AUTOMATICITY OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR

by

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ABSTRACT

Dual-process theories assume that there are two information processing systems that regulate human behavior: A reflective and an automatic system. Most physical activity (PA) intervention is grounded mainly on the reflective system that relies on individuals' intentions and regulatory goals or beliefs. Yet, such interventions are not leading to significant and sustained changes in PA. There is a growing body of research now focusing on the automatic regulatory system that occurs outside of intent. Automatic regulatory processes, however, are conceptualized far less in PA behavior. The broad aim of this dissertation is to expand our current understanding of automatic regulatory processes while accounting for dynamic aspects of PA, reflective processes, and individual differences. This dissertation consisted of three separate studies. The first study examined the automatic and reflective processes in relation to four different components of the PA domain: exercise, light and moderate to vigorous intensity non-leisure time PA (L-NLTPA and MV-NLTPA), and sedentary behavior (SED). AE of exercise was significantly correlated with moderate-to-vigorous PA (MVPA; min/d) and total PA (total activity counts [tac]/d), particularly in individuals with high PA intention and high self-efficacy. Executive function and personality indices (behavioral avoidance (or inhibition)/approach system [BIS/BAS] scale) significantly moderated the relationship between AE and PA behaviors. The second study aimed to investigate the stability of AE measures. Participants performed a computerized Single- Category Implicit Association Task (SC-IAT) twice, separated by 7-10 days. Internal consistency and test-retest reliability of the SC-IAT for the four PA domains

(Exercise, L-NLTPA, MV-NLTPA, and SED) were evaluated. SC-IAT for the exercise domain showed acceptable internal consistency and test-retest reliability. In study 3, we investigated automatic approach-avoidance tendencies in common scenarios where individuals are faced with decisions to approach or avoid energy conserving or energy expending activities. Our results indicate that individuals responded faster to energy conserving cues than energy expending cues. In summary, we found that AE and reflective processes synergistically predict PA in active, young adults. Individuals are also more sensitive to energy conserving than energy expending stimuli.

DEDICATION

This dissertation is dedicated to my father, Dr. Zagdsuren Demchigjav, MD, Ph.D.

“Nothing that was real ever died”- Eckhart Tolle.

LIST OF ABBREVIATIONS

AAT	approach-avoidance tasks
AE	automatic evaluations
ANOVA	analysis of variance
APE	associative and propositional processes in evaluation
ART	affective-reflective theory
BAS	behavioral activation (or approach) system
BAS-FS	BAS subfactor: fun-seeking
BAS-RR	BAS subfactor: reward responsiveness
BIAT	brief implicit association test
BIS	behavioral inhibition (or avoidance) system
BMEC	behaviors minimizing energetic costs
BMI	body mass index
BP	blood pressure
DPT	dual-process theories
E	exercise
EEG	electroencephalography
HR	heart rate

IAT	implicit association test
IC	inhibitory control
IPAQ-LF	international physical activity questionnaire-long form
kg	kilogram
L-NLTPA	light intensity non-leisure time physical activity
LTPA	leisure-time physical activity
MET	metabolic equivalent
min	minute
ms	milliseconds
MV-NLTPA	moderate-to-vigorous intensity non-leisure time physical activity
MVPA	moderate-to-vigorous intensity physical activity
NLTPA	non-leisure time physical activity
PA	physical activity
PACES	physical activity enjoyment scale
RIM	reflective-impulsive model
RT	reaction time
RT_{Block1}	reaction time in block 1
RT_{Block2}	reaction time in block 2
SC-IAT	single-category implicit association test
SD	standard deviation
SED	sedentary behavior
SES	self-efficacy scale

SPSS	statistical package for social sciences
SRBAI	self-report behavioral automaticity index
TECM	theory of energetic cost minimization

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CHAPTER 1

INTRODUCTION

Physical Inactivity as a Major Public Health Problem

The benefits of physical activity (PA) for health and well-being are well-documented. Participation in regular PA has been shown to decrease the risk of developing various diseases, including cardiovascular events [1, 2], musculoskeletal diseases [3], metabolic diseases [4], cancer [5], and improvements in brain health and function [6]. Despite the myriads of health benefits, 50% of the US adult population (approx. 126 million) fails to meet public health guidelines of 150 minutes per week of moderate-to-vigorous PA [6], making *physical inactivity* a significant public health challenge. Most public health guidelines offer educational, informational, and environmental interventions [7, 8] with an emphasis on health promotion. These interventions rely heavily on an individual's conscious effort to set goals, to self-monitor, and engage in repeated reflective processes in to successfully change their behavior [9]. Evidence suggests that such interventions engender large changes in intentions, however, do not always lead to long-term behavioral changes [10-13]. More recent research has focused on elucidating the automatic processes that influence PA behaviors. Dual-process theories, in particular, have guided these recent investigations, suggesting that PA behavior is, at least in part, modulated by subconscious automatic processes [14, 15].

Dual-process Theories

The use of dual-process theories to explain human behavior is not new; it has been applied to many areas of social, cognitive and behavioral psychology including perception, decision-making, stereotyping, and social attitudes [14, 16, 17]. Although these theories differ in their applications, definitions, and domains, they share a common assumption that there are two information processing systems operate to make decisions and shape behavioral outcomes: an automatic and a reflective system [14]. Many terms have been used to describe these processes such as heuristic versus analytic [18], automatic versus controlled [19], impulsive versus reflective [20], system one versus system two [21], and type one versus type two [19]. Automatic processes are characterized by a spontaneous, unconscious reaction to events or objects (i.e., cues) and involve constructs such as habits and automatic evaluations (AE). On the other hand, reflective processes represent conscious deliberation on available information and invoke constructs such as intentions, efficacy beliefs, outcome expectations and plans [19, 20]. There is now an established body of literature that has applied dual-process theories within the exercise and PA domain [9, 22-25].

The relationship and the interaction between these two systems (e.g., automatic and reflective) have been conceptualized in several theoretical models. One such model is the reflective-impulsive model (RIM) [20] that has been widely applied to exercise and PA behavior. Based on RIM, both reflective and impulsive systems activate simultaneously but independently and compete for control of an overt response. RIM discusses several determinants that may influence the components of reflective and impulsive systems that moderates the activation of behavioral schemata. For instance, distractions or extremely high or low level of arousal may interfere with reflective processes due to high cognitive demand related to the reflective system. In contrast, implicit system requires little to no cognitive effort and therefore may control behaviors under suboptimal conditions (e.g., self-control resources are low, cognitive capacity is diminished). Meanwhile, accessibility of the content and the strength of associative links among representations in the implicit system can also influence the directions of the behavioral schemata.

Consequently, the two processes may jointly activate behavioral schemata and facilitate behavior output (e.g., approach-approach), or they may compete with one another if they activate opposing schema (approach-avoidance) [20]. There are several different hypothetical patterns have been proposed by which these two processes interact with one another. In the first type of pattern, referred to as the double dissociation pattern, spontaneous behavior is predicted by the automatic system, while conscious behavior is predicted by the reflective system. This type of pattern is characterized by two psychological processes that function independently from one another [26]. In another type of pattern, referred to as the additive pattern, both systems explain unique variance in one behavior, and the effects of each process add together to influence behaviors [27]. In this type of pattern, behaviors result from the sum of the effects of automatic and reflective processes. The final type of pattern is the interactive pattern, which is characterized by automatic processes interacting with reflective processes to influence behaviors. In this type of pattern, both systems interact to activate behavior schemata [27].

Brand & Ekkekakis [28] developed the affective-reflective theory (ART) of physical inactivity, conceptualizing the sedentary behavior (SED) from the perspectives of dual-process models. The ART focuses on governing behavioral processes at the momentary state of physical inactivity. Based on the ART of physical inactivity, sedentary individuals automatically initiate the behavior response of inactive despite the conscious intentions to be active because their motivation to change is not strong enough at the moment of stimulation [28]. In other words, the pleasurable affect associated with being seated serves as a stronger motivator when encountered with explicit evaluation to exercise. Collectively, these theories highlight the importance of not only the automatic processes but also the interaction of the two information-processing systems in guiding PA behavior. Understanding this interaction may play a crucial role in developing interventions that potentially lead to long-term behavioral change.

Automatic Processes and Physical Activity Behaviors

A growing body of research has evaluated the AE of PA [9, 23, 29-31]. These studies examined the association between various measures of automatic processes (e.g., implicit attitudes/affective evaluation, attentional biases, approach-avoidance behaviors) and self-reported or objectively assessed PA behaviors. Their results, collectively, indicated that automatic processes predicted PA behavior [15, 32, 33] as well as exercise adherence [34]. Experimental studies examining the malleability of automatic processes related to PA behavior using affective conditioning techniques such as computer-based positive-affective training [34, 35] further support the role of automatic processes on PA behavior.

As described in RIM, there are many determinants that interplay within the dual processes. Several studies examined moderating effects of those factors (e.g., trait impulsivity, components of executive functions and trait personality indices) that may influence the activation of behavioral schemata through automatic processes. Cheval et al. [30] found automatic approach tendencies toward SED showed a strong negative association with objectively measured PA in individuals with a higher level of impulsivity. Similarly, Chevance and colleagues [31] found greater positive AE towards SED significantly impeded PA levels in individuals with low or moderate levels of executive function, but not with higher levels of executive function. Additionally, trait motivational tendency (based on reinforcement- sensitivity theory) have been reported to correlate with AE measures [36, 37]. The reinforcement-sensitivity theory proposes that behavior is triggered by two underlying motivational systems.

The Behavioral Activation System (BAS) is responsible for guiding goal-directed behavior, whereas the Behavioral Inhibition System (BIS) is responsible for guiding behavioral responses to threats [38]. The BIS/BAS components of the motivational tendency have shown significant correlation with PA affect [39], however, it has not been studied in context with AE in PA domain. Aside from these studies, relatively little is known about the moderating factors of individuals differences on the relationship between AE and PA behavior.

Low rates of PA in the general population are potentially explained by the fact that most people experience a negative affective response during many types of PA [40]. Lee, Emerson, & Williams [1] examined this negative affective response from an evolutionary perspective by addressing the question of why individuals engage in PA and what the functional significance of avoiding PA behavior is. For our evolutionary ancestors, avoiding predators and gathering food from scarce resources involved extensive energy expenditure. Expending energy through any extraneous PA had no purpose and would have decreased survival chance and reproductive fitness. As such, the proximate cause of the low adherence rate of PA is the human tendency to respond to PA with negative affect; and the ultimate cause is the human tendency to conserve energy [1]. To examine whether conserving energy is innately attractive to individuals, Cheval, Sarrazin, Boisgontier, and Radel [41] used words related to behaviors minimizing energetic costs (BMEC) as a primer in the context of PA goals using primed lexical decision task. The BMEC-related cues lead to the automatic activation of PA goals, particularly in successful exercisers. This demonstrates that BMEC act as a temptation that activates threatened goal (i.e., PA goal) based on asymmetric temptation- goal cognitive association [42]. Successful exercisers may have formed a strong cognitive association between BMEC and PA goals that their PA goal is protected against temptations such as BMEC. However, the BMEC primes and consequent activation of PA goals did not predict PA behaviors [43].

The role of AE in influencing PA behavior is increasingly recognized as a critical component that either accelerates or interferes with PA-related goals. These automatic processes are distinct from the reflective system and are associated with both quantity and quality of PA behaviors [9]. Repeated activation of positive associations with exercise strengthened the exercise affective evaluation association, indicating its potential as a modifiable target for long-term behavior change [34]. Hence, understanding automatic processes involved in the PA domain is an important consideration when developing more effective interventions aimed at increasing PA and reducing SED.

Measurement of Automatic Evaluation

A number of reaction time (RT) measures have been used to assess the AE of PA. These include the extrinsic affective Simon task [44, 45], sequential priming paradigms [46-48], impulsive approach-avoidance tasks (AAT) [32], and variants of the Implicit Association Test (IAT) [15, 49-51]. Although the procedures may differ, all of these methods are designed to measure the strength of AE processes. Among these measures, the most commonly used in the PA domain is the IAT. In a typical IAT, the participant is asked to pair target concepts (e.g., PA or SED) with attributes (e.g., good or bad). Across a series of trials, participants are asked to associate stimuli depicting target concepts (in the form of words or images) with various attributes. If a participant responds faster when a target concept is paired with positive attributes, versus when paired with negative attributes, then the participant is thought to have implicit favorability towards that target concept. A limitation of the IAT, particularly in the PA domain, is that the two target concepts (i.e., PA and SED) are not always apparent polar opposite to one another [24]. Much of the past research highlighted that SED and motivation towards SED influence PA behavior independently from PA motivation [52, 53]. The absence of an appropriate target concept opposite to another can limit the interpretation of the IAT.

Variants of the IAT, such as the Single-Category Implicit Association Test (SC-IAT) [54] and Brief Implicit Association Test (BIAT) [55], have been developed to overcome such a limitation. The SC-IAT uses one target concept, where the target concept is not compared to any other category. Eliminating the comparative target concept allows the test to be interpreted in absolute terms. The SC-IAT is the most widely applied AE measure in the PA domain and has demonstrated that the AE significantly predicted objectively measured PA [33]. Although the SC-IAT is the most widely used and accepted measurement for AE, there is still a lack of evidence regarding the stability of SC-IAT in the PA domain [25].

A few studies have used the AAT in PA contexts using manikin tasks [23, 30, 56]. The investigators studied impulsive approach tendencies toward PA and SED by asking the participants to move a manikin figure towards a PA image and away from a SED image, or vice versa. The approach or avoidance tendencies are calculated using differences in the mean or median RTs between the approach and avoidance trials.

Although the specific procedures and sequences differ among AE measures, all use target stimuli as well as attribute words or images to assess the targeted concepts. Undeniably, the choices of words or images are extremely important. More specifically, by including or not including certain types of PA, these tasks may not fully capture the AE of the PA-related behaviors [24]. Most studies testing the AE of PA have conceptualized PA and exercise as the same category. While both represent active behavior, the context of the behavior can be different. In public health literature, PA is defined as any bodily movement produced by skeletal muscles that result in energy expenditure. On the other hand, exercise is a subset of PA that is comprised of planned, structured, and goal-oriented behaviors that have the final objective of improving or maintaining physical fitness [57]. There are also other types of PA such as non-leisure time activities (NLTPA) which include occupational or household activities, which are not performed to improve fitness, but rather to accomplish daily tasks. While some studies have focused more on PA-related stimuli such as walking or hiking [15, 33], others have examined the AE of exercise such as running or gym workouts [58, 59]. However, no studies have examined whether there are distinct differences in the AE of PA based on varying components of PA such as light- versus vigorous-intensity activities and leisure time versus non-leisure time. PA is a complex behavior with many components that vary, such as the intensity of the PA, whether the PA was willful or compulsory, or whether the PA was performed on a weekday or weekend [57]. These components of PA may differ in the association of AE and PA behavior. Past researchers have postulated that AE is more relevant for non-intentional or spontaneous activities compared to more planned activities [15]. Similarly, relatively intense activities may be regulated by reflective systems while less intense activities may be regulated by more automatic processes [12]. However, no studies have attempted to empirically determine the effects of different properties of PA on the AE of PA. Hence, it is unclear whether the distinction of exercise versus NLTPA will moderate the AE of PA.

Research Objectives

Recent investigations have highlighted the significance of the AE in regulating PA behavior and its potential application for improving health promotion efforts. Nonetheless, this seminal line of research is still in its early phases. There are many lingering questions pertaining to the stability of AE measurements and potential differences in the AE of different PA behaviors. Furthermore, it is unclear how participant characteristics may influence these relationships (if at all). It seems logical then to address the knowledge gaps that could inform some of the most basic questions we have regarding the AE of PA behavior. Therefore, the overall objective of this dissertation is to expand upon the existing body of research by investigating important gaps in our current understanding of automatic regulatory processes regarding PA. Specifically, how varying components of PA influence not only the AE of PA but also the stability of these measures. Additionally, to expand our understanding of the theory of energetic cost minimization (TECM), this dissertation investigated impulsive approach tendencies towards behaviors that are energetically costly versus energetically efficient (e.g., taking stairs versus taking an elevator).

Specific Aims and Hypotheses

The purpose of this dissertation is to examine automatic and reflective processes in relation to PA and SED. Specific purposes for each individual study are described below:

Study 1.

Aim 1. Investigate the AE of four different components of PA domain: exercise, light and moderate-to-vigorous intensity NLTPA (L-NLTPA and MV-NLTPA), and SED. It is *hypothesized* that light intensity activities would be more closely associated with AE, whereas planned behaviors, such as exercise, would be associated with reflective processes.

Aim 2. Examine the interaction of automatic and reflective processes (i.e., PA intentions and PA self-efficacy) on PA behaviors. It is *hypothesized* that reflective processes partially mediate the relationship between automatic processes and PA-related behaviors.

Aim 3. Examine how executive function and personality measures moderate the relationships among automatic processes, reflective processes, and PA-related behaviors. We *hypothesized* that executive function and personality measures will partially mediate the relationships among automatic processes, reflective processes, and PA-related behaviors.

Study 2.

Aim 1. Examine the stability of the AE of several PA-related stimuli, namely, exercise, L-NLTPA, MV-NLTPA, and SED. It is *hypothesized* that the SC-IAT will demonstrate as a stable measure across this range of PA components.

Aim 2. Examine whether the stability of AE measures is influenced by explicit attitudes of PA (i.e., PA intentions, PA self-efficacy). We *hypothesize* that stability was related to the strength of explicit attitudes towards PA behaviors.

Study 3. Examine the hypothesis that automatic approach versus -avoidance tendencies inform our decision-making processes to engage in energy-conserving versus energy-expending activities (e.g., taking an elevator versus climbing stairs). We *hypothesize* that individuals exhibited innate tendencies to conserve energy.

Significance of the Dissertation

Little is understood about the automatic regulation of PA and SED. The three studies in this dissertation address important gaps in the research concerning the application of dual-process theories in PA-related behavior. Study 1 expands on previous findings by examining the AE of four different components of PA domain and their interactive influence on objectively measured PA behavior. Study 2 evaluates the stability of AE measures of four different PA-related stimuli. Study 3 examines the automatic tendencies towards particular behaviors, namely, activities that conserve energy versus activities that expend energy. Collectively, these studies broaden our understanding of the interplay between automatic and reflective processes in regulating PA behavior.

