0.019
11	-0.005	-0.060	-0.140	-0.116	0.019	-0.080	0.203	0.040	0.115	0.019	1.000

Figure 2. Correlation matrix from R-technique factor analysis.

Table 2. Participant demographics (Study 2; N = 11)

Participant ID (<i>Pseudonym</i>)	Age (years)	Height (cm)	Weight (kg)	Race	Gender Identity	Frequency of Muscle-Strengthening Exercise (Days per Week)	Training Experience (years)
P001 (<i>Nancy Drew</i>)	34	165.1	92.5	White	Woman	4	1.5
P002 (<i>Dawson</i>)	27	177.8	79.4	White	Man	5	12
P003 (<i>Lizzy</i>)	39	167.6	74.8	White	Woman	4	18
P004 (<i>Sullivan Strange</i>)	23	154.9	47.6	White	Woman	7	4
P005 (<i>Gabby</i>)	37	160	54.4	White	Woman	6	6
P007 (<i>Toby</i>)	26	185.4	74.8	White	Man	4	4
P008 (<i>Jean</i>)	29	160	67.1	White	Woman	6	14
P009 (<i>June</i>)	35	162.6	54.4	White	Woman	6	22
P011 (<i>Doom</i>)	50	158.8	53.1	White	Woman	5	10
P012 (<i>Oliver</i>)	28	180.3	104.3	White	Man	3	2
P013 (<i>VP</i>)	24	185.1	95.3	White	Man	4	10

Vita

Cory Thomas Beaumont was born in Erie, Pennsylvania on August 20th, 1990. He is the son of Elizabeth Beaumont and has one sibling, Mark. In 2016, Cory earned his Bachelor of Science in Health and Human Performance from Edinboro University of Pennsylvania. He then earned his Master of Science in Health, Physical Activity, and Chronic Disease from the University of Pittsburgh. Cory went on to attend The University of Tennessee, Knoxville and obtained his Doctor of Philosophy in Kinesiology and Sport Studies with a specialization in Exercise Physiology in 2022 under the supervision of his academic advisor, Dr. Kelley Strohacker. After earning his doctorate, Cory began his position as an assistant professor in the Department of Allied Health, Sport, and Wellness at Baldwin Wallace University in Berea, Ohio.