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CHAPTER 2

AUTOMATIC EVALUATION OF EXERCISE, NON-LEISURE TIME PHYSICAL ACTIVITY, AND SEDENTARY BEHAVIOR

ABSTRACT

Grounded in dual-process theories related to physical activity (PA) behavior, both reflective and automatic processes have been shown to predict PA. However, relatively little is known about the interaction or relative contributions of these two processing systems in relation to PA behavior. **PURPOSE:** To examine the relationships among automatic and reflective processes (i.e., PA intentions) across four different PA domains (i.e., exercise [EX], light [LPA] and moderate-to-vigorous intensity non-leisure time PA [MVPA], and sedentary behavior [SED]), and explore how individual factors modulate these associations. **METHODS:** Participants (≥18 years old) completed a Single Category Implicit Association Test (SC-IAT) measuring implicit attitudes towards PA and SED behaviors using images depicting the four different PA domains. They also completed questionnaires measuring PA intention and PA self-efficacy (SES). Habitual PA was measured using an accelerometer. Multiple regression analyses were used to examine whether AE predicted unique variance in levels of PA after controlling for PA intentions and SES. **RESULTS:** Sixty-six participants (63% women; 83% White; 92% students) were included in our final sample (M±SD: 23±8 y, 26.2±19.1 kg/m^2). AE of EX was significantly correlated with time spent in MVPA ($r=0.28$, $p=0.02$). Both SES and PA intentions interacted with AE of EX to predict MVPA ($\beta=0.31$, $p=0.02$ and $\beta=0.30$, $p=0.01$, respectively) and total activity counts per day (a measure of total PA $\beta=0.31$, $p<0.01$ and $\beta=0.31$, $p=0.01$, respectively). Simple slope analysis revealed AE of EX is positively correlated with MVPA and Total PA when there is high intention and high self-efficacy. **CONCLUSIONS:** AE of exercise significantly correlated with MVPA and Total PA, particularly in individuals who are highly active. Caution is warranted in generalizing our findings to other samples as ours was comprised of healthy, active, college-aged adults.

INTRODUCTION

New and emerging research that applies dual-process theories (DPT) to physical activity (PA) behavior has shown that PA is, at least in part, regulated by automatic processes [1-4]. In general, DPT assumes that there are two information processing systems regulating human behavior: A reflective system and an automatic or impulsive system [5]. The reflective system is characterized by deliberate, conscious, and explicit processing, while the automatic system is characterized by non-reflective, implicit, and non-deliberative processing [6]. These two systems may jointly activate behavioral schemata and facilitate behavior output, or they may compete with one another if they activate opposing schema [7].

This interaction between reflective and automatic precursors of PA behavior has been supported by several studies [2, 8-10]. These studies examined the association between various measures of automatic processes (e.g., implicit attitudes/affective evaluation, attentional biases, approach-avoidance behaviors) and self-reported or objectively assessed PA behaviors. Their results, collectively, indicated that automatic processes predicted PA behavior [2, 10, 11], as well as exercise adherence [12]. Experimental studies examining the malleability of automatic processes related to PA behavior using affective conditioning techniques such as computer-based positive-affective training [13, 14] further support for the role of automatic processes on PA behavior. Taken together, these studies highlight the importance of automatic processes in regulating PA behaviors and indicate the potential usefulness of targeting automatic processes in interventions designed to increase PA and improve exercise adherence.

Automatic evaluation (AE) of health behaviors has been studied extensively, albeit using different measures of automatic processes such as attentional biases, approach-avoidance, and affective valence [2, 3, 15, 16]. AE processes involve the perception of a concept or event, in this case PA, as pleasant/positive or unpleasant/negative, and this instantaneous evaluation occurs outside of a person’s awareness. This type of evaluation, i.e., pleasant/positive or unpleasant/negative, results in behavioral tendencies to approach or avoid the concept or event [17]. AE has been assessed with a variety of implicit measures such as the Implicit Association Test (IAT), evaluative priming tasks, and impulsive approach tendency tasks [6]. Although the measurement procedures may differ, the purpose of these tasks is to assess the strength of association between a target concept (e.g., PA) and affective response (i.e., pleasant/positive or unpleasant/negative affect) by measuring the accuracy and the speed of the response task. A variant of the IAT, the Single Category Implicit Association Test (SC-IAT), is the most commonly used task in the PA behavior literature due to its improved predictability of objectively measured PA compared to the original IAT [3]. The main advantage of the SC-IAT is that it uses a single target concept (e.g., PA) that does not need to be compared with any other concepts (e.g., sedentary). However, the validity of the SC-IAT, and other implicit measures, is, in part, dependent on how well the stimuli—words and images—represent the target constructs (e.g., PA, positive concepts) [18]. Hence, it is imperative that future research studies use stimuli that *fully* represent the targeted behaviors [4].

In general, exercise and PA have distinctly different meanings in exercise science and public health literature. PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. Exercise is a subset of PA that is planned, structured, and goal-oriented aimed at improving or maintaining physical fitness [19]. PA can be further distinguished by the *type* of activity being performed. For example, occupational PA, transportation PA, household PA, and leisure-time PA (LTPA) [20]. In contrast to LTPA (including exercise), occupational, transportation, and household PA, *or non-leisure-time PA* (NLTPA), are performed to accomplish specific daily tasks rather than for leisure or for improving a component of fitness. The distinction between LTPA and NLTPA is important because focusing only on LTPA underestimates total PA. While some studies focused more on activities such as walking or hiking [3, 4, 10], others have examined the AE of exercise specifically (e.g., running or gym workouts) [12, 21], and few have examined sedentary behavior (SED) [2, 22, 23]. Past researchers have postulated that AE is more relevant for non-intentional/spontaneous activities (i.e., NLTPA) than planned activities (i.e., exercise) [24]. Similarly, relative intense activities are regulated by reflective systems while less intense activities may be regulated by more automatic processes [25, 26]. However, no studies have examined whether there are distinct differences in the AE of PA based on varying components of PA such as light- versus vigorous-intensity or leisure versus non-leisure time activities. These components of PA may represent different affective association in individuals (e.g., one might have positive association with exercise but have negative association with NLTPA) which could be a determining factor their activity pattern.

As described in the reflective-impulsive model [7], there are many determinants that interplay within the dual processes. Several studies examined moderating effects of those factors (e.g., trait impulsivity, components of executive functions and trait personality indices) that may influence the activation of behavioral schemata through automatic processes. Cheval et al. [27]

found automatic approach tendencies toward SED showed a strong negative association with objectively measured PA in individuals with a higher level of impulsivity. Similarly, Chevance and colleagues [28] found greater positive AE towards SED significantly impeded PA levels in individuals with low or moderate levels of executive function, but not with higher levels of executive function. Additionally, trait motivational tendency (based on reinforcement-sensitivity theory) have been reported to correlate with AE measures [29, 30]. The reinforcement-sensitivity theory proposes that behavior is triggered by two underlying motivational systems. The behavioral activation (or approach) system (BAS) is responsible for guiding goal-directed behavior, whereas the behavioral inhibition (or avoidance) system (BIS) is responsible for guiding behavioral responses to threats [31]. The BIS/BAS components of the motivational tendency have shown significant correlation with PA affect [32], however, it has not been studied in context with AE in PA domain. Aside from these studies, relatively little is known about the moderating factors of individuals differences on the relationship between AE and PA behavior. In order to extend initial efforts investigating the joint role of both the reflective and automatic systems on PA behavior, the current study more comprehensively examined the interaction between these systems including investigating the moderating role of executive function and personality trait measures.

It should be appreciated that most of the studies conducted to date include students recruited from a college/university population [13, 33, 34] or older adults [22, 28]. This lack of diversity among study participants further impedes our understanding of the AE of PA behavior. As such, the current study attempted to include a large and diverse sample in terms of age, gender, body mass index (BMI), habitual PA level, income, education, and type of employment to explore the potential impact of these covariates on the automatic and reflective processes related to PA behaviors.

In an attempt to answer the gaps in the research to date outlined above, the current study addressed the following aims:

Aim 1. Investigate the AE of four different components of PA domain: exercise, light and moderate-to-vigorous intensity NLTPA (L-NLTPA and MV-NLTPA), and SED. It is *hypothesized* AE differ by the component of PA domain.

Aim 2. Examine the interaction of automatic and reflective processes (i.e., PA intentions and PA self-efficacy) on PA behaviors. It is *hypothesized* that reflective processes partially mediate the relationship between automatic processes and PA-related behaviors.

Aim 3. Examine how executive function and personality measures moderate the relationships among automatic processes, reflective processes, and PA-related behaviors. We *hypothesized* that executive function and personality measures will partially mediate the relationships among automatic processes, reflective processes, and PA-related behaviors.

METHODS

Due to COVID-19 precautions and restrictions, we allowed participants to participate via two methods of delivery: (1) In-person study participation and (2) Remote study participation. For in-person study participation, participants were invited to visit the laboratory on two separate occasions separated by a minimum of 7 days and a maximum of 10 days. For remote study participation, participants were invited to meet with the researcher using the Zoom video-conferencing platform. In both study methods, participants underwent the same measures of AE, reflective processes, and executive function tasks. In-person study participants were instructed to wear an accelerometer for 7 days. Remote study participants did not wear an accelerometer.

Participants

Faculty, staff, and students from The University of Alabama were recruited as participants for this study. All participants speak English as their first language and have no medical conditions that impair language perception or restrict regular PA participation. Overall, 104 participants were included in the study, 87 participated in person and 17 participated remotely. Of the 87 participating in-person, 4 participants dropped due to time conflict, 2 participants did not have accelerometer data due to malfunction of the device, and 15 participants did not reach accelerometer wear-time cut-off. This resulted in a final sample of 66 participants who were included in the analyses. Data from remote participation was not included in the analysis.

Research Design

During their initial visit to the laboratory, participants completed an informed consent prior to baseline measurements. Participants' height was measured with a manual stadiometer (SECA, Birmingham, UK) to the nearest mm. Weight was measured to the nearest 0.1 kg using a digital scale (Detecto DR 400, Missouri, USA). Height and weight were used to calculate BMI, expressed as $kg \cdot m^{-2}$, and then categorized as normal weight (18.5-24.9 $kg \cdot m^{-2}$), overweight (25 to 29.9 $kg \cdot m^{-2}$), and obese ($\geq$30 $kg \cdot m^{-2}$) [35]. Participants completed a series of computer-based tasks to assess the AE of PA-related behaviors (SC-IAT) and executive function task (Go/No-Go task). The order of these computerized tasks was randomized. Following the computerized tasks, participants completed a health history and demographics questionnaire, and self-report measures of reflective measures (self-efficacy, PA intentions, PA enjoyment scale). Last, participants were instructed to wear an accelerometer during all waking hours for 7 consecutive days. Participants returned to the laboratory after at least 7 days but no more than 10 days for visit two, where they returned their accelerometer and activity log to study personnel.

For remote participation, participants were invited to meet with the researcher using the Zoom video-conferencing platform. During their online meeting, participants completed informed consent and health and demographic questionnaire online via UA Qualtrics. Remote study participants self-reported their height and weight. Height and weight were then used to calculate BMI ($kg \cdot m^{-2}$), and categorized using the same methods described above. For the computerized tasks, participants were provided with a link to the testing packet through E-Prime Go, a remote data collection platform for E-Prime 3.0 Behavioral Research Software (Sharpsburg, PA). We asked the participants to silence their phone, alerts, music, and anything else distracting before starting the task. In addition, we asked the participants to have the Zoom meeting/connection on a separate device such as smartphone, iPad, or laptop to prevent any distractions during the tasks. Following the computerized tasks, participants completed self-report measures of reflective measures (self-efficacy, PA intentions, PA enjoyment scale), and the International Physical Activity Questionnaire Long Form (IPAQ-LF) [36] online via UA Qualtrics.

The measures for both studies are described in detail below.

Procedures

Contextual Stimuli

We conducted a pilot study to determine whether the images to be used in the AE tasks are most representative of the target concepts. A survey was distributed to students and faculty/staff campus-wide asking participants to classify each of the 29 images as a representation of one of the following categories: (1) SED behavior; (2) activity of daily living requiring low effort; (3) activity of daily living requiring moderate-to-vigorous effort; and (4) exercise. To minimize the bias associated with pictures depicting real people, an art designer designed pictograms representing various activities (see Appendix B). After categorizing the image, participants indicated the degree of certainty in their selection based on a 3-point scale: 1= uncertain, 2= certain, 3= very certain. Images resulting in the most accuracy and certainty were selected to be used for the current study. Less accurate images were further analyzed to evaluate any group differences among the participants (i.e., faculty/staff versus students). Based on the results of the pilot study, we modified some images to increase the accuracy with which they are perceived. Participants of the current study were also surveyed at the end of their participation regarding their ability to categorize the images accurately and with certainty. In addition, participants were asked to rate their perception of images as being less or more effortful on a scale of 0 to 10.

AE Measures

Single Category Implicit Association Test. The SC-IAT was used to measure the AE of the target concepts: Exercise (EX), light (L-NLTPA and moderate-to-vigorous intensity NLTPA (MV-NLTPA), and SED. The SC-IAT has demonstrated internal reliability (r=0.21-0.41) and predictive validity [37-39]. In this computerized task, the target concepts were represented by images depicting the target concepts (see Appendix B). The comparative categories were labeled as 'good' and 'bad' and consisted of positive or negative valence words related to feelings and experiences with PA (e.g., positive valence: beautiful, happy, delightful, energetic; negative valence: awful, agonizing, horrible, painful). Participants started the SC-IAT with 24 practice trials where the participants were asked to categorize positive or negative valence words quickly and accurately. Following the practice trial, the participants completed 4 blocks of experimental trials, each consisting of 72 test trials (see Table 2.1 for a detailed description of the experimental procedure). During the experimental trials, the stimuli (images depicting the target concept, positive and negative words) were presented randomly. The participants were asked to categorize each stimulus to the correct category labels that are presented at the top of the screen by pressing either the “Q” key or the “P” key on the keyboard. For example, when ‘exercise + good’ is presented at the top left corner of the screen and ‘bad’ is presented at the top right corner of the screen, the participants categorized the exercise-related images and ‘good’ words by pressing the ‘Q’ key, and ‘bad’ words by pressing the “P” key on the keyboard. Participants were instructed to categorize the images and words as quickly and as accurately as possible. If participants responded incorrectly (e.g., categorize exercise-related images into the ‘bad’ category), a red “ERROR” appeared on the screen before the next stimulus was presented.

AE was scored using the D-score algorithm [40]. Reaction times (RT) of less than 350 ms and more than 10,000 ms were eliminated from scoring for each test block within each experimental phase. After eliminating erroneous RT values, the mean (±*SD*) response value for each block was calculated. The difference between the average RT of the two critical blocks (block 1 and 2) were divided by the pooled SD of the RTs. The AE score for each of the target concepts was calculated as:

$$\text{D-Score} = \left[\frac{\text{Average RT}_{\text{Block2}} - \text{Average RT}_{\text{Block1}}}{\text{SD}_{\text{Pooled}}}\right],$$

where positive scores indicate a stronger association of AE toward the targeted behavior. D-scores were calculated for each domain separately.

Executive Function Measures

<u>Go/No-Go Task.</u> One of the important components of executive function is inhibitory control (IC), which refers to the ability to stop, change, or delay behavioral responses [41]. IC

was measured using a computerized Go/No-Go task that assesses the participant's ability to inhibit a habitual motor response when prompted by a stimulus (PA and SED) and their ability to shift attention. Participants were presented with images depicting PA and SED as stimuli (see Appendix B). During the task, participants were instructed to press the space bar of the keyboard as quickly as possible to target stimuli but withhold responses to distractor stimuli. Images were presented one by one for 500 ms in a randomized order followed by an inter-trial interval of 900 ms. The task was comprised of 2 practice blocks, followed by 8 experimental blocks. In each block of the task, either PA or SED-related images were identified as targets or distractors. Target stimuli were presented in an order of either PA-PA-SED-SED-PA-PA-SED-SED or SED-SED-PA-PA-SED-SED-PA-PA. This arrangement of the blocks creates 4 shift (PA-SED or SED-PA) and 4 non-shift (PA-PA or SED-SED) blocks (counterbalanced across the participants). The number of which participants erroneously pressed to a no-go stimulus (i.e., commission error) was used as a performance indicator for IC with a greater number indicating lack of IC towards the target concepts [41].

Behavioral inhibition (or avoidance) system and behavioral approach (or activation) system. The BIS/BAS scales [31] were used to measure certain aspects of participants' personalities. This 24-item questionnaire indicates the degree to which individuals engage in approach and avoidance behaviors (Appendix C). Responses are recorded using a 5-point Likert scale, indicating "strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, or strongly agree". Test-retest correlations over an 8-week period among college students (n=732) showed satisfactory reliability (r=0.59 to 0.69) [31]. Carter and White [31] also reported correlations with other related measures tapping similar domains such as positive and negative affect schedule, general temperament survey, and a tridimensional personality questionnaire. The

BAS subscales were positively correlated with extraversion positive affect and positive temperament (r=0.31 to 0.41), while BIS subscales were correlated moderately with trait anxiety, negative affect, and negative temperament (r=0.42 to 0.59). An example from the BIS subscale is, “If I think something unpleasant is going to happen, I usually get pretty ‘worked up’. The BAS scale measured three BAS subfactors, corresponding to reward responsiveness (BAS-RR), drive (BAS-Drive), and fun-seeking (BAS-FS). In this sample, the BIS and BAS scales had acceptable internal consistency (Cronbach’s alpha range: 0.79 to 0.83).

Reflective Measures

PA self-efficacy was measured using the 10-item Self-Efficacy Scale (SES) [42] that assesses the degree of confidence one has in achieving their PA intentions despite various barriers (see Appendix D). The barriers include items such as, “I am feeling tired”, “I have worries and problems”, and “I feel depressed”. The participants were asked to rate their confidence as a percentage from 0 to 100 in 10 percent increments (0=Not at all confident, 50=Moderately confident, and 100=Highly confident) as recommended by Bandura [42]. The internal consistency of SES was demonstrated with Cronbach alpha=0.91.

Intention to engage in PA most days of the week was assessed on two dimensions: Decisional intention, measured with a yes/no question, and Intention strength, using a 5-point Likert scale [43].

The Physical Activity Enjoyment Scale (PACES) [44] is an 18-item scale that assesses enjoyment of PA (see Appendix E). Participants were asked to rate how they feel at the moment about the PA they have been doing on a 7-point bipolar Likert scale, from 1 (*I enjoy it*) to 7 (*I hate it*). Eleven items were negatively worded, and seven items were positively worded. After reverse scoring the 11 negatively worded items, an overall enjoyment of physical activity score is determined by summing the items, with a range of 18–126 being possible. Higher scores indicate higher enjoyment. The PACES has demonstrated acceptable internal consistency with Cronbach alpha=0.80.

PA Measures

Habitual PA level was assessed using an accelerometer (ActiGraph, GT3X+, ActiGraph Corporation, Pensacola, FL, USA). Participants were given an accelerometer, along with instructions on how to wear the accelerometer and how to track their wear time and daily activities at the end of Visit 1. The ActiGraph is a small, lightweight triaxial device that measures body motion on three planes of movement. Participants were instructed to wear the accelerometer during all waking hours, except when swimming or bathing, for 7 consecutive days. A valid day was defined as ≥10 hours of wear time, and participants were required to have a minimum of three valid days to be retained in the analyses [44]. Objectively measured daily PA was quantified as time spent (min/d) engaging in LPA, MVPA, and SED activities in the last week (7-d). Total activity count per day (tac/d) was used as an index of total PA, with the main advantage being that it captures all intensity categories and weights per minute according to the frequency and intensity of movement. It has also shown stronger associations with cardiovascular markers than MVPA bouts derived from threshold-based cut-points [45]. Estimated PA cut points were determined using the validated Freedson adult vector magnitude algorithm [46]. Actigraph data were aggregated to 60s epochs. A cut-point of ≤150 counts/min was employed to define SED activity [47]. All accelerometer data were reviewed and compared with the participant's PA log before being processed via ActiLife data analysis software (ActiGraph Link, ActiGraph Corporation, Pensacola, FL, USA).

PA history index. As part of the demographic questionnaire, we asked the participants to rate their current level of PA (1=SED, 2=Low, 3=Moderate, 4=Recreationally Active, 5=High/Athlete) and how long they have been at this level of activity expressed in months. We then multiplied these two variables to obtain a measure of PA history expressed as PA history index (PA-his).

Statistical Analysis

AE of PA

In Aim 1, we investigated the AE of four different components of the PA domain using the SC-IAT. D-scores were calculated for each target domain: Exercise (D-E), L-NLTPA (D-L), MV-NLTPA (D-MV), and SED (D-SED). Visual inspections of histograms and scatterplots were used to identify potential outliers and to evaluate assumptions of normality. Winsorizing was utilized to correct outliers with implicit tasks, consistent with previous studies [28]. One-way repeated measures analysis of variance (ANOVA) was utilized to compare the AE of the different PA domains. In addition, a series of bivariate correlation analyses were used to assess the relationships between the AE measures and selected covariates (e.g., age, sex, PA level, BMI, PA intention, IC of PA and IC of SED, SES, BIS/BAS, and PACES).

To estimate the internal consistency of AE measures, the test trials were separated into two halves and D-scores were calculated for each half. Spearman-Brown correction for split-half reliability was used to determine the internal consistency. This follows the process of determining internal consistency outlined in previous studies [10, 37, 40].

Multivariate Analyses Predicting PA Behaviors

In Aim 2 and 3, we investigated the interaction of AE and PA intentions on PA behaviors while controlling for potential covariates. In order to test this aim, we used hierarchical multiple regression analysis. This method was selected so that we could evaluate the relative impact of covariates of interest when comparing the main predictor variables to PA behaviors. Before conducting our main analyses, tests of linearity, normality, and homoscedasticity were evaluated to ensure that assumptions of multiple regression analysis were met.

We performed a series of linear regression analyses to investigate the unique variance predicted by AE measures and PA intention on PA behaviors. D-scores (D-E, D-L, D-MV, D-SED) and PA intentions were entered as the main predictors of PA behaviors (Total PA, LPA, MVPA, SED). Each target domain was analyzed separately by its specific PA behavior (i.e., D-L and PA intention were entered as predictors of LPA). We first examined the effects of both automatic and reflective measures (i.e., D-scores and PA intention) independently on each of the PA domains while controlling for correlates such as IC, BIS/BAS scores, SES, PACES, and PA-his (Step 1). Next, we examined the conditional effect of AE × PA intentions on each of the four PA domains (two-way interaction; Step 2). We then conducted separate moderated moderation analyses (three-way interaction) to test whether the conditional effect of AE scores and PA intentions on PA measures varied depending on the aforementioned covariates of interest (Step 3). In an effort to reduce the number of parameters estimated in a single model, interactions were examined in separate regression models. Significant interactions were conditioned at high (+1 SD) and low (-l SD) levels of the moderator to determine the nature of the interactions [48]. All data were analyzed using SPSS (SPSS version 27.0, Chicago, IL, USA). P-values of ≤0.05 were regarded as statistically significant.

RESULTS

Descriptive Statistics

Descriptive data of the participants are shown in Table 2.2. Sixty-six participants (63% women; 83% White; 92% students) were included in the analyses with mean age (±*SD*) of 23±9 years. Based on accelerometer data, participants spent most of their waking hours performing light activities (773.4±70.8 min/d) and spent 53.4±26.1 min/d performing MVPA. Participants spent approximately 8 hr/d (505.3±82.7 min/d) in SED behavior. Most participants (80%; n=53) met the recommended minimum level of PA based on public health guidelines [20]. There were no significant sex differences in the PA and AE measures. Women had a greater BIS score (p=0.003) than men. There were no significant differences among the AE measures for the four domains of PA (D-E, D-L, D-MV, and D-SED) and no significant sex differences as well. Internal consistency of D-E showed moderate reliability (Spearman-Brown coefficient=0.61), however poor consistencies were shown for D-L, D-MV, and D-SED (Spearman-Brown coefficients: 0.07, 0.03, and 0.26, respectively). Hence, further analyses included D-E only.

Correlational Analyses

Bivariate correlations among PA measures, D-E, PA intention, and other variables are presented in Table 2.3. D-E was positively correlated with MVPA (r=0.28, p=0.02), total PA (r=0.27, p=0.02), and was negatively correlated with LPA (r=-0.29, p=0.02) and SED (r=-0.24, p=0.04). When comparing highly active vs. less active individuals (dichotomized based on median total activity count), D-E was significantly correlated with MVPA (r=0.59, p<0.01) and Total PA (r=0.54, p<0.01) in highly active individuals only. PA intention was negatively correlated with LPA (r=-0.32, p<0.01). Both BAS-Drive and SES were significantly correlated with Total PA (r=0.26, p=0.03 and r=0.38, p<0.01, respectively) and MVPA (r=0.26, p<0.01 and r=0.35, p<0.01, respectively). BAS-Drive and SES were significantly correlated with each other (r=0.41, p<0.01). PA intention was also significantly correlated with BAS-Drive (r=0.32,

$p<0.01$) and SES ($r=0.41$, $p<0.01$). PA-his was correlated with total PA ($r=0.36$, $p<0.01$), SES ($r=0.31$, $p=0.01$), BAS-Drive ($r=0.25$, $p=0.04$) and PA intention ($r=0.26$). Given that the BAS-Drive subscale had a significant correlation with the PA variables, this scale was used in further analyses.

Independent effect of AE and PA intention measures on PA behaviors

The results of regression analyses are summarized in Table 2.4.

<u>Predicting LPA</u>: Both D-E and PA intention were significantly and negatively correlated with LPA, and these relationships remained after controlling for the covariates.

When predicting LPA, a significant two-way interaction between D-E and PACES emerged ($F(3,61) = 4.97$, $p<0.01$, $R^2=0.20$). Simple slope analysis indicated that D-E was negatively associated with LPA in participants with low PA enjoyment ($\beta=0.26$, $p=0.04$). In addition, D-E approached statistical significance when entered with PA-his as predictor of LPA ($F(3,62) = 2.55$, $p=0.06$; $R^2= 0.11$).

<u>Predicting MVPA</u>: Significant two-way interactions emerged when predicting MVPA including D-E × Intention ($\beta=0.30$; $p=0.01$), and D-E × SES ($\beta=0.31$; $p=0.01$). Simple slope analysis revealed D-E is positively correlated with MVPA when there is a high intention to exercise and high self-efficacy (Figure 2.1 A and B). Both IC-PA and IC-SED interacted with D-E when predicting MVPA ($\beta=-0.38$, $p=0.01$ and $\beta=-0.28$, $p=0.03$, respectively). D-E is positively correlated with MVPA in individuals who have greater inhibitory control in both SED and PA stimuli. As low values of IC indicate greater inhibitory control (i.e., high executive function), IC-PA and IC-SED variables were dichotomized in reverse (i.e., low values of IC-PA and IC-SED are coded as 'high', high values were coded as 'low') for data visualization (Figure 2.1 C and D). A significant interaction is shown between D-E and BIS ($\beta=-0.24$, $p=0.05$). D-E positively correlated with MVPA among those with low BIS.

Predicting Total PA: Similar to MVPA, D-E significantly interacted with PA intentions ($\beta = 0.31$, $p=0.01$), IC of SED ($\beta=-0.33$, $p=0.01$), IC of PA ($\beta=-0.35$, $p=0.02$), SES ($\beta=0.28$, $p<0.01$) when predicting Total PA. Significant interactions between D-E and BAS-Drive ($\beta=0.26$, $p=0.03$)and BIS ($\beta=-0.37$, $p<0.01$) also emerged. D-E positively correlated with Total PA among those with high BAS-Drive and low BIS.

Additionally, a three-way interaction between D-E, PA intention, and PA-his emerged in the prediction of Total PA ($\beta=-0.56$, $p=0.01$). D-E negatively correlated with Total PA among those with low PA history and low intention, and positively correlated with Total PA among those with high PA history and low intention (Figure 2.2).

Predicting SED behavior: A significant interaction emerged in the prediction of SED (min/d) between D-E and IC-SED ($\beta=0.34$, $p<0.01$). A simple slope analysis showed D-E is negatively correlated with SED (min/d) in individuals with low IC-SED (i.e., high inhibition control toward SED; Figure 2.3).

DISCUSSION

We examined individual and combined effects of AE and reflective processes on PA behaviors. Several important results emerged from our study: (1) AE of exercise significantly correlated with MVPA and Total PA, particularly in individuals who are highly active, (2) reflective measures (intention and self-efficacy) moderated the relationship between AE and PA behavior, and (3) Inhibitory control and personality trait measures also moderated the relationship between AE and PA behavior.

AE of PA

AE of exercise (D-E) significantly correlated with objectively measured MVPA and Total PA, particularly in individuals who are highly active. This is in line with several previous studies that have shown a significant correlation between AE and PA behavior [15, 49] and significant differences reported between highly active and less active individuals [33, 50]. Supporting our hypothesis, AE was positively correlated with MVPA and Total PA when there is a high intention to exercise. Similarly, AE was positively correlated with MVPA and Total PA in individuals with high self-efficacy. This is in agreement with the Reflective-Impulsive Model [7] that both reflective and impulsive systems can synergistically activate behavioral schemata and affect outcome behavior.

In contrast to our hypothesis, we did not see any significant associations between domain-specific AE and PA behaviors. This could be indicative of conflict areas in the images that we presented for L-NLTPA and MV-NLTPA. All the images depicting L-NLTPA and MV-NLTPA were representative of common household activities such as mowing, sweeping, ironing. Implicit association measures may have been affected by increased accessibility of additional attributes associated with these types of household activities (e.g., mowing could be associated with heat, sweeping could be associated with dirty or messy, etc.). Consequently, it is possible that visual features of household activities might have acted as salient external cues, which triggered something other than energy expenditure. However, in our sample, D-E was negatively associated with LPA. That is, a negative association towards exercise was associated with greater participation in LPA and SED, while a positive association towards exercise was associated with lower LPA. This may indicate that there are differences in AE within the subsets of PA behavior. In other words, the positive AE towards exercise is may be driven by the aspects of competitiveness and rewards related to exercise performance [51], but have low attention or approach toward LPA.

Significant Moderators

BIS/BAS: When predicting Total PA, subsets of the BIS/BAS scale (i.e, BAS-Drive and BIS) were significantly moderated the relationship between AE and PA behaviors. Individuals with a highly activated BAS or low BIS seem to strengthen implicit tendencies to influence PA behaviors.

Inhibitory control: Inhibitory control is one of the most important facets of the executive function that is particularly pertinent to behavioral self-regulation [52]. It refers to one's ability to delay or suppress behavioral tendencies when behavior is inappropriate. Individuals with greater inhibition control have the ability to avoid or override immediate temptations or a reward that may have negative long-term outcomes and able to shift focus to delayed rewards that have long-term benefits [53]. It has shown to moderate relationship between implicit attitude and maladaptive health behaviors such as drinking behavior [54], substance use [55]. In the PA context, a stronger executive function has been linked with greater PA adherence [56, 57] and moderated the association between intention and PA [58]. In relation to AE, Padin et al. [59] used The Adult Temperament Questionnaire to assess executive function in relation to implicit attitudes and workout duration. The authors reported positive implicit attitudes were associated with average workout duration among those who have low inhibitory control. Similarly, Chevance et al., [28] found implicit attitude towards SED predicted PA behavior in individuals with low inhibitory control. In contrary to these previous studies, we used target-specific Go/No-Go task to assess the inhibitory control of PA and SED separately. Our results have shown that greater inhibition control of both PA and SED stimuli strengthened the relationship between AE and PA behavior. Also, greater AE towards exercise was associated with lower SED time in individuals who have high inhibition control towards SED stimuli. In other words, individuals who have a positive association with exercise are able to resist or delay SED temptations.

Limitations

The results of this study provide insight into our understanding of AE and PA, however, the limitations of this study require attention. Although we attempted to sample more diverse population, the majority of our participants are college-age, mostly healthy, and are highly active. Although participants reported broad ranges of PA levels, approximately 80% of our sample met the recommended minimum level of PA based on public health guidelines [20]. This may be one of the reasons that our result has shown a strong relationship between AE and objectively measured MVPA. Future studies should include participants who are seeking behavioral change that could conceptually involve antagonistic activation of implicit and reflective systems. Another limitation of the current study is the cross-sectional design and unable to establish causality. A prospective study examining AE and behavioral patterns over time might show interesting results.

CONCLUSIONS

In summary, this study demonstrated that AE of exercise predicted PA behavior above and beyond the potential moderators. In the prediction of MVPA and Total PA, AE interacts with reflective regulatory control (i.e., Intention, SES) and personality trait (BIS/BAS, inhibitory control). To our knowledge, this study is the first to demonstrate these interactions in addition to examining AE in relation to PA domains (i.e., LPA, MVPA, Total PA, and SED). Our findings offer preliminary evidence that the contribution of AE on PA behavior is dependent not only on the type of PA behavior but also on the personality trait dimensions. Combined, these findings have important theoretical and practical implications for interventions that attempt to increase PA participation.

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Table 2. 1. Detailed description of the single category implicit association task procedure.

Experimental Phases	Blocks	Number of Trials	Key "Q" Response	Key "P" Response
Practice	Practice	24	Good	Bad
EX	Block 1	72	Good + EX	Bad
	Block 2		Good	Bad + EX
L-NLTPA	Block 1	72	Good + L-NLTPA	Bad
	Block 2		Good	Bad + L-NLTPA
MV-NLTPA	Block 1	72	Good + MV-NLTPA	Bad
	Block 2		Good	Bad + MV-NLTPA
SED	Block 1	72	Good + SED	Bad
	Block 2		Good	Bad + SED

EX, Exercise. L-NLTPA, Light intensity non-leisure time physical activity. MV-NLTPA, Moderate-to-vigorous intensity non-leisure time physical activity. SED, Sedentary behavior.

Table 2. 2. Descriptive statistics of the study variables (*M*±*SD*).

Variables	**Total (*N=67*)**	**Men (*n*=25)**	**Women (*n*=41)**	***P*** [a]
Age (years)	23±9	22±7	23±9	0.84
Gender, % (*n*)				
Women	63 (41)			
Men	36 (25)			
Ethnicity, % (*n*)				
African American	9.1 (6)			
White	83.3 (55)			
Other	7.6 (5)			
BMI (kg/m^2)	26.2±4.9	27.3±4.2	25.5±5.2	0.06
BMI classification				
Normal weight	45.6 (30)			
Overweight	31.8 (21)			
Obese	19.7 (13)			
Waist circumference (cm)	80.5±12.8	87.6±12.4	76.2±11.1	<0.01
PA measures [a]				
Total PA (tac × 1000/d)	460.0±164.6	461.2±153.4	456.7±174.4	0.96
LPA (min/d)	773.4±70.8	769.6±73.5	776.1±70.8	0.74
MVPA (min/d)	53.4±26.1	55.2±24.5	52.1±27.6	0.65
SED (min/d)	505.3±82.7	508.0±87.0	503.7±81.0	0.84
AE measures (SC-IAT)				
D-E	0.07±0.61	0.05±0.60	0.08±0.60	0.83
Executive Function				
IC of PA	3.2±2.3	2.6±1.7	3.5±2.6	0.15
IC of SED	2.4±1.6	2.3±1.3	2.4±1.8	0.67
Intent-E	3.5±1.5	3.6±1.5	3.4±1.5	0.66
BAS-Drive	11.1±0.3	11.0±2.5	11.1±2.5	0.95
BIS	20.6±4.4	18.6±4.5	21.8±3.9	<0.01
PACES	88.2±18.7	87.1±12.3	88.8±21.8	0.71
SES	55.1±18.2	55.5±16.6	54.8±19.3	0.66
PA-his	234.5±335.0	205.5±243.0	252.2±382.0	0.58

[a] Different between men vs. women.
AE, Automatic evaluations. BAS-Drive, Behavioral activation system drive subscale. BIS, behavioral inhibition system. BMI, Body mass index. D-E, D-score in exercise domain. IC, inhibitory control. Intent-E, intention to exercise. LPA, light intensity PA. MVPA, Moderate-to-vigorous intensity PA. PA, physical activity. PACES, PA enjoyment scale. PA-his, PA history index. SC-IAT, Single Category Implicit Association Task. SED, sedentary behavior. SES, self-efficacy scale. tac, total activity count.

Table 2.3. Correlations between variables of interest.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. LPA (min/d)	--													
2. Total PA (tac/d)	.02													
3. MVPA (min/d)	-.08	.90**												
4. SED (min/d)	.53**	-.57**	-.40**											
5. Age (y)	.21	.15	-.02	-.03										
6. SC-IAT (D-E)	-.29*	.27*	.28*	-.24*	.01									
7. Intent-E	-.32**	.06	.07	-.16	-.18	.13								
8. BAS-Drive	.05	.26*	.26*	-.14	.08	.11	.32**							
9. BAS-RR	.07	.04	.04	-.07	.01	-.02	.10	.37**						
10. BAS-FS	.08	.09	.16	.06	-.12	-.02	-.01	.32**	.22					
11. BIS	.20	-.00	-.07	.06	-.06	-.24 ǂ	-.18	-.21	.09	-.24				
12. PACES	-.30*	.11	.10	-.14	.07	.27*	.48**	.12	.02	.00	-.22			
13. SES	-.05	.38**	.35**	-.21	.10	.31*	.41**	.41**	.09	.21	-.38**	.35**		
14. PA-his	-.04	.36**	.25*	-.33**	.37**	.24ǂ	.26*	.25*	-.07	.02	-.22	.23	.31*	--

AE, Automatic evaluation. BAS-Drive, Behavioral activation system drive subscale. BAS-FS, behavioral activation system fun-seeking subscale. BAS-RR, behavioral activation system reward responsiveness subscale. BIS, behavioral inhibition system. D-E, D-score in exercise domain. Intent-E, intention to exercise. LPA, light intensity PA. MVPA, Moderate-to-vigorous intensity PA. PA, physical activity. PACES, PA enjoyment scale. PA-his, PA history index. SC-IAT, Single category implicit association task. SED, sedentary behavior. SES, self-efficacy scale. tac, total activity count.

* <0.05. ** <0.01. ǂ =0.05.

Table 2.4. Independent effect of AE on PA behavior (*N*=66).

Total PA (tac/d)

Predictors	β	*P*	R^2
D-E	0.17	0.12	
Intent-E	0.07	0.75	
D-E×Intent-E	0.31	0.01	
Model		**0.01**	**0.16**
D-E	0.08	<0.01	
IC-PA	-0.13	0.43	
D-E×IC-PA	-0.35	0.02	
Model		**<0.01**	**0.16**
D-E	0.05	0.66	
SES	0.33	<0.01	
D-E×SES	0.28	<0.01	
Model		**<0.01**	**0.28**
D-E	0.17	0.09	
BAS-Drive	0.17	0.25	
D-E×BAS-Drive	0.26	0.03	
Model		**<0.01**	**0.19**
D-E	0.22	<0.01	
BIS	-0.01	0.81	
D-E×BIS	-0.37	<0.01	
Model		**<0.01**	**0.20**
D-E	0.12	<0.01	
IC-SED	0.17	0.09	
D-E×IC-SED	-0.33	0.01	
Model		**<0.01**	**0.17**

MVPA (min/d)

Predictors	β	*P*	R^2
D-E	0.17	0.13	
Intent-E	0.08	0.65	
D-E×Intent-E	0.3	0.01	
Model		**0.01**	**0.16**
D-E	0.07	<0.01	
IC-PA	-0.12	0.50	
D-E×IC-PA	-0.38	<0.01	
Model		**<0.01**	**0.18**
D-E	0.09	0.11	
SES	0.29	0.02	
D-E×SES	0.21	0.02	
Model		**<0.01**	**0.22**
D-E	0.16	<0.01	
IC-SED	0.24	0.04	
D-E×IC-SED	-0.28	0.03	
Model		**<0.01**	**0.17**

LPA (min/d)

Predictors	β	*P*	R^2
D-E	-0.3	0.01	
PACES	-0.25	0.02	
D-E×PACES	0.26	0.04	
Model		**<0.01**	**0.20**

SED (min/d)

Predictors	β	*P*	R^2
D-E	-0.09	<0.01	
IC-SED	-0.27	0.01	
D-E×IC-SED	0.34	0.01	
Model		**<0.01**	**0.18**

Note. Only significant results are shown.
BAS-Drive, Behavioral activation system drive subscale. BIS, behavioral inhibition system. D-E, D-score in exercise domain. IC-PA, inhibitory control score of physical activity, IC-SED, inhibition control of sedentary. Intent-E, intention to exercise. LPA, light intensity PA. MVPA, Moderate-to-vigorous intensity PA. PA, physical activity. PACES, PA enjoyment scale. SED, sedentary behavior. SES, self-efficacy scale. tac, total activity count.

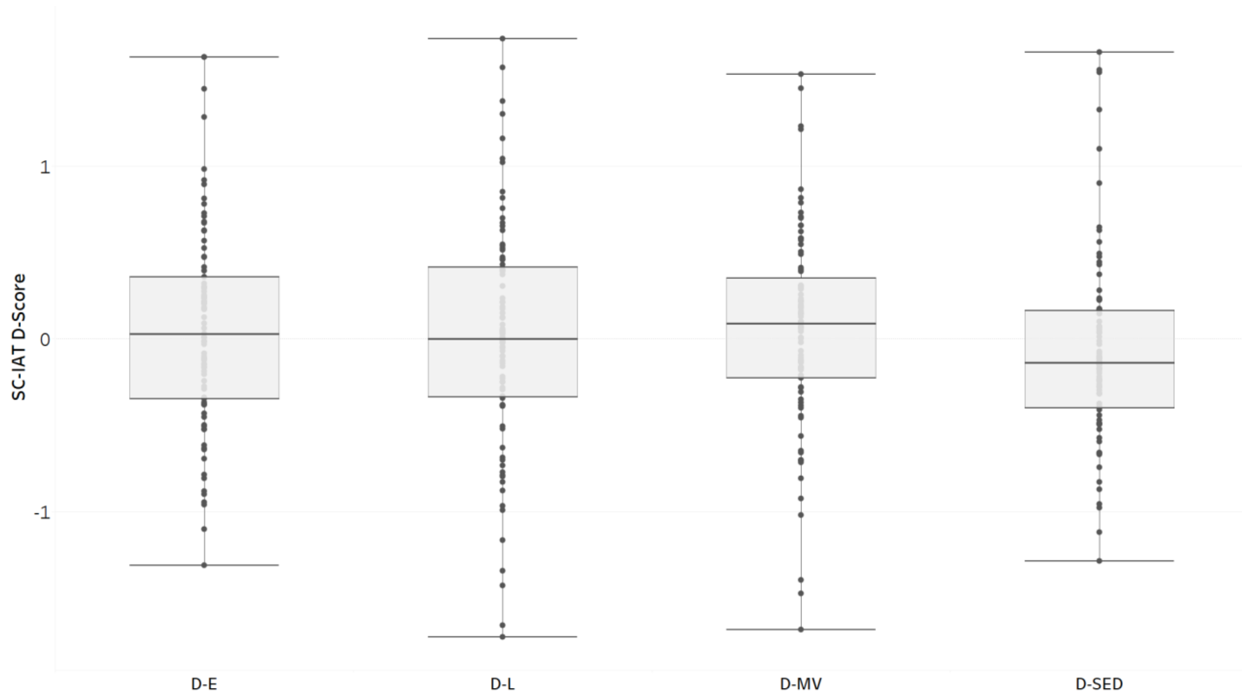

Figure 2.1. Dot plots (with box plot overlays) of participants SC-IAT D-scores across physcal activity domains.
D-E, D score in exercise domain. D-L, D score in light intensity non-leisure time physical activity. D-MV, D score in moderate-to-vigorous intensity non-leisure time physical activity. D-SED, D score in sedentary behavior. SC-IAT, Single category implicit association task.

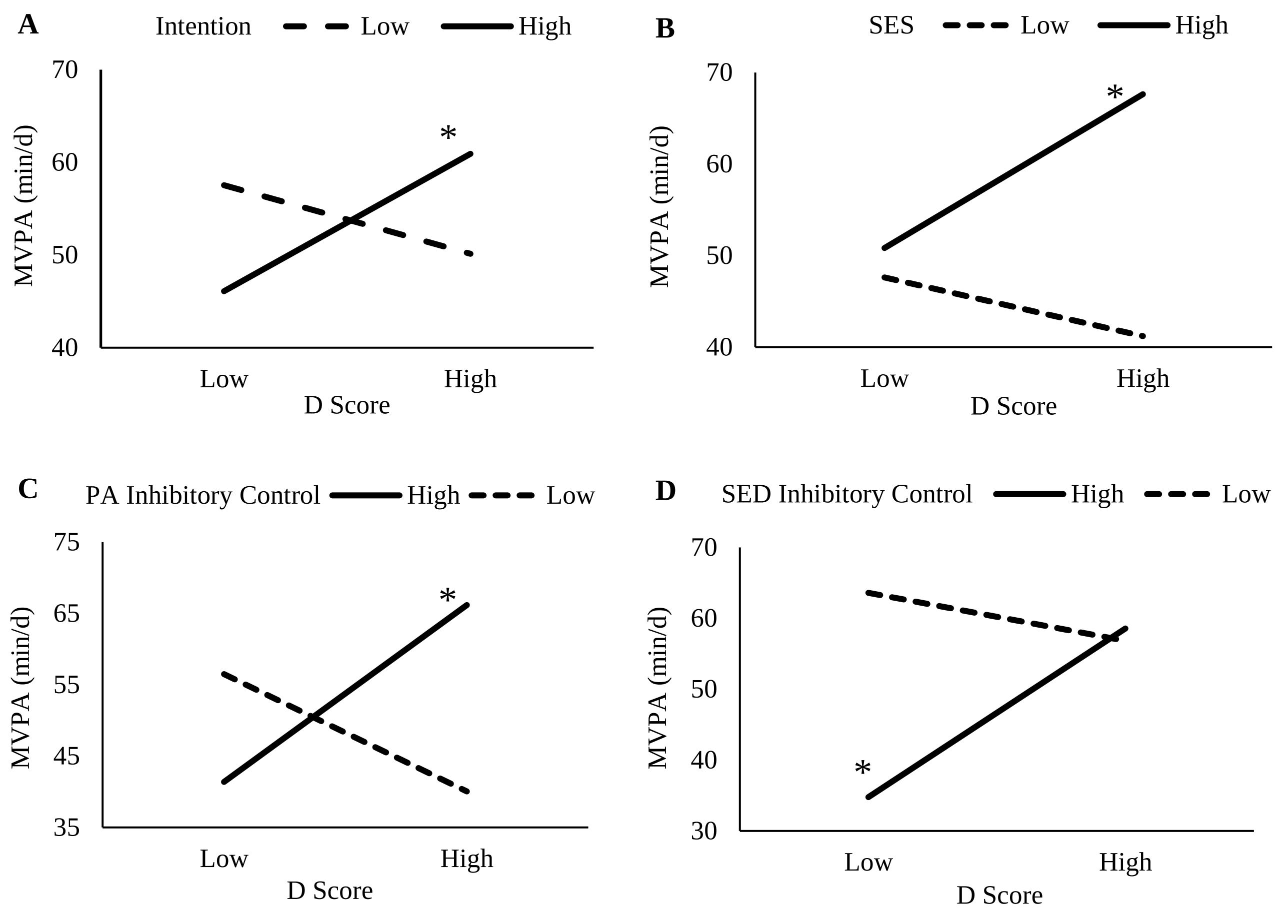

Figure 2. 2. Objective MVPA as a function of AE and other covariates.
Other covariates examined: Figure A. PA intention. Figure B. PA self-efficacy. Figure C. Inhibitory control towards PA cues. Figure D. Inhibitory control towards SED cues.
Note, continuous variables were dichotomized for data visualization purposes: Low values of IC-PA and IC-SED are coded as 'high' and high values were coded as 'low'.
D-E, D score in exercise domain. MVPA, Moderate-to-vigorous intensity physical activity. PA, physical activity. SED, sedentary behavior. SES, Self-efficacy scale.
*$p < 0.05$

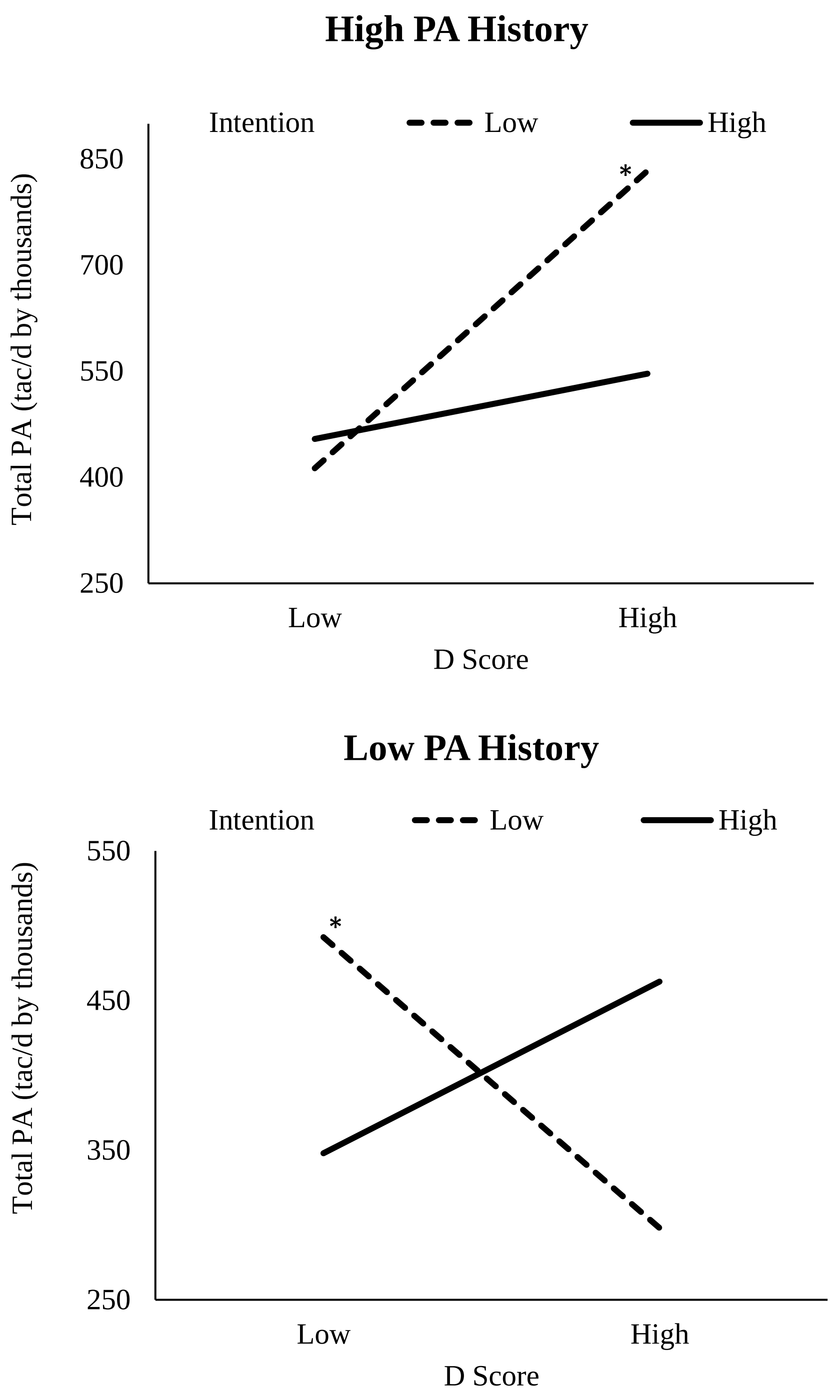

Figure 2. 3. Objective Total PA as a function of D-score for exercise × PA Intention × PA history.
D Score, D score in the exercise domain. PA, physical activity. tac/d, total activity count per day.
*$p < 0.05$

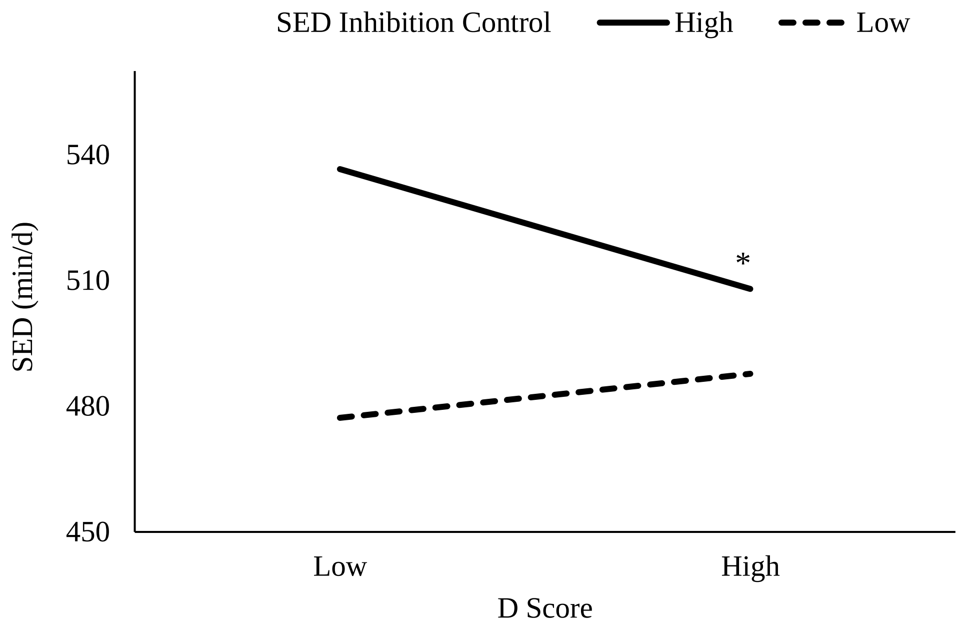

Figure 2. 4. Time spent in sedentary as a function of D-E and Inhibition Control.
Note, continuous variables were dichotomized for data visualization purposes: Low values of SED Inhibition Control are coded as ‘high’ and high values were coded as ‘low’.
D-SED, D score in sedentary domain.
* p <0.05.

CHAPTER 3

TEST-RETEST STABILITY OF THE SINGLE CATEGORY-IMPLICIT ASSOCIATION TEST: AUTOMATIC EVALUATION OF PHYSICAL ACTIVITY

ABSTRACT

An increasing amount of research has focused on elucidating how physical activity (PA) behavior is, in part, dictated by processes that occur outside of conscious awareness (i.e., automatic evaluation [AE]). Despite recent advances in the methodology used to assess the AE of PA behavior, there is insufficient evidence regarding the stability of these measures over time. **PURPOSE:** To examine the stability of the AE of PA focusing on several PA behaviors, namely, exercise (EX), light (L-NLTPA) and moderate-to-vigorous intensity non-leisure time PA (MV-NLTPA), and sedentary behavior (SED). **METHODS:** Participants (≥18 years old) completed measures of a Single Category Implicit Association Test (SC-IAT) twice, 7 days apart, measuring implicit attitudes towards PA and SED behaviors using images depicting four different PA domains. Habitual PA was measured using an accelerometer. Spearman-Brown coefficient was used to quantify internal consistency and test-retest reliability was evaluated using intraclass correlation coefficient (ICC). **RESULTS:** SC-IAT of EX showed acceptable internal consistency (Spearman-Brown coefficient=0.61) and significant test-retest reliability ($ICC_{1,2}$=0.35, $p<0.01$). **CONCLUSION:** The stability of SC-IAT of EX in the current study was consistent with previous studies (i.e., moderate internal consistency and low, albeit significant, test-retest reliability). The AE of non-leisure time activities exhibited much less stability perhaps due to task confusion.

INTRODUCTION

Public health recommendations suggest adults should engage in 150 to 300 minutes/week of moderate-intensity physical activity (PA), or 75 to 150 minutes/week of vigorous-intensity activity, or an equivalent combination of both for substantial health benefits [1]. Although these recommendations are generally well accepted and acknowledged by the public at large, there is still a large proportion of the population that is *insufficiently active* (i.e., not meeting the public health recommendation) or completely inactive [2]. In terms of PA and health promotion, the majority of the research conducted to date has focused on reflective processes that assume PA behavior is best predicted by conscious intentions [3, 4]. However, a recent meta-analysis showed that interventions aimed at increasing intentions to become more physically active do not elicit large behavioral changes [5]. In other words, people do not always behave in accordance with their intentions—at least not conscious ones. In the last few decades, an increasing amount of research has focused on elucidating how PA behavior is, in part, dictated by processes that occur outside of conscious awareness (i.e., automatic processes) [6, 7]. Automatic processes influence behavior through an associative network (i.e., automatic evaluation [AE]) or habit response that activates spontaneous behavioral tendencies without conscious intentions [8]. In terms of PA behaviors, AE reflects an individual's unconscious evaluation of PA as something that is pleasant/positive or unpleasant/negative. These associations, in turn, can serve as precursor to behavioral outcome [9].

There is an immense diversity in the methods to measure AE. Among these measures, the Implicit Association Test (IAT) [10] is the most common and widely used method in social behavioral research including PA behavior. The IAT measures the strength of the affective response (e.g., "good" or "bad") to a target concept (e.g., PA behavior). In general, a counter category is chosen against which the target concept of interest is contrasted, such as men versus women. However, it has been pointed out that, in many cases, due to the subjective nature of the contrast, the counter category choice may not be the natural opposite of the target concept (e.g., PA versus sedentary, liberal versus conservative) [11]. Due to this limitation, several non-relative measures have been developed, such as the Go/No-Go Association Task [12], the Extrinsic Affective Simon Task [13] , and the Single Category IAT (SC-IAT) [11]. While there is no “best overall” or gold standard measurement method of AE, the SC-IAT has been used in a broad range of research settings, including PA behavior [14]. Furthermore, the SC-IAT has demonstrated improved predictability of objectively measured PA compared to the original IAT [15].

Despite recent advances in the methodology used to assess the AE of PA behavior, there is insufficient evidence regarding the stability of these measures over time. Most studies assess the target trait or process at only a single time point, and thus, are unable to provide any evidence or degree of certainty regarding the stability of the trait, process, or measurement tool across time. The internal consistency of the SC-IAT has been established by several studies using split-half correlations (Cronbach alpha: 0.70 to 0.90) [11, 16]. However, in taking from the broader literature, AE exhibits low-to-moderate stability, but the degree of stability varies widely depending on the nature of the constructs and assessment interval [17-19]. For example, Cunningham, Preacher, and Banaji [20] investigated the stability of several implicit measures using structural equation modeling among college-age students and found that measures of the AE of race exhibited moderate stability (r=0.46) for the IAT, whereas stronger stability has been demonstrated for the AE of personality traits (r=0.88) [21]. Even fewer studies have investigated AE measurement stability in the context of PA behavior. Hyde et al. [22] examined the stability of the SC-IAT of PA over a one-week interval among 164 college-age students. Overall, the authors found the SC-IAT to have low test-retest reliability (r=0.22). However, stability differed based by the AE of PA baseline level. The authors observed a change in the AE among those who initially had a negative AE towards PA behavior reporting positive AE towards PA in one week. To limit real change in AE, Chevance et al. [16] used a one-hour interval and reported a low to moderate test-retest reliability for the AE of sedentary (r=0.20) and PA behavior (r=0.39) among older adults with chronic diseases.

Although these results provide insight concerning the stability of the AE of PA behavior, there are still important gaps in our understanding concerning the stability of AE measures in the PA domain. Thus, the purpose of the current study is to examine the stability of the AE of PA focusing on several PA behaviors, namely, exercise (EX), light and moderate-to-vigorous intensity non-leisure time PA (L-NLTPA and MV-NLTPA), and sedentary behavior (SED). Also, the extent to which stability is influenced by several covariates such as age, sex, and PA level.

METHODS

Due to COVID-19 precautions and restrictions, we allowed participants to participate via two methods of delivery: (1) In-person study participation and (2) Remote study participation. For in-person study participation, participants were invited to visit the laboratory on two separate occasions separated by a minimum of 7 days and a maximum of 10 days. For remote study participation, participants were invited to meet with the researcher using the Zoom videoconferencing platform. In both study methods, participants underwent the same measures of AE, reflective processes, and executive function tasks. In-person study participants were instructed to wear an accelerometer for 7 days. Remote study participants did not wear an accelerometer.

Participants

Faculty, staff, and students from The University of Alabama were recruited as participants for this study. All participants speak English as their first language and have no medical conditions that impair language perception or restrict regular PA participation. Overall, 104 participants were included in the study, 87 participated in person and 17 participated remotely. Of those 87 who participated in-person, 66 participants had valid accelerometer data (4 participants dropped due to time conflict, 2 participants did not have accelerometer data due to malfunction of the device, and 15 participants did not reach accelerometer wear-time cut-off). Data from remote participation was not included in the analysis.

Research Design

For in-person participation, participants visited the laboratory on two separate occasions separated by a minimum of 7 days and a maximum of 10 days. During their initial visit to the laboratory, participants completed an informed consent prior to baseline measurements. Participants' height was measured with a stadiometer (SECA, Birmingham, UK) to the nearest mm. Weight was measured to the nearest 0.1 kg using a digital scale (Detecto DR 400, Missouri, USA). Height and weight were used to calculate body mass index (BMI), expressed as $kg \cdot m^{-2}$, and then categorized as normal weight (18.5-24.9 $kg \cdot m^{-2}$), overweight (25 to 29.9 $kg \cdot m^{-2}$), and obese ($\geq$30 $kg \cdot m^{-2}$) [23]. Following the computerized tasks but before leaving the laboratory, participants completed the health history and demographics questionnaire and were instructed to wear an accelerometer during all waking hours for 7 consecutive days. Participants returned to the laboratory after at least 7 days but no more than 10 days for visit two, where they returned their accelerometer and activity log to study personnel. During the second visit, participants again completed the computerized tasks (i.e., SC-IAT).

For remote participation, participants were invited to meet with the researcher using the Zoom video-conferencing platform. During their online meeting, participants completed informed consent online via UA Qualtrics. Remote study participants self-reported their height and weight. Height and weight were then used to calculate BMI ($kg \cdot m^{-2}$) and categorized using the same methods described above. For the computerized tasks, participants were provided with a link to the testing packet through E-Prime Go, a remote data collection platform for E-Prime 3.0 Behavioral Research Software (Sharpsburg, PA). We asked the participants to silence their phone, alerts, music, and anything else distracting before starting the task. In addition, we asked the participants to have the Zoom meeting/connection on a separate device such as a smartphone, iPad, or laptop to prevent any distractions during the tasks. Following the computerized tasks, participants completed the health history and demographics questionnaire. During the second meeting, participants again completed the computerized task (i.e., SC-IAT) online.

Procedures

Contextual Stimuli

We conducted a pilot study to determine whether the images to be used in the AE tasks are most representative of the target concepts. A survey was distributed to students and faculty/staff campus-wide asking participants to classify each of the 29 images as a representation of one of the following categories: (1) SED behavior; (2) activity of daily living requiring low effort; (3) activity of daily living requiring moderate-to-vigorous effort; and (4) exercise. To minimize the bias associated with pictures depicting real people, an art designer designed pictograms representing various activities (see Appendix B). After categorizing the image, participants indicated the degree of certainty in their selection based on a 3-point scale: 1=uncertain, 2=certain, 3=very certain. Images resulting in the most accuracy and certainty were selected to be used for the current study. Less accurate images were further analyzed to evaluate any group differences among the participants i.e., faculty/staff versus students. Based on the results of the pilot study, we modified some images to increase the accuracy with which they are perceived. Participants of the current study were also surveyed at the end of their participation regarding their ability to categorize the images accurately and with certainty. In addition, participants were asked to rate their perception of images as being less or more effortful on a scale of 0 to 10.

AE Measures

Single Category Implicit Association Test. The SC-IAT was used to measure the AE of the target concepts: EX, L-NLTPA, MV-NLTPA and SED. The SC-IAT has demonstrated internal reliability (r=0.21-0.41) and predictive validity [24, 25]. In this computerized task, images depicting the target concepts were utilized (see Appendix B). The comparative categories were labeled as ‘good’ and ‘bad’ and consisted of positive or negative valence words related to feelings and experiences with PA (e.g., positive valence: beautiful, happy, delightful, energetic; negative valence: awful, agonizing, horrible, painful). Participants started the SC-IAT with 24 practice trials where the participants were asked to categorize positive or negative valence words quickly and accurately. Following the practice trial, the participants completed 4 blocks of experimental trials, each consisting of 72 test trials (see Table 3.1 for a detailed description of the experimental procedure). During the experimental trials, the stimuli (images depicting the target concept, positive and negative words) were presented randomly. Participants were asked to categorize each stimulus to the correct category labels that are presented at the top of the screen by pressing either the “Q” key or the “P” key on the keyboard. For example, when ‘exercise + good’ is presented at the top left corner of the screen and ‘bad’ is presented at the top right corner of the screen, the participants categorized the exercise-related images and ‘good’ words by pressing the ‘Q’ key, and ‘bad’ words by pressing the “P” key on the keyboard. Participants were instructed to categorize the images and words as quickly and as accurately as possible. If participants responded incorrectly (e.g., categorize exercise-related images into the ‘bad’ category), a red “ERROR” appeared on the screen before the next stimulus was presented.

AE was scored using the D-score algorithm [11]. Reaction times (RT) of less than 350 ms and more than 10,000 ms were eliminated from scoring for each test block within each experimental phase. After eliminating erroneous RT values, the mean (±*SD*) response value for each block was calculated. The difference between the average RT of the two critical blocks (block 1 and 2) were divided by the pooled SD of the RTs. The AE score for each of the target concepts were calculated as:

$$\text{D-Score} = \left[\frac{\text{Average RT}_{\text{Block2,}} - \text{Average RT}_{\text{Block1,}}}{\text{SD}_{\text{Pooled}}}\right],$$

where positive scores indicate a more positive association of AE toward the targeted behavior. D-scores were calculated for each domain separately.

PA Measures

Objectively measured PA behaviors were assessed using an accelerometer (ActiGraph, GT3X+, ActiGraph Corporation, Pensacola, FL, USA). Participants were given an accelerometer, along with instructions on how to wear the accelerometer and how to track their wear time and daily activities at the end of Visit 1. The ActiGraph is a small, lightweight triaxial device that measures body motion on three planes of movement. Participants were instructed to wear the accelerometer during all waking hours, except when swimming or bathing, for 7 consecutive days. A valid day was defined as ≥10 hours of wear time, and participants were required to have a minimum of three valid days to be retained in the analyses.

Objectively measured daily PA was quantified as time spent (min/d) engaging in LPA, MVPA, and SED activities in the last week (7-d). An index of total PA expressed as total activity count per day (tac/d) was obtained. Estimated METs and PA cut points were determined using the validated Freedson adult vector magnitude algorithm [26]. Actigraph data were aggregated to 60s epochs and the vigorous and very vigorous PA categories were combined. A cut-point of ≤150 counts/min was employed to define SED activity. All accelerometer data were reviewed and compared with the participant's PA log before being processed via ActiLife data analysis software (ActiGraph Link, ActiGraph Corporation, Pensacola, FL, USA). Participants also completed self-report PA measures using International Physical Activity Questionnaire (IPAQ, [27] during both visits reporting their daily PA in the last week.

As part of the demographic questionnaire, we asked the participants to rate their current level of PA (1=SED, 2=Low, 3=Moderate, 4=Recreationally Active, 5=High/Athlete) and how long they have been at this level of activity expressed in months. We then multiplied these two variables to obtain a measure of PA history expressed as PA history index (PA-his).

Statistical Analysis

To estimate internal consistency, the test trials were separated into two halves and D-scores were calculated for each half. Spearman-Brown correction for split-half reliability was used to determine the internal consistency. This approach follows the process for determining internal consistency outlined in previous studies [11, 25, 28].

The stability of the SC-IAT was evaluated using the intraclass correlation coefficient (ICC) estimates based on a mean-rating (k=2), absolute agreement, 2-way mixed-effects model.

Reliability coefficients were interpreted using the following: <0.50 is considered poor, 0.50-0.75 is considered moderate, 0.75-0.90 indicate good, and >0.90 is considered excellent [29]. The influence of select covariates (e.g., changes in PA, PA-his, and prior experience with RT-based measures) were also evaluated. All data were analyzed using SPSS (SPSS version 27.0, Chicago, IL, USA). P-values of ≤0.05 were regarded as statistically significant.

RESULTS

Internal consistency results are presented in Table 3.2. Internal consistency of the SC-IAT for exercise (D-E) showed moderate reliability for in-person participants (Spearman-Brown=0.61). D-scores for L-NLTPA (D-L), MV-NLTPA (D-MV), and SED (D-SED) showed poor internal consistency (Spearman-Brown coefficients: 0.07, 0.03, and 0.26, respectively).

Test-retest reliability coefficients for the SC-IAT for the four target domains are presented in Table 3.3. A significant test-retest reliability coefficients were found for D-scores for exercise ($ICC_{1,2}$=0.35, p<0.01) and MV-NLTPA ($ICC_{1,2}$=0.36, p=0.02), but not in D-scores for L-NLTPA and SED domains. Individuals who had previous experience with implicit tasks (n=30) elicited more consistent measures for D-E (ICC=0.47, p=0.03) than those who did not. Based on the IPAQ, individuals (n=43) who reported less moderate PA than the previous week also showed more consistent D-E measures (ICC=0.41, p=0.04). The same pattern emerged for individuals (n=35) who did not exercise on the day before (ICC=0.46, p=0.04).

DISCUSSION

The goal of the current study was to examine the stability of the SC-IAT of four different target domains: Exercise, L-NLTPA, MV-NLTPA, and SED. The internal consistency of the SC-IAT for the exercise domain in our sample (Spearman-Brown coefficient=0.61) is comparable with previous research ranging 0.60-0.63 [16, 22]. The test-retest reliability coefficient observed for the exercise domain demonstrated low reliability ($ICC_{1,2}$=0.35, p<0.01). Typically, AE measures demonstrate lower reliability than corresponding reflective measures and are often below that which would be considered satisfactory [20, 30, 31]. For example, Chevance et al. [16] reported a test-retest correlation of r=0.33 for AE of PA and r= 0.19 for AE of SED, which is similar to our results.

Test-retest reliabilities are likely to vary considerably as a function of several factors including measurement error, trait changes, and learning effects [30]. Cunningham et al [20] used latent variable analysis to significantly improve test-retest correlation (from r=0.27 to r=0.55) by separating measurement error from estimates of stability. State-trait-analysis of the IAT in previous studies suggests that the IAT not only measures individual stable variances but also occasion-specific variances resulting in reliable but less stable measurement [21, 32].

Hyde et al. [22] reported that the stability of the AE of PA (measured by SC-IAT) comprised both stable and time-varying components whereby attenuation of AE scores was seen in those individuals who had greater changes in self-reported PA. Another factor that might contribute to instability is changes in test-taking strategies. Particularly with the SC-IAT using images, participants are more likely to learn the patterns of the task and spontaneously or deliberately simplify the task by accepting or rejecting stimuli based on the format of the presentation (i.e., if images hit the key, otherwise hit the other key). However, previous studies noted that such attempts lead to greater errors during the task [33]. Additionally, participants may think about the purpose and the construction of the task in between test and re-test measurement which might lead to a shift in AE at re-test through forming new associations of the target concept. Foroni and Mayr [34] examined task manipulation on a flower-insect attitude IAT. After reading a short ‘pro-flowers’ story, participants completed the flower-insect IAT as a baseline measure. Next, participants read a brief fictitious story about dangerous flowers and valuable insects following a nuclear war. Participants showed less positivity toward flowers relative to insects in the follow-up flower-insect IAT. These results indicate new associations to target concepts can have an immediate effect on AE. Likewise, previous day exercise affected the test-retest association in our sample supporting the sensitivity of AE to recent exposure or experience. Rudman [35] stated that both early experience and recent experience can influence implicit associations. A recent exposure such as previous day exercise may have served as priming manipulation which was more accessible than early experiences. However, future studies are needed to establish the sensitivity of AE to recent experience in the context of PA.

We did not find acceptable internal consistency and test-retest reliability for the L-NLTPA, MV-NLTPA, and SED domains in our sample. In evaluating our results, the lack of reliability indices in these domains may be due to task confusion. Task confusion occurs when participants cannot identify stimuli as a clear representation of the three categories (i.e., good, bad, and PA). The stimulus images we selected for L-NLTPA and MV-NLTPA were representative of common household activities such as mowing, sweeping, ironing. Implicit association measures may have been affected by increased accessibility of additional attributes associated with these types of household activities (e.g., mowing could be associated with heat, sweeping could be associated with dirty or messy, etc.). Consequently, it is possible that visual features of household activities may have acted as salient external cues that are not related to energy expenditure, which may have led to task confusion. Based on our pilot study examining these images, participants were most sure of images related to exercise and SED compared to images depicting L-NLTPA and MV-NLTPA. Future research may consider a different measure of AE when examining non-leisure time activities such as Evaluative Decision Task where PA-related stimuli are presented as primes.

We have taken several steps to reduce random measurement error such as taking in-person participants in a private, quiet laboratory room with no visual distractions, and by standardizing instructions. For remote participants, we advised participants to take the tasks in a quiet room with no distraction. We did not reach a sufficient number of remote participants to examine reliability measures for this sample, thus they were removed from the analysis.

In conclusion, the stability of Exercise- SCIAT in the current study was consistent with previous studies (i.e., moderate internal consistency and low, albeit statistically significant, test-retest reliability). Conversely, the AE of non-leisure time activities exhibited much less stability perhaps due to task confusion.

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Table 3. 3. Detailed description of the single category implicit association task procedure.

Experimental Phases	**Blocks**	**Number of Trials**	**Key "Q" Response**	**Key "P" Response**
Practice	Practice	24	Good	Bad
EX	Block 1	72	Good + EX	Bad
	Block 2		Good	Bad + EX
L-NLTPA	Block 1	72	Good + L-NLTPA	Bad
	Block 2		Good	Bad + L-NLTPA
MV-NLTPA	Block 1	72	Good + MV-NLTPA	Bad
	Block 2		Good	Bad + MV-NLTPA
SED	Block 1	72	Good + SED	Bad
	Block 2		Good	Bad + SED

EX, Exercise. L-NLTPA, Light intensity non-leisure time physical activity. MV-NLTPA, Moderate-to-vigorous intensity non-leisure time physical activity. SED, Sedentary behavior.

Table 3. 1. Split-half reliability (with Spearman-Brown correction) estimates of internal consistency for the SC-IAT of the different PA domains.

Target PA domains/ D-scores	Visit 1 (*N* = 87)	Visit 2 (*N* = 77)
Exercise (D-E)	0.61	0.53
L-NLTPA (D-L)	0.07	0.21
MV-NLTPA (D-MV)	0.03	0.05
SED (D-SED)	0.26	0.35

D-E, D-score in exercise domain. D-L, D-score in light intensity PA domain. D-MV, D-score in the moderate-to-vigorous intensity PA domain. D-SED, D-score in sedentary domain. L-NLTPA, light intensity non-leisure time PA. MV-NLTPA, moderate-to-vigorous intensity non-leisure time PA. PA, physical activity. SC-IAT, single category implicit association task. SED, sedentary behavior.

Table 3. 2. SC-IAT scores (*M*±*SD*) and stability for the different PA domains.

Target PA Domains / D-scores	Visit 1 (*N* = 87)	Visit 2 (*N* = 77)	Stability		
			ICC	95% CI	*P*
Exercise (D-E)	0.07 ± 0.6	0.50 ± 0.5	0.35	-0.00, 0.58	<0.01
L-NLTPA (D-L)	0.00 ± 0.6	0.22 ± 0.5	0.27	-0.13, 0.53	0.08
MV-NLTPA (D-MV)	0.04 ± 0.5	0.12 ± 0.6	0.36	0.13, 0.59	0.02
SED (D-SED)	-0.05 ± 0.6	0.07 ± 0.5	0.21	0.11, 0.57	0.14

D-E, D-score in the exercise domain. D-L, D-score in the light intensity PA domain. D-MV, D-score in the moderate-to-vigorous intensity PA domain. D-SED, D-score in the sedentary domain. ICC, Intraclass correlation coefficient. L-NLTPA, Light intensity non-leisure time PA. MV-NLTPA, Moderate-to-vigorous intensity non-leisure time PA. PA, Physical activity. SED, Sedentary behavior. SCIAT, Single category implicit association task.

CHAPTER 4

AUTOMATIC BEHAVIORAL TENDENCIES TO MINIMIZE ENERGETIC COST

ABSTRACT

For our evolutionary ancestors, avoiding predators and gathering food from scarce resources involved extensive energy expenditure. Expending energy through any extraneous physical activity (PA) had no purpose and would have decreased survival chance and reproductive fitness. The theory of effort minimization in PA (TEMPA) assumes that biomechanically efficient behaviors have a rewarding value and that an evolutionary inclination to avoid any unnecessary PA acts as a restraining force that hinders the ability of individuals to implement their conscious intention to exercise. **PURPOSE:** To examine whether there is an automatic approach or avoidance tendencies towards activities that conserve energy. **METHODS:** Participants (≥18 years old) completed an approach-avoidance task (AAT) as a measure of automatic approach-avoidance behavioral tendencies toward activities that are energy-conserving (EC) or energy expending (EE). During the task, participants listened to a short description of a scenario that describes situations where individuals are faced with behavioral alternatives (e.g., taking stairs versus elevators). Participants were then asked to react to the format of the stimuli (square or circle) in which the stimuli contained an image depicting the target concepts (EC and EE). Additionally, a situated decision questionnaire (SDQ) was used as a measure of explicit proxies of AATs where participants reported their strength of tendencies in the same scenarios. An accelerometer was used to measure daily activity over a seven-day

period. **RESULTS:** Participants had a greater tendency to approach EC stimulus in most of the scenarios. Approach tendency to EE was negatively correlated with light intensity PA ($r=-0.37$, $p<0.01$). There were no significant correlations between SDQ and AAT scores.
CONCLUSION: Our findings support the concept of TEMPA in a way that there is an approach tendency towards EC.

INTRODUCTION

The multitude of health benefits associated with regular participation in physical activity (PA) is well-established including the decreased risk of developing various diseases, including cardiovascular events [1, 2], musculoskeletal diseases [3], metabolic diseases [4], cancer [5], and improvements in brain health and function [6]. Despite these well-known health benefits, half of the US adult population fails to meet the public health guideline for PA, making *physical inactivity* a major public health challenge [6]. Low rates of participation in exercise and PA among the general population may be explained, in part, by the fact that most people experience a negative affective response while performing different types of intentional PA [7]. Lee, Emerson, and Williams [1] proposed an evolutionary perspective to further investigate negative affective responses during exercise, which was framed by two primary questions: Why does exercise behavior occur and what is the functional significance of avoiding PA behavior? For our evolutionary ancestors, avoiding predators and gathering food from scarce resources involved extensive energy expenditure. Expending energy through any extraneous PA served no purpose and would have likely contributed to a decreased chance of survival and reproductive fitness. As such, the proximate cause of the low adherence rate of PA is the human tendency to respond to PA with negative affect; and the ultimate cause is the human tendency to conserve energy [1]. To examine whether conserving energy is innately attractive to individuals, Cheval et al. [8] used words related to behaviors minimizing energetic costs (BMEC) as a primer in the context of PA goals using a primed lexical decision task. The BMEC-related cues lead to the automatic activation of PA goals, particularly in successful exercisers. This demonstrates that BMEC act as a temptation that activates the threatened goal (i.e., PA goal) based on asymmetric temptation-goal cognitive association [9]. Successful exercisers may have formed a strong cognitive association between BMEC and PA goals such that their PA goal is protected against temptations such as BMEC [8]. However, the BMEC primes and consequent activation of PA goals did not predict PA behaviors. To better understand this phenomenon, Cheval et al. [10] used electroencephalography (EEG) to examine approach-avoidance tendencies towards PA and sedentary behavior (SED) cues in college-aged students. This seminal study showed that avoiding SED stimuli required more brain resources (i.e., higher inhibitory activity) compared to avoiding PA stimuli. Similar results have been demonstrated in food-related studies where increased recruitment of inhibitory processes was required to avoid high caloric foods compared to low caloric foods [11-13]. Together, these compelling results support an evolutionary explanation of our innate tendencies towards the consumption of high caloric foods and the avoidance of unnecessary PA to conserve energy.

The human tendency to move in energetically optimal ways has been theorized to occur over both evolutionary [14] and developmental timescales [15-17]. Bipedalism in humans represents a fundamental evolutionary adaptation to stand, walk, and run efficiently [14]. Selection and transition for facultative bipedalism (i.e., climbing), walking, and later running in early hominins seem to favor efficiency in relation to habitat. For instance, the selection of facultative bipedalism was advantageous in rain forest habitats, whereas habitual bipedalism facilitated long distance walking in open and hot habitats and selection of running was advantageous for open grassland habitats [14]. In addition to occurring over evolutionary timescales, energy optimization also appears to occur over the course of a lifetime. For example, Selinger et al. [16] had participants wear a robotic exoskeleton that shifted their normally preferred stepping frequency to higher or lower frequencies that were not energetically optimal. Within minutes, individuals were able to adapt to the new energetic optima. When the participants were held away from their preferred stride frequency using a metronome and then released, they returned to their new preferred step frequency within seconds. The authors concluded that energetic cost plays a central role in shaping motor movements and that alterations that favor energy optimization occurs rapidly and continuously throughout the lifespan.

Overall, as the theory of effort minimization in PA (TEMPA) suggests, energy optimization may play a role in preventing individuals from engaging in energy-consuming behaviors such as PA. The opportunity to engage in SED can be conceived as a reward, which is consistent with the evolutionary explanation towards the conservation of energy and thereby may help explain why so many individuals experience negative affect in response to and during exercise [18]. However, there is limited research evaluating this hypothesis. Hence, the purpose of this study is to investigate the hypothesis that automatic approach versus -avoidance tendencies inform our decision-making processes to engage in activities that are energy conserving versus activities that are energy expending (e.g., taking an elevator vs. climbing stairs).

METHODS

Due to COVID-19 precautions and restrictions, we allowed participants to participate via two methods of delivery: (1) In-person study participation and (2) Remote study participation.

For in-person study participation, participants were invited to visit the laboratory on two separate occasions separated by a minimum of 7 days and a maximum of 10 days. For remote study participation, participants were invited to meet with the researcher using the Zoom videoconferencing platform. In both study methods, participants underwent the same measures of approach-avoidance tasks and a demographic questionnaire. In-person study participants were instructed to wear an accelerometer for 7 days. Remote study participants did not wear an accelerometer.

Participants

Faculty, staff, and students from The University of Alabama were recruited as participants for this study. All participants speak English as their first language and have no medical conditions that impair language perception or restrict regular PA participation. Overall, 104 participants were included in the study, 87 participated in person and 17 participated remotely. Of those 87 who participated in-person, 66 participants had valid accelerometer data (4 participants dropped due to time conflict, 2 participants did not have accelerometer data due to malfunction of the device, and 15 participants did not reach accelerometer wear-time cut-off). Data from remote participation was not included in the analysis.

Research Design

For in-person participation, participants visited the laboratory on two separate occasions separated by a minimum of 7 days and a maximum of 10 days. During their initial visit to the laboratory, participants completed an informed consent prior to baseline measurements. Participants' height was measured with a stadiometer (SECA, Birmingham, UK) to the nearest mm. Weight was measured to the nearest 0.1 kg using a digital scale (Detecto DR 400, Missouri, USA). Height and weight were used to calculate body mass index (BMI), expressed as $kg{\cdot}m^{-2}$., and then categorized as normal weight (18.5-24.9 kg·m^{-2}), overweight (25 to 29.9 kg·m^{-2}), and obese (≥30 kg·m^{-2}) [19]. Following the computerized tasks but before leaving the laboratory, participants completed the health history and demographics questionnaire and were instructed to wear an accelerometer during all waking hours for 7 consecutive days. Participants returned to the laboratory after at least 7 days but no more than 10 days for visit two, where they returned their accelerometer and activity log to study personnel.

For remote participation, participants were invited to meet with the researcher using the Zoom video-conferencing platform. During their online meeting, participants completed informed consent online via UA Qualtrics. Remote study participants self-reported their height and weight. Height and weight were then used to calculate BMI (kg·m^{-2}) and categorized using the same methods described above. For the computerized tasks, participants were provided with a link to the testing packet through E-Prime Go, a remote data collection platform for E-Prime 3.0 Behavioral Research Software (Sharpsburg, PA). We asked the participants to silence their phone, alerts, music, and anything else distracting before starting the task. In addition, we asked the participants to have the Zoom meeting/connection on a separate device such as a smartphone, iPad, or laptop to prevent any distractions during the tasks. Following the computerized tasks, participants completed the health history and demographics questionnaire.

Procedures

Approach-Avoidance Task

The approach-avoidance task (AAT) was used to measure automatic approach-avoidance behavioral tendencies toward physical activities that are energy-conserving (EC) or energy expending (EE). During the task, participants listened to a short description of a scenario. The audio priming is generated by a text-to-speech app (Natural Reader App 3.2, Natural Soft

Limited) with a sound pitch ranging from 250 Hz to 1,000 Hz. An example scenario would be *"You have a meeting on the third floor of a building. There is an elevator right across from the entrance and stairs are located down the hall. You now have to decide whether to take the elevator or stairs."* Participants were asked to react to the format of the stimuli (square or circle) in which the stimuli contained an image depicting the target concepts (EC and EE). The paradigm required participants to move the manikin on the screen toward or away from the stimuli by pressing the "2" or "8" key on a keyboard.

Each trial started with a fixation cross in the center of the screen. Participants pressed the space key to begin listening to the scenario and pressed the enter key to move on to the task at the end of the audio. A manikin appeared in either the upper or the lower half of the screen. Depending on the condition, participants were asked to move the manikin as quickly and accurately as possible towards a square image and away from a circle image, or vice versa. Participants completed 7 scenarios, each of which included two blocks of trials with each block consisting of 8 test trials totaling 112 test trials. The order of the blocks was counterbalanced across participants. The reaction time (RT) between the appearance of the image and the first key press, was used for analysis. Incorrect responses and response latencies that were less than 300 ms and more than 1,500 ms were excluded as recommended by Krieglmeyer, Deutsch, and Roland [20]. The mean RT for each block was calculated. Approach tendencies for each of the targeted behaviors—energy-conserving (AppEC) and energy expending (AppEE)—were calculated as:

$$\textit{Approach Tendency} = \left(\text{Average RT}_{\textit{Avoidance}} - \text{Average RT}_{\textit{Approach}}\right),$$

where a positive score indicates approach tendencies towards the target behavior, and a negative score indicates avoidance tendencies towards the target behavior. This version of AAT has been previously validated as a measure of approach-avoidance tendencies for various target concepts [20, 21] including PA and sedentary behavior [22, 23].

Situated Decisions Questionnaire (SDQ)

A situated decision to exercise questionnaire, developed by Brand and Schweizer [24], has been modified for the current study and was used to measure an individual's decision-making tendencies to be physically active when faced with situations or scenarios involving behavioral alternatives. The original questionnaire consists of 8situations in which participants are asked to decide to choose between engaging in various forms of exercise (i.e., sport-related activities that are deliberately pursued) or refraining from participation. For the current study, we developed a similar questionnaire consisting of 7situations in which participants are asked to choose between two behavioral alternatives that involve common daily activities and occur spontaneously (see Appendix G). For example, *"You have a meeting on the third floor of a building. There is an elevator directly across from the entrance and the stairs are located down the hall. Will you take the elevator?"* Participants are then asked to indicate their answer using a 5-point scale, ranging from 1 = *By no means/Definitely no* to 5 = *By all means/Definitely yes*.

PA Measures

PA behaviors were measured using an accelerometer (ActiGraph, GT3X+, ActiGraph Corporation, Pensacola, FL, USA). Participants were given an accelerometer, along with instructions on how to wear the accelerometer and how to track their wear time and daily activities at the end of Visit 1. The ActiGraph is a small, lightweight triaxial device that measures body motion on three planes of movement. Participants were instructed to wear the accelerometer during all waking hours, except when swimming or bathing, for 7 consecutive days. A valid day was defined as ≥10 hours of wear time, and participants were required to have a minimum of three valid days to be retained in the analyses.

Objectively measured daily PA was quantified as time spent (min/d) engaging in LPA, MVPA, and SED activities in the last week (7-d). An index of total PA expressed as total activity count per day (tac/d) was obtained. Estimated METs and PA cut points were determined using the validated Freedson adult vector magnitude algorithm [25]. Actigraph data were aggregated to 60s epochs and the vigorous and very vigorous PA categories were combined. A cut-point of ≤150 counts/min was employed to define SED activity. All accelerometer data were reviewed and compared with the participant's PA log before being processed via ActiLife data analysis software (ActiGraph Link, ActiGraph Corporation, Pensacola, FL, USA).

As part of the demographic questionnaire, we asked the participants to rate their current level of PA (1=SED, 2=Low, 3=Moderate, 4=Recreationally Active, 5=High/Athlete) and how long they have been at this level of activity expressed in months. We then multiplied these two variables to obtain a measure of PA history expressed as PA history index (PA-his).

Statistical Analysis

Mean RTs were calculated for each condition (approach or avoidance) on each task, removing trials with extreme RTs (<300 ms or >1,500 ms) and incorrect responses. Internal consistency of AAT was measured by computing within-subjects split-half correlations with Spearman-Brown corrections for RTs from each block/scenario. Mean RTs were submitted to analyses of variance (ANOVAs) with 2 trial types (approach and avoid) × 2 stimuli (EE and EC). Additionally, approach tendency scores were calculated separately for EC and EE stimulus by subtracting the mean approach RT from the avoidance RT (i.e., AppEE and AppEC). A positive score indicates approach tendency towards the stimulus. Correlational analysis was used to examine relationships among approach tendency scores (AppEC and AppEE), SDQ scores, and PA level. All data were analyzed using the SPSS (SPSS version 27.0, Chicago, IL, USA). P-values of ≤0.05 were regarded as statistically significant.

RESULTS

Descriptive data of the participants are shown in Table 4.1. Eighty-seven participants were included in the analyses (63% women; 83% White; 92% students) with mean age (±*SD*) of 23±9 years. Based on accelerometer data, participants spent most of their waking hours performing light activities (773.4 min/d) and spent 53.4 min/d on average performing MVPA. Participants spent 505.3 min/d (approx. 8 hr/d) in SED behavior. Most participants (80%; n=53) met or exceeded the recommended minimum level of PA based on public health guidelines [6]. Internal consistency of AAT scores (mean RT) across all scenarios was 0.92 for approach and 0.90 for avoidance trials.

Approach Tendency Scores

There was no significant difference between mean approach tendency scores (*AppEE* and *AppEC*). The mean SDQ score (3.09±0.53) did not correlate with approach tendency scores, however, LPA (min/d) was negatively correlated with *AppEE* ($r=-0.37$, $p<0.01$). When comparing *AppEC* vs *AppEE* for each scenario (e.g., elevator vs. stairs, jaywalk vs. crosswalk), participants demonstrated significantly greater approach tendencies towards jaywalking compared to crosswalk (mean difference [MD]=82.2, 95% *CI*: 27.5, 137.1 points, $d=0.33$, $p=0.04$) (Figure 4.1). There was no significant difference in *AppEE* scores between EE scenarios. Bonferroni corrected pairwise comparisons showed *AppEC* of '*all bags'* (carrying all bags of groceries) had significantly lower approach tendency scores than other *EC* scenarios: '*Elevator*'

($p<0.01$), '*Jaywalk*' ($p= 0.01$) and '*Drive In'* ($p=0.02$), and tended to have lower approach tendency scores compared to '*Close*' ($p=0.08$) and '*Ride*' ($p=0.09$) (Figure 4.2). Since participants responded significantly differently to the '*all bags'* scenario compared to the other EC scenarios, the '*all bags'* scenario was omitted and study analyses were re-run.

With '*all bags*' removed, there was a significant difference between mean approach tendency scores (AppEE and AppEC; MD=47.0, 95% *CI*: 22.7, 71.4 points, $d=0.41$, $p<0.01$). The mean SDQ score did not correlate with approach tendency scores, however, LPA (min/d) was negatively correlated with AppEE ($r=-0.27$, $p=0.02$).

Effects of AAT

There was a significant *Stimulus Type* × *Trial Type* interaction ($F_{1,86}=5.01$, $p=0.02$, $eta^2=0.05$) indicating that participants had a greater tendency to approach and an impaired tendency to avoidance the EC stimulus. A significant 3-way interaction (*Trial Type* × *Stimulus Type* × *LPA*) was shown when PA level was added as covariate ($F_{1,64}=4.7$, $p=0.03$, $eta^2=0.07$). Bonferroni pairwise comparisons revealed RT differences in both *Stimulus* and *Trial Types* *(*$p=0.01$ *and* $p=0.02$, respectively*)* among those engaging in high LPA, but not low LPA (Figure 4.3).

DISCUSSION

The purpose of the current study aligns with the conception of TEMPA in that the attraction to conserve energy and effort serve as a constraining factor in the regulation of PA behavior. We measured automatic approach-avoidance tendencies in common scenarios where individuals face decisions whether to conserve energy or expend energy (e.g., taking an elevator vs. stairs). Active individuals with a long history of PA responded faster in approaching EE stimuli. Repeated experiences such as having strongly held PA habits strengthens the cognitive accessibility of the related concepts. Accessibility refers to an idea or a concept can be retrieved from memory with ease. For highly accessible attitudes (e.g., strongly formed habits), there is a strong mental representation or schema of the concept in memory and the presentation of cues will likely activate the schema spontaneously favoring the cognitive efficiency [26]. Hence, individuals with strong and long history of habitual PA are more likely to engage or respond to PA related cues due to the highly accessible mental representation of PA-related concept. This is similar to a previous study showing greater approach bias [27] and attentional bias [28] towards PA-related cues in active individuals.

After removing the influential scenario (i.e., 'All Bags'), participants had a greater tendency to approach EC stimuli and have difficulty avoiding EC stimuli. This supports our hypothesis that individuals have automatic attraction to energy-conserving cues. We have also seen a tendency to approach EC in individuals with high LPA, but not with low LPA. This indicates individuals who spend more time in light-intensity activity may have a greater affinity to conserve energy, but not to be idle. In other words, conserving energy or effort in some tasks, perhaps inessential tasks, provides opportunities to invest more energy or effort in essential pursuits. This is in line with the evolutionary perspective that hunter-gatherers are evolved to be more active (i.e., acquire and spend more energy) than our immediate ape ancestors allowing humans to have bigger brains, and highly selective reproductive strategies [29, 30], and yet are also evolved to refrain from activities that are unnecessary [1, 31]. Based on TEMPA, effort minimization process and attraction to conserve energy is always at work as any movement related cues are perceived as effortful. The intensity of this attraction, however, may vary based on individual and behavioral characteristics, and environmental conditions [32]. Houten et al., [33] examined the effects of two experimental conditions on elevator use. In one condition, several signs such as *'Save energy. Use the stairs for short trips', 'Exercise Your Heart. Use the stairs. A flight a day can mean the difference'*, and '*Burn calories. Use the stairs*.' were mounted on each elevator door. In the second condition, the elevator door was delayed by 26 seconds. Results indicated neither of the signs reduced the elevator usage, while the use of the door delay reduced the elevator consumption by one-third. These results demonstrate the decision-making process can be influenced by perceived inconvenience or time delay even though the alternative choice is more effortful (i.e., choosing stairs). TEMPA also discusses the influence of other situational factors such as time availability, daily demands, physical and cognitive fatigue on the decision-making process. In our study, energy-consumption cues were associated with LPA (high LPA was associated with greater approach to EC and LPA negatively correlated with EE cues). Our result seem to be similar with an earlier study by Oliver and Kemps [34] regarding the contribution of approach-avoidance of PA cues on incidental PA. They reported that individuals who have greater approach tendency PA cues did not engage in much incidental PA, despite having both intrinsic and extrinsic motivation. The authors concluded that one potential explanation for this relationship could be the gap or hypocrisy that exists between internal beliefs and behavior output where the requirements of daily living (time, energy, environment, etc.) hinders individuals' choices to act on their internal beliefs [34]. This ties in with the conception of TEMPA where dispositional and situational factors that moderate the effect of perceived effort on the decision-making process. It is possible that daily variation of LPA (i.e., spontaneous PA) influence the strength of attraction towards effort minimization and decision-making process. In other words, individuals may have more sensitivity towards EC cues on the days they have more daily tasks.

The current research has several strengths. Both explicit and implicit measures were used to evaluate the decisional approach and avoidance tendency to common scenarios. It included a prospective design with audio priming and assessment of PA with accelerometers. It also presents several limitations. First, the decisional approach-avoidance tendency was measure by a manikin task with audio priming. Although audio priming techniques have been used in other fields employing implicit measures [35], it has not been used in implicit measures in the PA domain. It is unclear whether this approach can be generalized across fields. Secondly, the scenarios employed in the current study may not have represented energy expending and energy-conserving consistently. When contemplating potential scenarios, we were strictly thinking about energy expenditure. For instance, in the scenario where there is a decision whether to carry all of the grocery bags in one single trip or carry smaller loads on multiple trips, carrying all bags was the choice for energy conserving. However, when looking from an effort perspective, carrying a large load at a single time might have been perceived as more effortful than carrying small loads on multiple trips. Future studies should be careful when selecting vignettes such as this.

In conclusion, in support with the concept of TEMPA, our findings demonstrated that individuals have greater approach tendencies towards EC cues. Our data further revealed that individuals with long history of habitual PA had greater approach tendencies to energy consumption cues. Our result also indicated individuals who spend more time in light-intensity activity may have a greater affinity to conserve energy. The attraction to energy efficiency may have reinforced by individuals' task-related PA demands. Future research is required to investigate this further

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Table 4. 1. Sample descriptive statistics (*M* ± *SD*).

Variables	**Total (*N* = 87)**	**Men (*n* = 35)**	**Women (*n* = 52)**
Age (years)	23±8	23±7	23±8
BMI (kg/m^2)	26.0±4.7	27.1±4.4	25.3±4.8
BMI classification			
Normal	45.6 (30)		
Overweight	31.8 (21)		
Obese	19.7 (13)		
Approach tendency scores (ms)			
Approach to EC scenarios	61.7±88.7	67.7±82.5	57.7±93.5
Approach to EE scenarios	44.7±86.7	46.5±86.3	43.5±87.7
AAT reaction times (ms)			
Avoidance to EC	758.4±177.9	786.3±202.4	739.5±158.6
Avoidance to EE	742.1±175.6	777.6±200.2	718.3±154.4
Approach to EC	696.6±162.5	715.3±168.7	684.1±158.6
Approach to EE	697.5±193.0	727.8±213.2	677.1±177.4
PA measures			
MVPA (min/d)	53.4±26.1	55.2±24.5	52.2±27.2
LPA (min/d)	773.4±70.9	769.7±73.5	775.7±70.0
SED (min/d)	505.4±82.8	508.0±87.1	503.8±81.1
Total PA (tac × 1000/d)	460.0±164.6	461.2±153.4	459.3±172.9
SDQ	3.1±0.6	3.1±0.5	3.1±0.6

AAT, approach-avoidance task (see text for description). BMI, body mass index. EC, energy conserving. EE, energy expending. LPA, light intensity PA. min/d, minutes per day. ms, milliseconds. MVPA, moderate-to-vigorous intensity PA. PA, physical activity. SED, sedentary activity. SDQ, situated decision questionnaire. tac, total activity count.

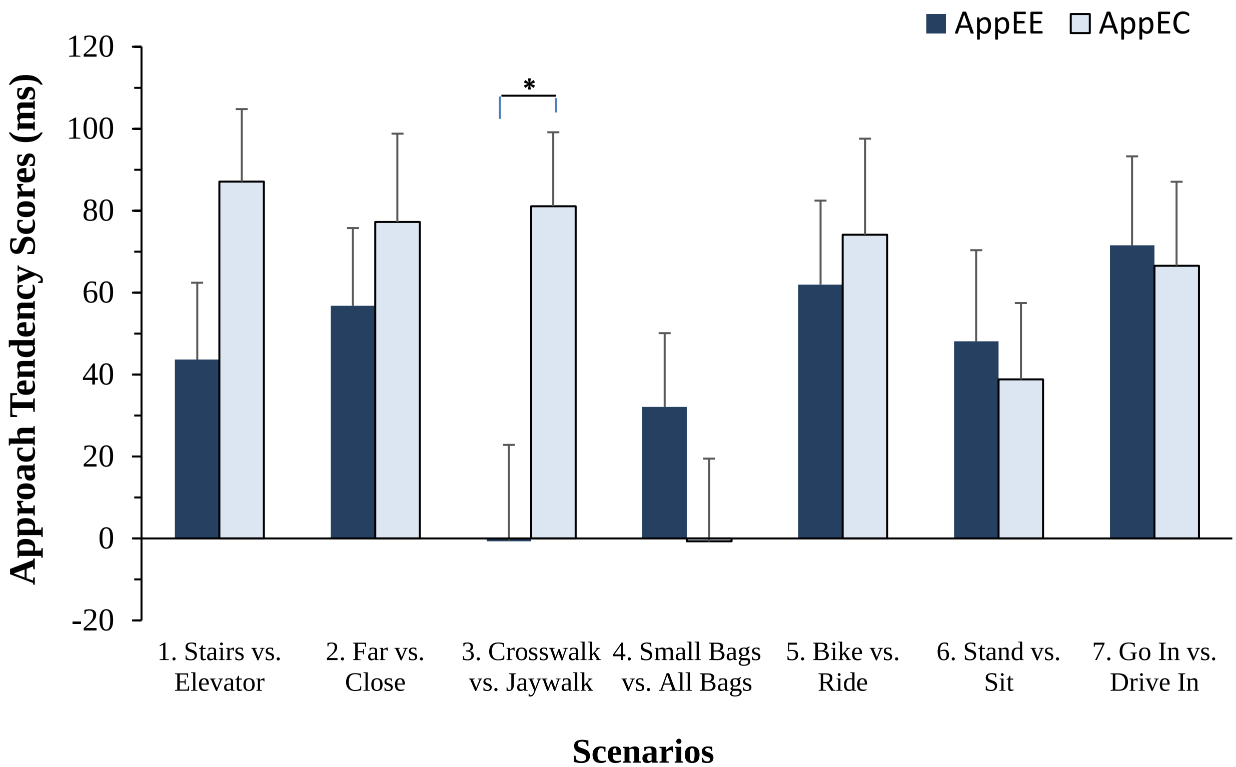

Figure 4. 1. Difference between approach tendency towards energy expending (EE) vs. energy conserving (EC) scenarios. Error bar indicates standard error of the mean.
AppEC, approach tendency towards energy conserving scenarios. AppEE, approach tendency towards energy expending scenarios.
* Participants had significantly greater approach tendencies towards '*jaywalk*' compared to *'crosswalk'* (*d*=0.33, p=0.04).

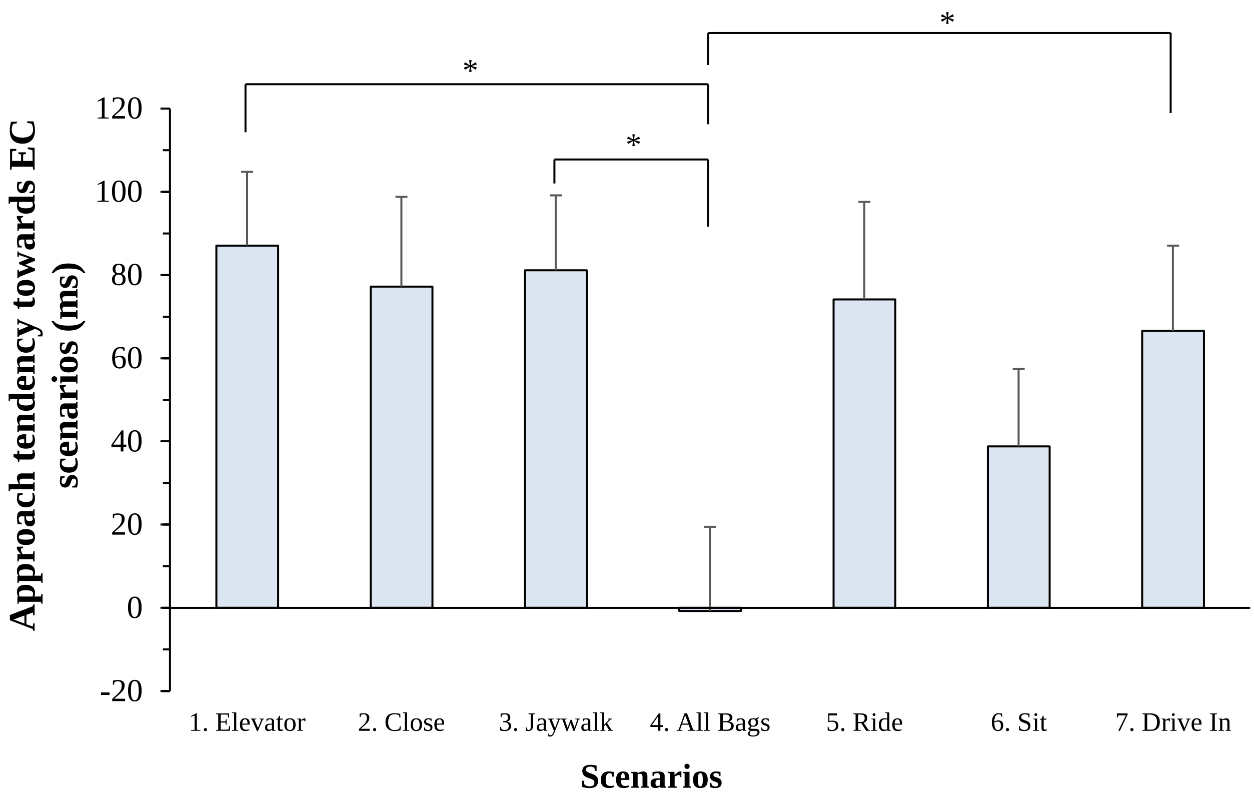

Figure 4. 2. Differences between mean approach tendency scores for energy conserving (EC) scenarios. Error bar indicates standard error of the mean.
* Bonferroni corrected pairwise comparison of approach tendency score to *'All Bags'* is significantly lower than approach tendency to: '*Elevator*' ($p<0.01$), '*Jaywalk*' ($p=0.01$), and '*Drive In'* ($p=0.02$).

A

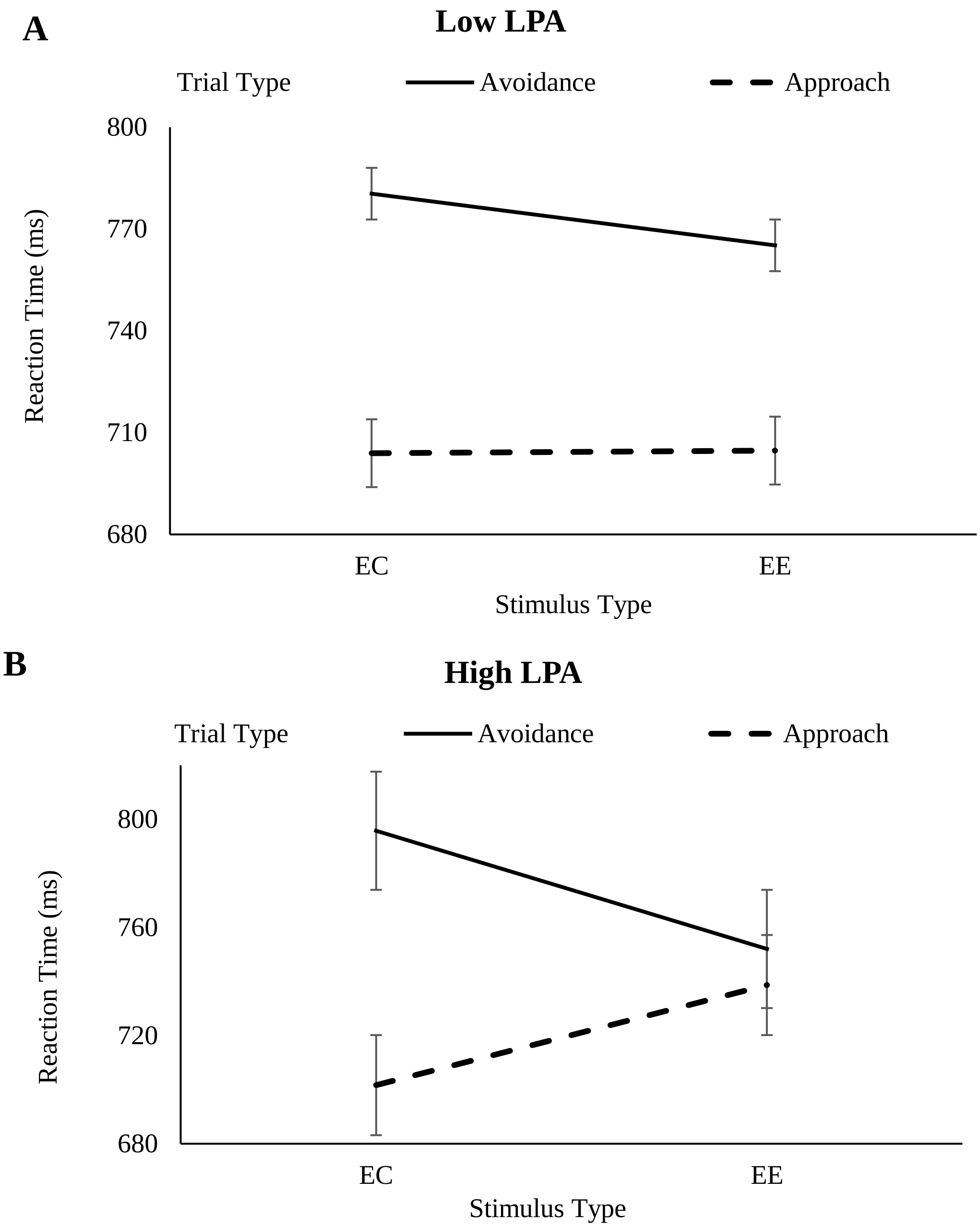

Figure 4. 3. Interactive effect of habitual physical activity× stimulus type × trial type on reaction time. Figure (A) displays reaction times for approach and avoidance trials for low LPA and (B) for high LPA.
EC, energy-conserving stimuli. EE, energy expending stimuli. LPA, light intensity physical activity.

CHAPTER 5

CONCLUSION

New and emerging research that applies dual-process theories (DPT) to physical activity (PA) behavior has shown that PA is, at least in part, regulated by automatic processes [1-4]. The use of DPT has been applied to many areas of social and cognitive psychology including perception, decision-making, stereotyping, and social attitudes [5-7]. The DPT assumes that there are two information processes operating to make decisions and shape behavioral outcomes: automatic and reflective [5]. Automatic processes are characterized by a spontaneous, unconscious reaction to events or objects and involve constructs such as habits and automatic evaluations (AE). On the other hand, reflective processes represent conscious deliberation on the available information and invoke constructs such as intentions, efficacy beliefs, outcome expectations, and plans [8]. Conventional PA motivation theories mainly focus on reflective processes such as offering educational, informational, and environmental interventions [9, 10]. Evidence suggests that such interventions engender large changes in PA intentions, however, do not always lead to long-term behavioral changes [11-13].

More recent research has focused on elucidating the automatic processes that influence PA behaviors, however, little is understood about the role of automatic processes across the wide range of PA behavior. The broad aim of this dissertation is to expand upon the existing body of research by investigating important gaps in our current understanding of automatic regulatory processes regarding PA. Specifically, how varying components of PA influence not only the AE of PA but also the stability of these measures. Additionally, to expand our understanding of the theory of energetic cost minimization (TECM), this dissertation investigated impulsive approach tendencies towards behaviors that are energetically costly versus energetically efficient (e.g., taking stairs versus taking an elevator).

We examined the automatic and reflective processes in relation to four different components of the PA domain: exercise, light and moderate to vigorous intensity non-leisure time PA (L-NLTPA; MV-NLTPA), and sedentary behavior (SED). Secondly, we investigated the stability of AE measures of those components of PA. Lastly, we investigated automatic approach-avoidance tendencies in common scenarios where individuals are faced with decisions to approach or avoid energy conserving or energy expending activities. Participants completed Single-Category Implicit Association Task (SC-IAT) to measure AE of PA, Approach-Avoidance Task (AAT) for approach tendencies to conserve or expend energy, self-report reflective measures of PA intention, self-efficacy scale (SES), BIS/BAS scale, PA enjoyment scale (PACES), and Go/No-Go task as a measure of executive function. Habitual PA level was measured using accelerometers. Participants completed repeated measures of SC-IAT separated by 7-10 days.

For Study 1, AE of exercise significantly correlated with MVPA and Total PA in individuals who are highly active, and reflective measures (Intention and Self-efficacy), inhibitory control, and personality trait measures moderated the relationship between AE and PA behavior. Our result supports the Reflective-Impulsive Model where the two processes may jointly activate behavioral schemata and facilitate behavior output (e.g., approach-approach) [8]. For instance, for individuals who are highly active and hold positive evaluations of PA, the public message that 'exercise is good' strengthens the behavior outcome (i.e., approach PA with ease).

One of the reasons that our result has shown this synergetic relationship among AE, reflective, and objectively measured MVPA is maybe due to the fact that our participants were highly active (approximately 80% of our sample met the recommended minimum level of PA based on public health guidelines). Future studies should include participants who are seeking behavioral change that could conceptually involve antagonistic activation of implicit and reflective systems (e.g., approach-avoidance).

When examining the stability of SC-IAT of four different components of PA in Study 2, we found SC-IAT for the exercise revealed the most stable compared to the other domains (L-NLTPA, MV-NLTPA and SED). In evaluating our results, the lack of reliability indices in these domains may be due to task confusion. Implicit association measures may have been affected by increased accessibility of additional attributes associated with types of activities selected as stimuli for each domain. For example, stimulus images we selected for L-NLTPA and MV-NLTPA were representative of common household activities such as mowing, sweeping, and ironing (e.g., mowing could be associated with heat, and sweeping could be associated with dirty or messy, etc.). Consequently, it is possible that visual features of household activities may have activated associative cluster that are not related to energy expenditure, which may have led to task confusion.

Findings for Study 3 satisfied the study hypothesis that individuals have a general tendency to approach EC cues. This result was particularly significant in individuals with high LPA. That is, individuals who spend more time in light-intensity activity may have a greater affinity to conserve energy to do more, but not to be idle. This is in line with the evolutionary perspective that hunter-gatherers are evolved to be more active (i.e., acquire and spend more energy) than our immediate ape ancestors allowing humans to have bigger brains, and highly selective reproductive strategies [14, 15], and yet also selected against activities that are unnecessary [16, 17]. It would be interesting to investigate in the future, whether the approach to EC (i.e., sensitivity to EC cues) varies on the days when individuals are engaged in greater LPA than less LPA.

This dissertation was a compilation of studies examining the automatic processes of PA. As a result, both automatic and reflective processes an important role in the regulation of PA including the automatic tendencies to conserve energy. An important implication of the current study is that potential intervention strategies targeting both automatic and reflective processes may elicit greater success. Different strategies have been studied in health behaviors such as overcoming or bypassing negative automatic tendencies [18], altering behavioral responses to cues [19], and selective attention training [20]. Further pursuit of research involving combined effort to incorporate above-mentioned intervention strategies with conventional reflective strategies (e.g., intention, self-determination) will be invaluable.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD CERTIFICATION

THE UNIVERSITY OF ALABAMA | Research & Economic Development
Office for Research Compliance

October 14, 2020

Battogtokh Zagdsuren
Dept. of Kinesiology
College of Education
Box 870312

Re: IRB #: e-Protocol ID 18-08-1467 "The Automatic Evaluation of Physical Activity and Sedentary Behavior"

Dear Battogtokh Zagdsuren:

The University of Alabama Institutional Review Board has granted approval for your proposed research. Your application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies

Please note that no study activities may begin until approval from the UA College of Education for your *Research Activity Plan* has been secured. Upon receipt of the appropriate approval, please forward a copy of the documentation to the UA IRB in the form of a modification request via the e-Protocol system. The approval for your application will lapse on October 13, 2021. If your research will continue beyond this date, please submit the Continuing Review to the IRB as required by University policy before the lapse. Please note, any modifications made in research design, methodology, or procedures must be submitted to and approved by the IRB before implementation. Please submit a final report form when the study is complete.

Please use reproductions of the IRB approved informed consent/assent form to obtain consent from your participants.

Good luck with your research.

Sincerely,

THE UNIVERSITY OF ALABAMA® | Research & Economic Development
Office for Research Compliance

February 8, 2022

Battogtokh Zagdsuren
Department of Kinesiology
College of Education
The University of Alabama
Box 870312

Re: IRB # 18-08-1467-A-R1 "The Automatic Evaluation of Physical Activity and Sedentary Behavior"

Dear Battogtokh Zagdsuren:

The University of Alabama Institutional Review Board has granted approval for your renewal application. Your renewal application has been given expedited approval according to 45 CFR part 46. Approval has been given under expedited review category 7 as outlined below:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

The approval for your application will lapse on February 7, 2023. If your research will continue beyond this date, please submit a continuing review to the IRB as required by University policy before the lapse. Please note, any modifications made in research design, methodology, or procedures must be submitted to and approved by the IRB before implementation. Please submit a final report form when the study is complete.

Good luck with your research.

APPENDIX B

IMAGES AND WORDS IN AUTOMATIC EVALUATION TASKS

Images in Single Category Implicit Association Test (SC-IAT) and Go/No-Go Task

1. Results from Pilot Study

Exercise Images								
								
Total Sample								
Accuracy (%)	95.26	95.21	94.21	92.84	91.74	87.66	84.52	65.62
Certainty (%)	96.47	97.36	96.47	95.21	91.96	92.84	91.49	74.68
Faculty/Staff								
Accuracy (%)	95.03	95.65	93.78	94.40	92.54	87.57	85.71	81.36
Certainty (%)	98.13	93.78	93.16	95.65	88.19	90.06	87.57	72.67
Students								
Accuracy (%)	95.40	95.28	94.37	92.80	91.77	87.77	84.51	64.18
Certainty (%)	92.80	95.08	93.28	90.26	84.21	85.72	83.30	57.71

Light Intensity Images				
Image				
Total Sample				
Accuracy (%)	80.22	75.04	82.59	57.58
Certainty (%)	84.30	81.24	83.36	78.90
Faculty/Staff				
Accuracy (%)	82.60	81.40	91.30	65.20
Certainty (%)	78.26	86.50	88.50	84.50
Students				
Accuracy (%)	80.21	74.5	81.7	56.8
Certainty (%)	69.93	81	83	78.5

Moderate-to-Vigorous Images								
Image								
Total Sample								
Accuracy (%)	71.13	49.86	35.43	18.57	12.73	10.91	7.05	5.73
Certainty (%)	84.10	73.86	74.66	80.36	88.02	88.02	89.75	84.13
Faculty/Staff								
Accuracy (%)	82.6	59.6	34.16	24.2	11.8	18.01	13.04	3.10
Certainty (%)	76.39	77	56.52	79	65.21	73.91	80.12	76.63
Student								
Accuracy (%)	70.04	48.9	35.63	18	12.82	10.22	6.47	5.98
Certainty (%)	68.66	73.5	54.32	80.5	63.70	76.76	80.52	69.26

Sedentary Images								
Image								
Total Sample								
Accuracy (%)	97.52	98.73	89.31	94.44	97.85	97.41	90.47	73.33
Certainty (%)	93.47	97.60	93.31	91.32	94.88	96.50	91.32	88.13
Faculty/Staff								
Accuracy (%)	97.50	99.40	98.8	98.3	98.10	99.37	96.89	73.90
Certainty (%)	90.06	96.96	93.16	91.30	96.89	95.65	90.06	94
Students								
Accuracy (%)	97.50	98.72	89.89	94.50	97.88	97.33	89.95	73.35
Certainty (%)	88.14	95.52	86.75	89.83	89.99	93.28	82.81	77.25

2. Revised Images to be used in the dissertation.

Exercise Images

Accuracy (%)	94.21	91.74	84.52	87.66	95.26	New	92.84	95.21
Certainty (%)	96.47	91.74	84.52	87.66	95.26		92.84	95.21

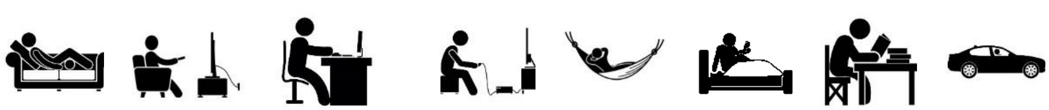
Moderate-to-Vigorous Images

Accuracy (%)	71.13	New	New	New	New	New	New	New
Certainty (%)	84.10							

Light Intensity Images

Accuracy (%)	New	80.22	75.04	82.59	82.98	88.76	83.53	85.62
Certainty (%)		84.30	81.24	83.36	80.91	84.13	88.02	89.75

Sedentary Images



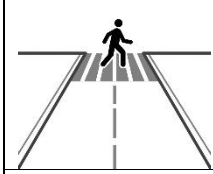
Accuracy (%)	97.52	98.73	89.31	94.44	97.85	97.41	90.47	73.33
Certainty (%)	93.47	97.60	93.31	91.32	94.88	96.50	91.32	88.13

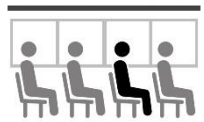
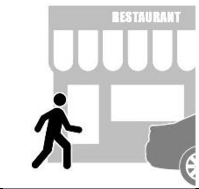
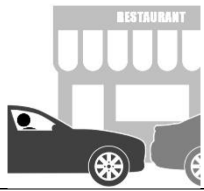
Words in Single Category Implicit Association Test (SC-IAT)

SC-IAT Attribute Words

Words Associated with Positive Affect	Words Associated with Negative Affect
Beautiful	Awful
Fantastic	Agonizing
Happy	Horrible
Pleasurable	Painful
Energetic	Tragic
Delightful	Terrible

Image in Approach- Avoidance Task

Images associated with energy expending activities	Images associated with energy conserving activities
	
	
	
	
	

	
 RESTAURANT	 RESTAURANT

APPENDIX C

BIS/BAS SCALES

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses.

	Very true 1	**Somewhat true 2**	**Somewhat false 4**	**Very false 5**
1. A person's family is the most important thing in life.	O	O	O	O
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.	O	O	O	O
3. I go out of my way to get things I want.	O	O	O	O
4. When I'm doing well at something I love to keep at it.	O	O	O	O
5. I'm always willing to try something new if I think it will be fun.	O	O	O	O
6. How I dress is important to me.	O	O	O	O
7. When I get something I want, I feel excited and energized.	O	O	O	O
8. Criticism or scolding hurts me quite a bit.	O	O	O	O
9. When I want something I usually go all-out to get it.	O	O	O	O
10. I will often do things for no other reason than that they might be fun.	O	O	O	O
11. It's hard for me to find the time to do things such as get a haircut.	O	O	O	O
12. If I see a chance to get something I want I move on it right away.	O	O	O	O
13. I feel pretty worried or upset when I think or know somebody is angry at me.	O	O	O	O
14. When I see an opportunity for something I like I get excited right away.	O	O	O	O
15. I often act on the spur of the moment.	O	O	O	O
16. If I think something unpleasant is going to happen I usually get pretty "worked up."	O	O	O	O
17. I often wonder why people act the way they do.	O	O	O	O
18. When good things happen to me, it affects me strongly.	O	O	O	O
19. I feel worried when I think I have done poorly at something important.	O	O	O	O
20. I crave excitement and new sensations.	O	O	O	O
21. When I go after something I use a "no holds barred" approach.	O	O	O	O
22. I have very few fears compared to my friends.	O	O	O	O
23. It would excite me to win a contest.	O	O	O	O
24. I worry about making mistakes.	O	O	O	O

APPENDIX D

PHYSICAL ACTIVITY SELF-EFFICACY MEASURES

Using the scale below, please indicate to what extent you are certain about the statement. The closer you place the tick to 100%, the more certain you are with the statement. The closer you place the tick to 0%, the more uncertain you're with the statement.

I can manage to carry out my physical activity intentions even if when……..											
	0 %	10%	20%	30%	40%	50%	60%	70%	80%	90 %	100 %
I have worries and problems	O	O	O	O	O	O	O	O	O	O	O
I feel depressed	O	O	O	O	O	O	O	O	O	O	O
I feel tense	O	O	O	O	O	O	O	O	O	O	O
I am tired	O	O	O	O	O	O	O	O	O	O	O
I am busy	O	O	O	O	O	O	O	O	O	O	O
I have health complications	O	O	O	O	O	O	O	O	O	O	O
I don't have support from my family and friends	O	O	O	O	O	O	O	O	O	O	O
I have other time commitments	O	O	O	O	O	O	O	O	O	O	O
the weather is very bad	O	O	O	O	O	O	O	O	O	O	O
I don't have access to any facilities	O	O	O	O	O	O	O	O	O	O	O

APPENDIX E

PHYSICAL ACTIVITY ENJOYMENT SCALE

INSTRUCTIONS: Please rate how you feel at the moment about the physical activity you have been doing.

1	I enjoy it	① ② ③ ④ ⑤ ⑥ ⑦	I hate it
2	I feel bored	① ② ③ ④ ⑤ ⑥ ⑦	I feel interested
3	I dislike it	① ② ③ ④ ⑤ ⑥ ⑦	I like it
4	I find it pleasurable	① ② ③ ④ ⑤ ⑥ ⑦	I find it unpleasurable
5	I am very absorbed in this activity	① ② ③ ④ ⑤ ⑥ ⑦	I am not at all absorbed in this activity
6	It's no fun at all	① ② ③ ④ ⑤ ⑥ ⑦	It's a lot of fun
7	I find it energizing	① ② ③ ④ ⑤ ⑥ ⑦	I find it tiring
8	It makes me depressed	① ② ③ ④ ⑤ ⑥ ⑦	It makes me happy
9	It's very pleasant	① ② ③ ④ ⑤ ⑥ ⑦	It's very unpleasant
10	I feel good physically while doing it	① ② ③ ④ ⑤ ⑥ ⑦	I feel bad physically while doing it
11	It's very invigorating	① ② ③ ④ ⑤ ⑥ ⑦	It's not at all invigorating
12	I am very frustrated by it	① ② ③ ④ ⑤ ⑥ ⑦	I am not at all frustrated by it
13	It is very gratifying	① ② ③ ④ ⑤ ⑥ ⑦	It's not all gratifying
14	It's very exhilarating	① ② ③ ④ ⑤ ⑥ ⑦	It's not at all exhilarating
15	It's not at all stimulating	① ② ③ ④ ⑤ ⑥ ⑦	It's very stimulating
16	It gives me strong sense of accomplishment	① ② ③ ④ ⑤ ⑥ ⑦	It does not give me any sense of accomplishment
17	It's very refreshing	① ② ③ ④ ⑤ ⑥ ⑦	It's not at all refreshing
18	I felt as though I would rather be doing something else	① ② ③ ④ ⑤ ⑥ ⑦	I felt as though there was nothing else, I would rather be doing

APPENDIX G

SITUATED DECISIONS QUESTIONNAIRE

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the

	Definitely no 1	**No 2**	**Neutral 3**	**Yes 4**	**Definitely Yes 5**
1. You have a meeting on the third floor of a building. There is an elevator right across from the entrance and stairs are located down the hall. Will you take the elevator or not?	O	O	O	O	O
2. You are in a parking lot in a busy shopping mall. There are available parking spots far away from the mall entrance. You are not sure if there is any available spots closer to the mall entrance. Will you hunt for one closer to your destination?	O	O	O	O	O
3. You are standing beside a semi-busy road to cross the road. There is a crosswalk a block away. Will you cross the road if you get a chance now (without walking to the crosswalk)?	O	O	O	O	O
4. You are about to bring in groceries. You can carry them all inside at once or you can make multiple trips with smaller loads. Will you carry them all in at once?	O	O	O	O	O
5. You are about to leave the house when you notice your car has a flat tire. You have a bike that you can use for the trip. You also know your roommate or neighbor is driving in the same direction soon. Will you ask your roommate or neighbor for a ride?	O	O	O	O	O
6. You are standing on a public bus. One seat becomes available and you have two more stops to go. Will you take the available seat?	O	O	O	O	O
7. You are about to get lunch in a busy fast food restaurant. You can either go in to take out your lunch or go through a long line in the drive through. Will you wait in the drive through?	O	O	O	O	O

items. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses.