TARGETING REWARD AND REGULATORY PATHWAYS TO INCREASE PHYSICAL ACTIVITY: DEVELOPMENT OF A GUIDED IMAGERY INTERVENTION

by

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A thesis submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Master of Arts in
Psychology

Charlotte

2021

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ABSTRACT

ALEXIS D. MITCHELL. Targeting Reward and Regulatory Pathways to Increase Physical Activity: Development of a Guided Imagery Intervention.
(Under the direction of DR. SARA LEVENS)

Physical activity provides numerous health benefits. However, many individuals are chronically underactive and have difficulty maintaining regular physical activity. Physical activity interventions may benefit from integrative, experimental approaches based in neurobiological models of behavior that also combine mind-body techniques such as mindfulness and guided imagery. Mindfulness is evidenced to amplify self-regulatory ability and guided imagery is shown to have a positive influence on goal-setting and physical activity motivations. This 2-phase study includes an initial development process to create brief (~4 minutes) mindfulness informed physical activity based guided imagery audio files that target distinct cognitive and affective processes that underly neurobiological models of behavior. In the second phase, participants completed a 2-week pilot intervention study to gather qualitative and quantitative data on intervention feasibility and acceptability. Results indicate that participants found the mindfulness informed guided imagery to be easy to use, enjoyable and helpful. Over a two-week intervention period participants reported positive shifts in behavior change, physical activity enjoyment, increased mindfulness during physical activity, and increased physical activity self-efficacy and satisfaction. Interview data revealed that participants increased their frequency of physical activity and tended to experience positive affect during physical activity, engaged in future oriented thinking and were able to view physical activity in a more positive light. This study extends health behavior change intervention research and provides supporting evidence for a flexible and tailorable online mindfulness-based intervention.

ACKNOWLEDGEMENTS

I would like to give a special thank you to the chair of this advisory committee, Sara Levens, Ph.D. I greatly appreciate her dedication, support, and contributions. The advisory committee to this project has provided constructive feedback throughout – thank you Jennifer Webb, Ph.D., Jeanette Bennett, Ph.D., and Mike Turner, Ph.D. Thank you also to Erin Basinger, Ph.D. for providing guidance regarding the qualitative data analysis. I would also like to acknowledge the support I received for data collection and data management from Levens Emotion and Cognition research assistants. Lastly, thank you to the field experts that provided their time and expertise to the guided imagery development process: Laura Martin, Ph.D., Austin Baldwin, Ph.D., Eric Vidoni, PT, Ph.D., and Natalie Fulton, MS, ACSM-RCEP.

DEDICATION

This Master's Thesis is dedicated to my partner and family who have always believed in me and supported my ideas.

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Mindfulness-informed Guided Imagery to Target Physical Activity: A Mixed Method Feasibility and Acceptability Pilot Study

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1.1 ABSTRACT

Physical activity offers substantial mind-body health benefits and reduced mortality, yet many individuals are chronically underactive. Physical activity interventions may benefit from integrative approaches that join components of mindfulness and neurobiological models of behavior. Mindfulness increases one's awareness of cognitions and physical sensations to potentially facilitate self-regulation, while neurobiological models such as the dual system model of health behavior offer guidance on improving physical activity intervention targets. This 2-phase study includes an initial development process to create brief (~4 minutes) mindfulness informed guided imagery audio files that target distinct cognitive and affective processes to promote physical activity. In the second phase, participants completed a 2-week pilot intervention study to gather qualitative and quantitative data on intervention feasibility and acceptability. Participants endorsed the mindfulness informed guided imagery as easy to use, enjoyable and helpful. Over a two-week intervention period participants reported positive shifts in behavior change, physical activity enjoyment, increased mindfulness during physical activity, and increased physical activity self-efficacy and satisfaction. Interview data revealed that participants increased their frequency of physical activity and tended to experience positive affect during physical activity, engaged in future oriented thinking and were able to view physical activity in a more positive light. Findings support the feasibility and acceptability of an integrative online mindfulness informed guided imagery intervention to promote physical activity enjoyment and engagement. This study extends health behavior change intervention research and provides supporting evidence for a flexible and tailorable online mindfulness-based intervention.

Keywords: mindfulness-informed[1], guided imagery[2], physical activity[3], reward[4], episodic future thinking[5] behavior change[6]

1.2 INTRODUCTION

Physical activity has been shown to exhibit a wide range of physical health benefits, from improvements in mood (Rebar et al., 2015) to reduced risk for all-cause mortality (Lear et al., 2017). Yet, recent data indicate that 77% of adults 18 and over do not meet federal physical activity guidelines (National Center for Health Statistics, 2018) of engaging in at least 150 minutes of moderate-intensity aerobic physical activity per week (US Department of Health and Human Services, 2018). Although evidence supports implementation of physical activity interventions for improving individual and population level health (Gardner et al., 2016), there is significant heterogeneity among findings and a lack of clarity regarding what intervention techniques, or what psychological correlates to behavior change, are most effective or involved in influencing physical activity behaviors and attitudes (Howlett et al., 2019). Consequently, it is critical to develop integrative physical activity interventions that incorporate both psychological approaches and neurobiological models to influence physical activity engagement. The present study builds on theoretical and empirical health behavior change research (Hofmann et al., 2008; Schuman-Oliver et al., 2020), existing online and mobile-based physical activity interventions (Bort-Roig et al., 2014; Jahangiry et al., 2017) and online mindfulness based interventions (Cavanagh et al., 2018; Toivonen et al., 2017) to design and test the feasibility and acceptability of a novel, mindfulness-informed guided imagery intervention that targets physical activity related cognitions and emotions to increase physical activity enjoyment and engagement.

Mindfulness, conceptualized as a nonjudgmental stance toward present moment experiences (Kabet-Zinn, 2005), may serve as a mechanism through which positive behavior change can be initiated and maintained to improve health and reduce disease risk (Sagui-

Henson et al., 2018; Sala et al., 2020; 2021). In the domain of physical activity, mindfulness has been shown to facilitate the maintenance of physical activity (Ulmer et al., 2010) and promote physical activity satisfaction (Tsafou et al., 2017). Mindfulness is purported to influence health behaviors like physical activity through improved attention regulation (Hölzel et al.,2011; Vago & David, 2012), the adoption of a *non-evaluative* stance to the present moment (Baer, 2003), and an increased willingness to experience and accept "negative" sensations (Arch & Caske, 2006). Collectively these processes interact to enhance self-regulation (Teasdale et al., 2000) which may increase one's capacity to maintain goal-directed physical activity behavior in the face of physical discomfort (e.g., labored breathing) and self-limiting judgements (e.g., "I can never be healthy/fit/active"). Mindfulness is a trainable skill (Baer, 2003; Hayes et al., 2012; Teasdale et al., 2000) and transdiagnostic technique (Garland et al., 2014) that can address various maladaptive cognitive, affective, and behavioral patterns associated with mental and physical health concerns and support improvements in stress (Grossman et al., 2004), anxiety (Manzoni et al., 2008), and pain (Chiesa & Serretti, 2011). Mindfulness-informed interventions have also been identified as having wide reaching population level benefits for health behavior change via primary care (Gawande et al., 2019) and workplace settings (Horan & Taylor, 2018), as well as through online-delivery formats for improving health outcomes in the public (Spijkerman et al., 2016). Interventions that incorporate mindfulness therefore have the potential to make meaningful improvement in low engagement health behaviors such as physical activity.

Health behavior research has also identified neurobiological models[7] that offer guidance on improving physical activity intervention targets. The National Institutes of Health Science of Behavior Change (SOBC) working group (Nielson et al., 2018) calls for health

behavior change interventions to target underlying neurobiological mechanisms that influence behavior, such as specific neural pathways and associated cognitive-emotional, or reflective-affective processes (Hofmann et al., 2008). One prominent health related neurobiological model is the dual-systems model of health behavior (Hofmann et al., 2008; Lieberman, 2007; Wiers et al., 2007). The dual-systems model proposes that health behavior is driven by interactions between the *regulatory*, cognitively effortful (i.e., future-orientation, self-regulated behaviors) and *reward-laden*, habitual (i.e., present-orientation, impulsivity) neural networks in the brain. This framework purports that reasoned actions and self-control involved in healthful behaviors, such as physical activity, may be at conflict with automatic, impulsive affective and behavioral associations. For instance, for physical activity to occur, an individual's goal and intent to be physically active (regulatory system) would need to override the pleasurable impulse to remain sedentary (reward system), which often does not occur. The interplay between regulation and reward that defines the dual-systems model has been implicated in a range of health behavior interventions, including reducing alcohol (Hamilton et al., 2020) and sugar consumption (Hagger et al,, 2017), as well as increasing physical activity levels (Phipps et al., 2021; Maher & Conroy, 2016; Strobach et al., 2020).

According to the dual systems model, health behavior interventions should target either the reward system, the regulatory system, or both. The reward system is targeted via emotional mechanisms, such as positive affect and the facilitation of positive reappraisal of negative stimuli, which has been shown to influence physical activity behavior (Rhodes & Kates, 2015). Positive affect is strongly associated with physical activity motivations (Ekkekakis et al., 2013) and implementing positive reappraisal during physical activity has been shown to improve performance and reduce negative affect during physical activity (Giles et al., 2018). Further,

positive associations with physical activity, such as experiencing satisfaction, influence the maintenance of physical activity (Baldwin et al., 2013; Rothman, 2000; Rothman et al., 2011), with satisfaction experienced as little as two weeks after initiating regular physical activity predicting physical activity maintenance (Fleig et al., 2011). The dual system model also posits that physical activity behaviors will become habitual when an individual increasingly relies on implicit associations in the reward system (Hagger, 2020; Smith & DeCoster, 2000) as opposed to the regulatory system, suggesting that interventions should target increasing positive associations with physical activity to increase physical activity engagement.

Activation of the regulatory system, on the other hand, involves increased self-regulatory ability and executive functions, such as goal setting and planning (Hofmann et al., 2008; Metcalfe & Mischel, 1999). Physical activity interventions have traditionally targeted the regulatory system through examination of self-regulatory processes like planning and goal-setting (Rhodes & Pfaeffli, 2010). However, many regulatory based physical activity interventions fall prey to the intention behavior gap, in which participants don't follow through from intention to behavior (Fife-Schaw et al., 2007; Rhodes & Dickau, 2012). Accordingly, health behavior scientists have explored the use of episodic future thinking to target the regulatory system (Dassen et al., 2016; O'Donnell et al., 2017; Sze et al., 2017). Episodic future thinking is a form of prospection that involves directing thoughts to a specific autobiographical experience that may happen in the future (Atance et al., 2001). Episodic future thinking targets the regulatory system, as executive functioning (e.g., working memory) and attentional processes are required to mentally visualize a subjective future event (Schacter et al., 2017). Episodic future thinking also assists with behavioral regulation by reducing preferences for immediate compared to delayed rewards (Cheng et al., 2012; Lin & Epstein,

2014; Peters & Büchel, 2010). The ability to form internal representations of the future and to abstain from short-term, unhelpful impulses, such as remaining sedentary, is necessary to facilitate goal-directed actions (Bandura, 2001; Barkley, 2001), suggesting that interventions that use physical activity-oriented episodic future thinking may facilitate regulation to increase physical activity engagement.

While mindfulness, positive affect, and episodic future thinking are separate constructs that each have the potential to increase physical activity engagement, one approach that can integrate mindfulness and dual-system reward and regulatory content, is guided mental imagery visualization. Guided mental imagery visualization is regarded as a relaxation-based practice (Luberto et al., 2020) involving multisensory processes in the brain to create vivid mental images of specific places, events, or behaviors, such as themselves engaging in physical activity (Martin & Hall, 1995). Guided imagery is theorized to influence behavior change and self-regulation by strengthening the link between cognitions and goal-directed actions (Renner et al., 2019) and can be used in a range of contexts to increase motivation towards exercise behavior (Martin & Hall, 1995). For example, a brief guided imagery audio intervention that focused on future thinking in relation to physical activity was effective in increasing exercise motivation and frequency of physical activity in a sample of sedentary adults (Giacobbi et al., 2014), illustrating the capacity of guided imagery for delivering episodic future thinking intervention content. Further, guided imagery delivered before or during physical activity is shown to amplify physical activity enjoyment and satisfaction (Stanley & Cumming, 2010), highlighting its capacity to target the reward system outlined in the dual-system model.

Guided imagery is often conceptualized as a relaxation strategy, distinct from mindfulness (Luberto et al., 2020). Importantly, these two mind-body practices have similar

qualities and engage similar regulatory processes. For instance, research demonstrates that mindfulness informed (Morton et al., 2020) and guided imagery-based interventions (Bigham et al., 2014) have the potential to reduce stress and improve physiological functioning. Research also shows that multimodal mind-body interventions that integrate both mindfulness and relaxation practices such as guided imagery demonstrate feasibility and efficacy for improving health outcomes (Kraemer et al., 2016; Stagl et al., 2015; Vranceanu et al., 2016). Mindful body scan is an example of a mindfulness informed practice used to increase awareness of bodily sensations that can be implemented through guided mental imagery (Creswell, 2017; Hamilton et al., 2013; Schuman-Olivier et al., 2020). Additionally, mindfulness and relaxation-based techniques are shown to have a similar effect of facilitating cognitive distancing (e.g., taking a step back from negative thoughts and beliefs) (Feldman et al., 2010; Lancaster et al., 2016). Moreover, the present study seeks to pilot test a novel intervention that integrates mindfulness practices, such as mindful breathing, a non-judgmental stance, and attentional awareness with guided imagery, future episodic thinking and positive affect to target reward and regulatory processes in the brain to increase physical activity enjoyment and engagement, an approach that has not yet been tested.

The combination of mindfulness-informed and guided imagery approaches to target reward and regulation processes has the potential to strengthen the underlying neural connections that link physical activity and reward to increase the likelihood of physical activity engagement[7]. Further, the combination of mindfulness-informed and guided imagery approaches to target reward and regulation processes addresses the need for integrative physical activity interventions that incorporate both psychological approaches and neurobiological models to influence physical activity engagement. There is however significant

heterogeneity between mindfulness-informed and relaxation-based intervention formats (i.e., self-paced, instructional) and deliveries (i.e., audio, classroom/lab setting, online accessibility), making it difficult to extend feasibility and acceptability from one intervention to another. To address critical issues with intervention access inequity (Onken et al., 2014), scalable and accessible interventions are needed (Bedford, 2012) making feasibility and acceptability work in this area particularly important. An integrative intervention that can be delivered remotely and flexibly via a low-cost mainstream online format (e.g., audio file) has the potential to influence physical activity behavior at a large scale.

Accordingly, the present study aimed to test the feasibility and acceptability of a newly developed brief, online mindfulness-informed guided imagery intervention grounded in the dual-system health behavior model and that targets physical activity enjoyment and engagement. This study involved two distinct phases, an intervention development phase and a pilot test phase. Intervention development involved development of four distinct guided imagery scripts that incorporated physical activity-oriented prompts related to goal-setting and episodic future thinking, positive affect and reappraisal, and mindfulness. An iterative intervention development process was employed in which subject matter experts and a panel of underactive community members were asked to provide feedback on intervention content and delivery. The final approved scripts were used to create the intervention audio recordings to be delivered online to a sample of underactive adults.

To obtain feasibility and accessibility data, we employed a mixed-methods approach that collected both self-report and qualitative data from participants on their experiences listening to the guided imagery immediately prior to physical activity. We also implemented a 2x2 factorial experimental approach to test the feasibility of conducting a study with different

mindfulness-informed guided imagery scripts, in which participants were randomly assigned to one of four mindfulness-informed guided imagery conditions that differentially targeted the reward and regulatory systems proposed in the dual-system model: 1) episodic future thinking, 2) positive affect and reappraisal, 3) combined episodic future thinking and positive affect condition, and 4) control condition with neutral prompts. Findings from the present intervention content and delivery may inform future studies to further improve acceptability, feasibility, and outcomes.

1.3 MATERIALS AND METHOD

Phase I: Guided Imagery Development

Phase I of the present study consisted of an iterative intervention development process to create the mindfulness-informed guided imagery content. First, drafts of intervention content were designed based on previously developed guided imagery related to healthy eating (Levens et al., 2019). Four guided imagery scripts were drafted such that each script included mindfulness-based intervention content that specifically targets physical activity enjoyment and engagement: 1) episodic future thinking, 2) positive affect and reappraisal, 3) Combined positive affect and reappraisal and episodic future thinking, or 4) a guided imagery control (see Final Intervention Content section for descriptions of the four conditions). Components of mindfulness utilized in the guided imagery scripts included: mindful awareness of the breath, physical sensations of movement, emotional awareness, and linguistic presentation that encourages non-evaluation of one's physical activity goals, actions, and sensations. For instance, listeners were guided to refrain from using evaluative labels with their experience of physical activity and to consider their goals in relation to their actions in the present moment.

All four guided imagery scripts begin with a brief guided breathing exercise and end with bringing awareness to the present moment and one's emotional state.

Professional advisory panels. Once initial guided imagery scripts were drafted, feedback was solicited from a professional advisory panel. Members of the professional advisory panel (N = 3) volunteered their time to assist with the project. Professional advisors included two doctoral level university researchers in physical activity, affect, cognition, and behavior change, and one master's level exercise physiologist with extensive applied experience in physical activity intervention implementation in a healthcare setting. Guided imagery scripts were subsequently edited and adapted according to expert feedback. Edits made to intervention content included: (a) shortening the audio files to approximately an average of 3 minutes and 30 seconds (with the exception of the combined guided imagery condition, which was shortened as much as possible to ensure content was covered and participants had adequate pauses to follow the guided imagery's instructions), (b) adding phrases related to increased physical capabilities (e.g., "Perhaps you are doing activities now that you could not before… perhaps these activities take less effort now that you are more active"), (c) addition of explicit instructions for guided breathing at the beginning of each guided imagery, (d) inclusion of word suggestions such as "stronger" and "accomplished" (e.g., "imagine that on this journey you are being physically active…moving your body…accomplishing goals, and becoming stronger, more focused, and healthier"), (e) recommendations to increase the reward value of physical activity (e.g. physical sensations are a sign of one's body being challenged in a positive way that leads to increases in strength and energy), and (f) inclusion of language that positions the listener's daily physical activity effort, without evaluation, in the context of their larger goals and health (e.g., "Attach no evaluations

to your journey…it is your own;"). Guided imagery scripts were also sent to a Community Advisory Panel for review after the first round of feedback from the professional advisory panel was incorporated.

Community advisory panel. Following the first round of Professional advisory panel feedback and subsequent adjustments, the scripts and audio files of each guided imagery were edited and then sent to a community advisory panel (N = 6) for feedback. The community advisory panel included 3 female and 3 male individuals with an average age of 31.5 years (SD= 10.67; range = 21- 50), and mostly white (n = 5), with one reviewer identifying as Latino. Community reviewer feedback was collected via an electronic survey. Community members provided their impressions of the intervention content via Likert-scale and open-ended questions in a Qualtrics survey. The first round of Community Advisory panel feedback was reviewed and evaluated for appropriateness and congruence with expert feedback, after which the scripts were edited, rerecorded, and then sent to the Professional Advisory panel review for a second round of review. Community Panel members provided specific feedback for refining the scripts. Two participants suggested that the Combined condition be simplified and lengthened (e.g., include longer pauses) as it was 1) "too much information" and 2) "easy to lose track while listening." To address this feedback statements included in the Combined condition were streamlined, reordered and longer pauses were added between statements to improve flow. Two participants noted the need for greater inflection in the recorder's voice to increase the energetic tone of the recording to align with exercise engagement. Each guided imagery condition was re-recorded with a slightly more energetic inflection in the recorder's voice. Approved guided imagery content from the Professional Advisory panel was then sent back to the Community Advisory panel for a second round of feedback. Both the Professional

Advisory and Community Advisory panels reached agreement and saturation (had no additional suggestions to provide) in the second round of review resulting in the finalized guided imagery scripts and audio files.

Final Intervention Content

Our iterative intervention development yielded four guided imagery scripts/audio files that differentially target physical activity enjoyment divided into four experimental conditions: 1) episodic future thinking, 2) positive affect and reappraisal, 3) combined positive reappraisal and episodic future thinking condition, and 4) a neutral control condition. All intervention scripts/audio files were designed to include elements of mindfulness. Each intervention condition began with a brief mindful breathing exercise, and included content that (1) encouraged a non-evaluative stance towards physical activity (i.e., "Attach no evaluations to your [physical activity] journey…it is your own."), (2) a focus on mind-body sensory engagement (e.g., imagery aimed to engage senses as if they were there in the moment they were imagining), and (3) guided participants to redirect their focus to their mental image (i.e., "It's ok if your mind wanders just return to this vision of yourself") or the present moment (i.e., "Bring your attention back to the present. Awaken your muscles so you can continue on your journey and ready them for activity").

The *episodic future thinking* condition (audio length: 3 minutes 26 seconds) targets non-evaluative future thinking and visualization of physical activity benefits for future self, goal achievement, and the impact of effort on overall health. In this guided imagery condition, in accordance with episodic future thinking techniques, listeners are prompted to visualize a future ideal version of themselves in 6 months accomplishing a physical activity goal. Sample statements include: "take a moment to create a picture in your mind of a future ideal version of

yourself—a future version of yourself who is healthy, strong and embodies what you strive for...” and “Now, 6 months have passed on your journey. Imagine that you have accomplished one of your physical activity goals.” See Supplemental Materials for full script.

The *positive affect and reappraisal* condition (audio length: 3 minutes 56 seconds) aimed to increase likelihood of experiencing positive affect associated with physical activity (e.g., enjoyment and satisfaction) through prompting positive introspection about the benefits of physical activity and feelings experienced after physical activity is completed (e.g., accomplished, satisfied). Example statements include: “…the increase in sensations can be a good thing… your body is responding to the challenge you are giving it and becoming stronger, healthier, energized…” as well as “imagine that you’ve finished your activity and you feel satisfied, accomplished, confident, and energized… let this feeling build.” See Supplemental Materials for full script.

The *episodic future thinking and positive affect and reappraisal condition* [combined guided imagery] (audio length: 5 minutes 35 seconds) integrates the two aforementioned conditions to assess the impact of both episodic future thinking and positive affect and reappraisal on the experience of physical activity. All intervention content from the episodic future thinking and positive affect and reappraisal only conditions are included in the combined condition, and content that is common between both conditions is stated once. See Supplemental Materials for full script.

Finally, the guided imagery *control condition* (audio length: 3 minutes 9 seconds) focuses on the physical actions of a neutral, routine activity that occurred in the last week. The control condition was designed to promote mindful practice and include the delivery components of the intervention conditions (guided mindful breathing, prompted mindfully

vivid recall of an event, and normalization of mind wandering and language to redirect listener's attention back to the present as the guided imagery concludes) without the target intervention content of episodic future thinking and positive affect and reappraisal (i.e., reward/positive affect focus, future thinking, and link to broader health was absent in the control condition). For instance, the control condition includes the following statement: "Imagine a moment where you were doing a simple activity, an activity that you do every day." See Supplemental Materials for full script.

Intervention Mode of Delivery

The intervention content was designed to be delivered as an online audio file that could be accessed directly via participants' smart phones through their email or as a saved audio file. Participants were informed they could download the guided imagery audio file directly to their personal device to ensure access even without internet. Audio files were recorded using Audacity audio recording software. Participants received a scheduled email each day in the morning of the 2-week intervention period. This daily email contained a link to the audio file for their assigned intervention condition as well as an online survey taken after engaging in physical activity to assess physical activity and intervention access experience. Participants only had access to the audio file for the condition to which they were assigned at the Part 1 session. Each participant was instructed to listen to their assigned audio file prior to engaging in physical activity each time they engage in physical activity over a 2-week period. Given that the sample consisted of underactive adults with varying health statuses, we instructed participants to listen to the guided imagery audio file before physical activity a minimum of three times (see Procedures for more detail).

Phase II: Feasibility Pilot Study Methods

Participants

Thirty-one participants were recruited in a metropolitan area in the southeast United States through a 4-year state university research listserv announcement available to the campus community. The feasibility pilot study was advertised as an opportunity to engage in a remote intervention targeting physical activity enjoyment. Interested participants completed a pre-screen eligibility survey embedded in the listserv announcement.

Eligibility

Study inclusion criteria required that participants were over the age of 18, fluent in English, did not meet recommended physical activity guidelines and were considered underactive at time of study participation (i.e., engage in less than 60 minutes of moderate or vigorous physical activity a week), had an internet accessible device to play the mindful guided imagery audio file, and the capacity to engage in physical activity safely (access to safe areas to engage in physical activity). Physical activity levels were determined by the International Physical Activity Questionnaire (Craig et al., 2003). Exclusion criteria included having a medical diagnosis in which a physician advises against engaging in physical activity and engaging in more than 60 minutes of moderate or vigorous physical activity at time of study participation. This pre-screen eligibility survey was programmed to determine participant eligibility at the point of completion. Eligible participants were subsequently contacted by the research team for scheduling.

Design

As this is a pilot study to test the feasibility and acceptability of an integrative mindfulness-informed guided imagery intervention in anticipation of conducting larger scale clinical trials, we employed a 2x2 factorial design commonly used to isolate main and

interactive effects of condition. While our pilot sample size of 31 participants does not support any 2 (future episodic thinking present vs. absent) by 2 (positive affect and reappraisal present vs. absent) factorial analyses or between-group comparisons, we sought to use the design to maximize feasibility and acceptability inferences from data collection. This approach also allowed us to test randomization and experimental procedures.

Randomization

Participants were randomized to one of four intervention conditions, which represented the four distinct guided imagery audio files. To achieve randomization, each condition was assigned a number and a random order generator determined the allocation assignment sequence. The randomly generated allocation sequence was listed in a spreadsheet and participants were assigned their condition sequentially at their intake session before they were provided training on accessing and using the guided imagery audio file. Participants were blinded to their condition assignment and were unaware that there were multiple intervention conditions. The experimenter facilitating the participant's intake and follow-up session adhered to the preset, random assignment order and was knowledgeable of condition assignment to provide participants with their assigned intervention audio file.

Procedure

To limit in-person transmission of the coronavirus and test the feasibility of remote intervention enrollment, all study protocols were implemented virtually and remotely. All study procedures were approved by the university's Institutional Review Board. Participants were informed that the study comprised three parts: a virtual intake session (Baseline - Part 1), a two-week intervention use time period (Intervention Use - Part 2), and a virtual outtake session approximately 14 days after Part 1 (Follow-up - Part 3). At the virtual intake session,

participants were lead through consent and enrollment by the experimenter on a video chat platform. Participants completed a battery of questionnaires (see Table 1) and were sent their initial intervention use email which included the guided imagery audio file (mp4). During the 2-week intervention period, participants received a daily email that provided 1) online access to their assigned guided imagery audio file and 2) an online survey to be completed immediately following each physical activity session. The daily online survey assessed their physical activity and intervention use experience. To provide attainable goals for a sample of underactive adults, participants were asked to engage in physical activity and listen to the guided imagery beforehand for a *minimum* of 3 times. Participants were instructed they could exceed this number if they desired and that if they did, each session of exercise should begin with listening to their assigned audio file and end with completing the online survey. Participants were instructed that if they did not engage in physical activity that day, they should complete the survey at night before bed.

For each bout of exercise, we asked participants to engage in at least 15 minutes of physical activity and encouraged them to reach a level of moderate intensity, such that they could feel slight changes in physical sensations: labored breathing, increased sweat, and increased heart rate. Participants were given leeway to select the intensity, duration, and activity type of their choice and in our instructions we emphasized the need for participants to listen to their body as not to increase risk for injury. We asked each participant to identify safe physical activity options during the interview to confirm their access to safe physical activity options. Participants were not provided any other instructions.

Following the 2-week intervention period, participants returned to the lab for a virtual follow-up session. During this follow-up session, participants completed a battery of

questionnaires that included measures assessed at baseline and self-report questions to assess their experience using the intervention. This follow-up session also included a brief audio recorded semi-structured interview in which participants were asked to provide feedback on intervention acceptability. Participants were compensated $40 in electronic gift cards for their time and debriefed about the goal of study of influencing physical activity enjoyment.

Measures

Demographic Information. Participants self-reported demographic information in the Part 1 baseline survey which included age, sex, gender identity, racial and ethnic identity, educational attainment, occupational status, presence of mental and physical health conditions, and household income. Participants' physical activity levels were assessed in the eligibility questionnaire using International Physical Activity Questionnaire (Craig et al., 2003).

Intervention Use Data

Intervention feasibility and acceptability were assessed through mixed-method self-report and coded interview data. Participants were asked to 1) listen to the provided guided imagery audio file, 2) engage in a physical activity of their choice, and 3) complete the intervention use daily survey immediately following physical activity (the daily survey ended if participants endorsed not listen to the guided imagery that day).

Intervention adherence. We defined intervention engagement as the number of times the participant listened to the guided imagery immediately before physical activity. This was assessed through the daily survey participants were asked to complete following physical activity (or before bed if they did not engage in physical activity that day). Participants were asked whether they listened to the guided imagery and engaged in physical activity afterwards.

If “yes,” participants were provided additional questions to complete. See Table 1 for measurement assessment throughout the study.

Type of physical activity. Participants were asked to provide a qualitative description of the physical activity they completed (e.g., “Describe in detail the activity you completed”). Responses from the entire sample were coded by type of physical activity.

Physical activity intensity. Participants were asked to self-rate the physical activity intensity they engaged in (“Please rate the intensity (degree of increased heart and breathing rate) of your activity based on your own self-rating…”) using the following response options*:* 1 = *Not intense,* 2 = *Slightly intense,* 3 = *Moderately intense,* and *Very intense*). Given that survey submissions varied by participant based on number of intervention uses, responses were averaged for each participant and then again across conditions submissions for an average sample intensity score.

Physical activity duration. Participants were asked to report the length of their physical activity bout using the following response options: (1) *Less than 10 minutes* (2) *10 minutes*, (3) *15 minutes*, (4) *20-30 minutes*, (5) *30-45 minutes*, (6) *45-60 minutes*, (7) *More than 60 minutes*. Responses were calculated in same manner as physical activity intensity.

Self-report feedback during intervention use. Participants completed three self-report feasibility and acceptability questions at the end of the daily us survey. Questions targeted enjoyment (“I enjoyed listening to the guided imagery”), ease of use (“I found the guided imagery easy to use”), and whether they found the guided imagery helpful (“I found the guided imagery helpful”). Participants responded using a 5-pt Likert scale (1 = *Strongly disagree,* 5 = *Strongly agree*). As the number of times participants listened to the intervention and engaged

in physical activity varied, responses for each self-report question were averaged for each participant, with higher scores indicating positive feasibility and acceptability.

Physical activity enjoyment. The intervention use daily survey included the Physical Activity Enjoyment Scale (Mullen et al., 2011) to assess physical activity enjoyment. Physical activity enjoyment is regarded as a distinct affective experience derived from physical activity that may influence satisfaction and intrinsic motivation (Rhodes et al., 2009). Participants rated 8 items that assessed how they felt in the moment about the physical activity just completed (e.g., "It's very gratifying") using a 7-point Likert scale (1 = *Strongly disagree*, 4 = *Neither agree nor disagree,* 7 = *Strongly agree*). Participant responses were summed by instance and then averaged across the 2-week period for each participant and then for the sample.

Intervention Feasibility and Acceptability at Follow-up

To assess intervention use, feasibility, and acceptability at follow-up, participants were asked to complete both self-report questions related to intervention use, feasibility, and acceptability, as well as a qualitative semi-structured interview designed to gather additional data on feasibility and acceptability (see Table 1).

Self-report feedback. Self-report questions assessed delivery quality, ease of use of delivery format (i.e., audio file in an electronic survey included in a daily email), whether directions and prompts in the intervention content were clear and easy to follow, applicability of the intervention content to other areas of their life, and likelihood of using the intervention outside the context of the present study. Participants also provided ratings on their overall experience with the intervention content, including: degree of acceptability, satisfaction, whether the individual thought about the intervention content during their physical activity, whether the intervention content made the participant want to increase their physical activity

levels, and whether they could see other individuals in their life enjoying and benefiting from the intervention content to increase their physical activity levels. All questions were answered using one of the following 5-point Likert scales: 1 = *Totally disagree* to 5 = *Totally agree*; or 1 = *Extremely dissatisfied* to 5 = *Extremely satisfied*; or 1 = *Not at all acceptable* to 5 = *Extremely acceptable*.

Interview feedback. Open-ended interview questions pertained to the participant's initial impressions of the intervention content, barriers and facilitators influencing their use of the guided imagery, most and least helpful components of the intervention content, and feedback relating to the degree to which the intervention content influenced physical activity levels, enjoyment of physical activity, and could be used outside the context of the present study.

Outcome Measures

Stage of Physical Activity Behavior Change. Current stage of physical activity behavior change was assessed using a previously validated measure (Romain et al., 2012) derived from the Transtheoretical Model of Behavioral Change (Prochaska & DiClemente, 1983). Participants are asked to respond to "yes" or "no" to the following questions which each represent a different stage of health behavior change, 1) "Do you currently engage in regular physical activity?," 2) "Do you intend to engage in regular physical activity in the next 6 months?," 3) "Do you intend to engage in regular physical activity in the next 30 days?" and 4) "Have you been regularly physically active for the past 6 months?". The scale specifically defines 'regular physical activity' as at least 30 minutes a day for 4 days of the week. Stage calculation is based on participants' responses on to each of the above items. Stages include: (1) pre-contemplation stage answering 'no' to all four items (i.e., individual does not intend to

take action and could be unaware of the pros of changing their behavior), (2) contemplation stage answering yes to “Do you intend to engage in regular physical activity in the next 6 months? (i.e., individual is intending to start the behavior but may still be ambivalent toward changing their behavior), (3) preparation stage answering ‘yes’ to “Do you intend to engage in regular physical activity in the next 30 days? (i.e., individual is ready to act and small steps towards behavioral change and likely believe in the positive outcomes of the behavior), (4) action stage answering ‘yes’ to “Do you currently engage in regular physical activity?” and ‘no’ to “Have you been regularly physical activity for the past 6 months?” (i.e., individual has recently changed their behavior and will be more likely to consider ways to further modify their behavior), and (5) maintenance stage: answering yes to “Do you currently engage in regular physical activity?” and “Have you been regularly physically active for the past 6 months?” (i.e., individual has sustained a behavior change and likely works to prevent relapse of negative health behaviors, like remaining sedentary). This measure was included at baseline and follow-up (see Table 1).

Physical Exercise Self-Efficacy. Perceived self-efficacy has been noted as a driving force for forming intentions to exercise and maintaining the practice over an extended period (Sheeran et al., 2016). The 5-item Physical Exercise Self-Efficacy Scale (Schwarzer & Renner, 2000) is a 5-item questionnaire in which participants are prompted to respond to the following statement, “How certain are you that you could overcome the following barriers…” with a 4-point scale (1 = *Very uncertain*, 4 = *Very certain*). Example items include “Even when I am busy” and “even when I am tired.” Item responses are summed to yield a total score, with higher scores indicating higher self-efficacy for physical exercise (score range: 4 =16). This

scale demonstrates excellent internal consistency (α = .88) (Sheeran et al., 2016). This measure was assessed at baseline and follow-up (see Table 1).

Mindfulness in Physical Activity. Given that this study was designed to incorporate elements of mindfulness, a measure was included to assess the guided imagery's potential impact mindful qualities experienced during physical activity. The Mindfulness in Physical Activity (MFPA) (Tsafou et al., 2016) six-item scale was included to measure state mindfulness experienced during physical activity. It is a validated measure that demonstrates good internal consistency (α = .84). The questionnaire begins with the statement "When I am doing physical activity" followed by six items (e.g., "I am focused on what I am doing"). Responses are on a 5-point Likert scale (1 = *Totally disagree*) to (5 = *Totally agree*) and are summed. Higher summary scores represent greater levels of mindfulness during physical activity. This measure was included at a baseline and follow-up (see Table 1).

Satisfaction with Physical Activity. Satisfaction with physical activity was measured using an eight-item scale developed for a previous study (Tsafou et al., 2017). This scale extends previous one-item assessments of satisfaction (Baldwin et al., 2013) to assess satisfaction with engagement in (i.e., during) and outcomes of physical activity. This measure demonstrates excellent internal consistency (α = .90). The scale stem, "When I am doing physical activity," is followed by items such as "I am satisfied with the results." Responses are on a 5-point Likert scale (1 = *Totally agree*) to (5 = *Totally disagree*) and summed across items. Higher summary scores indicate greater levels of satisfaction with physical activity. This measure was assessed at baseline, during intervention use, and follow-up (see Table 1).

Data Analysis

We conducted both quantitative and qualitative analysis of the data. As this is a pilot study focused on feasibility and acceptability of an online mindfulness-informed guided imagery intervention with insufficient power to conduct factorial analyses or explore effect sizes, our quantitative analyses collapsed across condition and focused on sample wide outcome measures and feasibility and acceptability observations. Descriptive statistics were conducted for all demographic variables, outcome measure data, intervention use responses, and self-report feasibility and acceptability responses. To assess whether data meets acceptability and feasibility guidelines, we followed implementation science recommendations stipulating that the cut-off for determining an intervention as acceptable is an average rating of 4.0 or higher on 5-point scales with questions like "How acceptable was your experience with the guided imagery?" (4 = *Acceptable*, 5 = *Extremely Acceptable*) and "The guided imagery was easy to use" (4 = *Agree*, 5 = *Strongly Agree*) (Proctor et al., 2011; Weiner et al., 2017). To examine change in outcome measures across the course of the study, we conducted paired t-tests comparing baseline and follow-up summary scores for Stage of Behavioral Change, Exercise Self Efficacy, Mindfulness in PA, and Satisfaction with Physical Activity.

A thematic coding procedure was performed with all qualitative interview data collected from the semi-structured interviews. First, transcripts for each interview were checked alongside audio recordings for accuracy by research assistants. Second, participant interview responses were then coded by a quantitative methods trained senior graduate-level researcher based on themes demonstrated in the following interview question categories: Initial impressions of the guided imagery, delivery method, facilitators and barriers, most and least liked/helpful components of the guided imagery, influence on physical activity behaviors and experience of physical activity, generalizability and improvements to the guided imagery, and

use beyond present study. An inductive coding and theme development process (Terry et al., 2017) was conducted to determine the dominant themes within each category for each condition. Themes were then compared across conditions for similarity and frequency of occurrence to determine broader full sample level themes.

1.4 RESULTS

Results are presented in four sections. The first section presents condition assignment and demographic data (see Table 2). The second section presents intervention use and physical activity statistics (see Table 3) as well as self-report feedback assessed during intervention use (see Table 4). The third section includes self-report data (see Table 5) and thematic coded interview data collected at follow-up (see Table 6 for full sample and individual condition themes). The final section presents baseline and follow-up comparisons of outcome measures (e.g., for Stage of Behavioral Change, Physical Exercise Self Efficacy, Mindfulness in Physical Activity; see Table 7). All questionnaire scores were evaluated via descriptive statistics to ensure that all means were within a reasonable range, and that all standard deviations indicate acceptable response variability.

Demographics

Participants (N = 31) consisted of underactive individuals (i.e., individuals who engage in less than 60 minutes of physical activity at time of study participation) who ranged from absent to lower levels of physical activity. At time of study participation, 48% (n = 15) reported zero engagement in any moderate or vigorous physical activity, 16% (n = 5) participants reported engaging in 0 – 45 minutes of moderate or vigorous physical activity in the previous week, and 36% (n = 11) participants reported engaging in 45 – 60 minutes of

moderate-vigorous physical activity. See Table 2 for participant demographics (age, gender, race/ethnicity) across the full sample and by condition.

Intervention Use Data

Intervention use data (physical activity intensity, duration, self-report feasibility and acceptability, and physical activity enjoyment) were averaged across each participants' number of daily survey submissions due to variation in number of reported intervention uses and subsequent instances of physical activity. Full sample and condition averages for intervention use and physical activity statistics are presented in Table 3, and self-report intervention use feedback is presented in Table 4.

During the 2-week intervention period and across the four conditions, the entire sample used the intervention audio files before physical activity a total of 164 times, with a range of 3 to 12 uses. Average use of the guided imagery across all conditions was 5.35 (*SD* = 2.99). Participants reported engaging in physical activity that included an element of cardio or aerobics (e.g., walking, jogging, using a cardio machine like a stepper or elliptical machine, playing a sport outside such as soccer) paired with another activity like stretching the most frequently (85 instances), followed by just cardio (59 instances), strength training (e.g., body-weight exercises, lifting weights) and cardio combined (37 instances), use of a video or virtual fitness class (26 instances), or yoga, Pilates, and stretching (25 instances).

In regard to the intensity level of activities, participants reported engaging in moderately intense activities most frequently (76 instances), followed by slightly intense (52 instances), very intense (21 instances), and not intense (16 instances) activities. Average physical intensity ratings endorsed across all conditions were between slightly intense and moderately intense. Participants reported an average physical activity duration between 20-30

minutes and 30-45 minutes of physical activity (see Table 3). Participants reported engaging in physical activity for 20-30 minutes most frequently (72 instances), followed by 30-45 minutes (29 instances), 45-60 minutes (28 instances), 15 minutes (18 instances), greater than 60 minutes (9 instances), and finally 10 minutes or less (8 instances).

Descriptives of self-report questions asked during the intervention use daily survey are presented in Table 4. On a 5-point Likert style scale (4 = *Agree*, 5 = *Strongly Agree*), participants rated the guided imagery as enjoyable to listen to (M = 4.08, SD = .72), easy to use (M = 4.47, SD = .82), and helpful (M = 4.00, SD = .82). In terms of enjoyment experienced during physical activity (7-point Likert scale, 7 = *Strongly agree*), participants indicated that the guided imagery on average influenced their degree of enjoyment experienced during physical activity (M = 5.14, SD = .79).

Intervention feasibility and acceptability at follow-up

Self-report feasibility and acceptability responses assessed at follow-up are summarized in Table 5. Overall, participants endorsed high satisfaction with the intervention, M = 4.26, SD = .82 (Likert scale, 1 = *Extremely dissatisfied* to 5 = *Extremely satisfied*) and rated it as acceptable, M = 4.65, SD = .82 (Likert scale, 1 = *Not at all acceptable* to 5 = *Extremely acceptable*). Participants also endorsed the guided imagery files as clear and easy to follow (M = 4.90, SD = .30) and easy to use (M = 4.90, SD = .30; 5-point Likert scale (1 = *Totally disagree* to 5 = *Totally agree*).

Responses to the semi-structured interview were also coded for intervention use, feasibility, and acceptability themes (see Table 6). Responses to one question that related to a different question or category were included with the related category or theme.

Initial impressions. Thirty-two percent of all participants described feeling more focused on physical activity after listening to the guided imagery, and more motivated to complete physical activity after listening (n = 9), with 7 of these 9 participants noting they were surprised by how much the imagery influenced their motivation for physical activity. Thirty-two percent of all participants also reported that their impression was that the guided imagery motivated physical activity. Lastly, 23% of the sample described the guided imagery as relaxing, calming, and/or soothing.

Delivery method feedback. Participants across all four intervention conditions volunteered the following themes regarding the guided imagery delivery method: 65% of the sample described having zero issues with the delivery method and/or noted the delivery method as easy to use and access, which included being able to access the imagery through their personal/cellular device. Nineteen percent of participants noted a desire for quicker access to the guided imagery through a mobile application and 10% noted that the guided imagery was best listened to with headphones. Additionally, 29% of the sample described that the length of the guided imagery as ideal, with a small subset noting that the length of the imagery needed to be lengthened or shortened. Sixteen percent reported that that the imagery became "routine" and/or "memorized" after 2-3 uses. Lastly, 48% of participants reported that the guided imagery should be delivered with "different" or "multiple" versions that, for example, could be tailored to "how you're feeling that day" and "different ability levels" to reduce boredom with imagery and increase likelihood of routine use.

Facilitators and Barriers. Participants were asked to describe the barriers or challenges they confronted with listening to the guided imagery before engaging in physical activity, as well as the facilitators, or reasons why, they chose to utilize the guided imagery. In the context

of barriers, 48% (n = 15) of participants endorsed zero specific barriers or challenges to using the guided imagery for physical activity. Of the participants that endorsed barriers, 29% noted time and busy schedules as a barrier, 13% noted life stressors as distracting, and two participants described COVID-19 limitations as a barrier (e.g., not being able to work-out at a gym). Regarding facilitators, 53% of participants described a desire to use the guided imagery because of feeling hopeful about change (e.g., increase physical activity, feel more joy during physical activity) or noticing positive benefits of using the guided imagery during study. For instance, one participant in the Combined condition described feeling motivated to use the guided imagery because "Everything I have tried in the past to motivate myself has not worked." Additionally, participants in the Combined condition described using the guided imagery for the positive reinforcement offered through the guided imagery (n = 4) as well as to have "accountability" and "motivation" when feeling tired before or during physical activity (n = 2).

Most helpful and Least Helpful Components. Of the full sample, 35% endorsed that the voice of the guided imagery was one of the most helpful components, in that it was "soothing," (n = 7), "encouraging," (n = 3), and "sounded like a friend" (n = 1). Several participants described that they found thinking more positively about their exercise and themselves as most helpful. Additionally, 39% of participants liked the opportunity for intention setting and goal clarification and 36% found it helpful to deepen their connection between themselves and their actions in the present with themselves in the future. For example, a participant in the combined condition described that the guided imagery helped them identify the "larger purpose of physical activity" in benefiting their future. Further, one participant in the future thinking condition stated, "it was an opportunity to check in with my emotions and connect this with

doing physical activity" and that the guided imagery included "inclusive language" that allowed the participant to create a visual image of "my own version of what healthier looks like."

Themes identified in relation to unhelpful aspects of the guided imagery included that some of the guided imagery instructions were slow to progress, that the guided imagery was "too calming" before physical activity, the specific focus of guided imagery did not appeal to them and some noted discernible pauses in the guided imagery that caused a degree of distraction. Finally, 48% of the sample noted that there were no specific aspects of the guided imagery that they found unhelpful.

Influence on physical activity behaviors and experience of physical activity. Across the full sample, 90% of participants noted an increase in positive emotions (e.g., pride, achievement, satisfaction, enjoyment) and experienced a shift to a more positive mindset (e.g., empowered, change in thinking about physical activity) before and during physical activity that they attributed to the guided imagery. For instance, one participant in the future thinking condition described feeling "more empowered and less distraught" about physical activity, whereas another participant in the positive affect and reappraisal condition described that they experienced increased enjoyment in a brief period, stating they felt the guided imagery could "rewire your brain." Thirty-two percent of participants also described experiencing increased mindfulness, attention, and engagement during physical activity. When asked about how the guided imagery influenced their physical activity engagement, participants qualitatively described the guided imagery as beneficial for increasing physical activity: 71% of participants reported an improvement in physical activity behaviors, including an increase in frequency and intensity. Additionally, 23% of participants expressed feeling more motivated for physical

activity due to realizing how their actions and behaviors were going to benefit their future. Lastly, 10 participants specifically noted that the guided imagery *did not* increase their degree of enjoyment experienced during physical activity.

Generalizability and improvements to guided imagery. Participants were asked to provide feedback on what would increase the generalizability and applicability to other individuals and suggested improvements. The following themes were described in relation to generalizability: two participants suggested creating a reflection based guided imagery to listen to *after* physical activity to reaffirm physical activity cognitions and behaviors and link them back to the guided imagery, another two participants suggested that it would be important to maintain inclusive language, with one of these participants suggesting that we continue to ensure that that content does not focus on weight and can be tailored. One participant suggested the imagery be adapted for different hearing abilities. Three participants also suggested that different voices (e.g., dialects) and languages would increase generalizability. Of the full sample, 26% noted that other individuals they knew (e.g., friends and parents) would find the guided imagery motivational and/or easy to use for physical activity.

Lastly, of the suggested changes participants provided, two themes were identified across the sample: (1) pair guided imagery with a workout video, instructions, or embed within group exercise format and (2) to initiate specific changes to the intervention content to include components of the guided imagery present in conditions other than the condition the participant was randomized to, such as adding a planning statement (e.g., when, where, etc., will you complete physical activity), ensure that the imagery includes statements about physical activity goals, that the guided imagery focused on goals, and in the context of challenging/busy schedules and lives, one participant in the positive affect condition suggested the inclusion of a

statement that encourages listeners to "ignore outside stressors." One participant in the future thinking condition suggested adding a "sympathetic" statement to the future thinking condition that acknowledges how difficult physical activity can be. Lastly, 10% of participants reported that mid-day phone reminders to listen to the guided imagery and complete physical activity would be a helpful improvement to increase likelihood of regular use.

Use this guided imagery outside context of study. Participants were asked to provide feedback on whether they would use the guided imagery outside the context of the present study. Of the full sample, 64.5 % described that they would use the guided imagery in the future in some capacity, with 39% of this subset of the sample noting they would utilize the guided imagery specifically for physical activity (e.g., to increase intensity, frequency, motivation, etc.). The other 26% of the participants stated that they would use the guided imagery for contexts not directly related to physical activity, such as for academic assignments or projects (e.g., with "big writing projects"), to maintain a "growth mindset" toward physical activity, to be "more optimistic," and to change eating patterns.

Outcome Measures

To examine whether any key outcome measures changed across the course of the study, we conducted descriptive statistics (see Table 7) and paired t-tests comparing baseline and follow-up summary scores for intervention outcome variables. Results of the paired t-test revealed that Stage of Physical Activity Behavior Change changed significantly from baseline to follow-up, $t(29)=3.28$, $p=.003$, with participants on average shifting ($M=0.6$, $SD=1.0$) to a *higher* stage of change. According to Stage of Physical Activity Behavior Change, the full sample averaged to be within the 'preparation stage' range of physical activity change at follow-up ($M = 3.54$, $SD = 1.25$), which indicates that most of the sample endorsed that they

intended to engage in regular physical activity in the 30 days after the study ended. In addition, Physical Exercise Self-Efficacy, $t(30)=2.73$, $p=.011$, Mindfulness in Physical Activity $t(30)=2.98$, $p=.006$, and Physical Activity Satisfaction $t(30)=2.99$, $p=.006$, all increased significantly from baseline to follow-up assessment (see Table 7 for means across Time 1 and Time 2).

1.5 DISCUSSION

The overarching goal of this study was to develop, and pilot test an integrated intervention that combines mindfulness with guided imagery and targets underlying mechanisms involved in health behavior engagement, specifically reward and regulatory processes (Hofmann et al., 2008). Our integrative design approach incorporates mindfulness, positive affect, and episodic future thinking into a guided imagery to promote physical activity enjoyment and engagement. This study is the first, to our knowledge, to include both mindfulness and dual-system reward and regulation content into an online accessible guided imagery intervention designed to promote physical activity. Given that this intervention approach has not been empirically tested before, we aimed to explore the feasibility and acceptability of our novel intervention in a sample of physically underactive adults.

Findings consistently support the feasibility and acceptability of the intervention content and its delivery. According to our benchmark cutoff of above 4 on a 5-point scale (Proctor et al., 2011), full sample level findings indicate that participants found the guided imagery to be acceptable, satisfactory, easy to use and access, and that included instructions were clear and easy to follow, with an average acceptability rating of 4.65 (SD = 0.55) for the study. We applied this benchmark set by intervention implementation research to the self-report feedback questions included in this study. Questions included cover similar concepts to

those included in the validated Acceptability Intervention Measure (AIM) and Feasibility of Intervention Measure (FIM) (Weiner et al., 2017). In addition, reported physical activity behavior supports our feasibility findings—participants used the guided imagery before physical activity an average of 5.35 times, on average 2.5 *more* uses over the 2-week intervention period than required (study required minimum of 3 uses). In addition, participants engaged in a range of physical activities at slight to moderate intensity with an average exercise bout between 20 – 45 minutes in length. Participants' self-report feedback also indicated that they tended to enjoy listening to the guided imagery and found it to be helpful. Given that this sample was comprised of underactive adults, these feasibility findings are promising. Integrative interventions such as this, delivered in a simple and straightforward way as online audio recording, have the potential to help individuals reach the recommend 150 minutes a week of moderate-intensity aerobic physical activity guideline (US Department of Health and Human Services, 2018).

Participants also consistently rated the delivery method positively. Over 75% of participants described having no barriers or challenges to using the guided imagery prior to physical activity, with a small portion of the sample endorsing environmental barriers to use, including busy schedules, life stressors, and COVID-related limitations (e.g., gym closure). Over 50% of the sample qualitatively described the delivery method as easy to use and access. Participants liked having access to the guided imagery on their phone, with a small subset of participants describing during the interview that they prefer *quicker* access to the guided imagery recording through a mobile application on their phone, or the pairing of the guided imagery with mid-day phone reminder notifications.

Approximately 30% of the sample reported the length of the guided imagery recording as appropriate. Interestingly, although the Combined guided imagery condition was the longest, length did not appear to have a strong influence on intervention acceptability or overall perceptions for participants in this condition. Also, a subset of participants (less than 20%) noted that the guided imagery content became routine and/or memorized after approximately 3 uses. The quick assimilation of the intervention content as routine after just a few uses is promising as it suggests the formation of positive habitual associations that could implicitly cue physical activity. It is also possible that mindfulness components of the intervention help facilitate the retainment of intervention content. Mindfulness training has been shown to support free-recall and enhance episodic memory recall in a recognition memory task (Brown et al., 2016). The quick assimilation of the intervention content, however, may also suggest that individuals could become bored or disinterested in the guided imagery content due to lack of variability. Two participants noted that the guided imagery may be "too calming" before physical activity, and about one-third of participants reported that they would be more likely to use the guided imagery if it could be delivered through different variations, perhaps based on physical activity level or other individual characteristics or preferences. The potential to tailor the intervention content and provide participants with multiple guided imagery recording options (i.e., access to audio files from all 4 intervention arms) is a promising feasibility and acceptability future direction.

In regard to increasing physical activity engagement, participants agreed that the intervention content motivated them to increase their physical activity. About 70% of the sample expressed during their interview that they noticed an increase in their physical activity engagement, including increase in physical activity frequency, duration, and intensity. In

addition, over 25% of the sample stated that the guided imagery increased their motivation and readiness for physical activity, with some participants noting surprise at their own increase in motivation. These findings suggest that the intervention may be acceptable even for individuals who may be initially hesitant to try a new approach like mindfulness-informed guided imagery. In terms of physical activity outcome measures, we found an overall positive shift in stage of behavior change and physical exercise self-efficacy across the entire sample. This finding suggests that the intervention may have increased physical activity intentions from a contemplation to preparation stage. Participants also reported an increase in physical activity self-efficacy which may have increased perception of one's ability to engage in physical activity. Participants provided a range of reasons for listening to the guided imagery before physical activity, including feeling hopeful about experiencing a change in their physical activity level, noticing some immediate benefits derived from using the guided imagery (e.g., increased motivation), benefiting from positive reinforcement for physical activity, and using the guided imagery for motivation for physical activity when tired. The collective reporting of increases in motivation during and following the intervention use period also supports the overall feasibility and acceptability of the intervention content and delivery.

As this is the first online mindfulness-informed physical activity intervention that also incorporates content to target reward and regulatory pathways, our goal was to test sample wide feasibility and acceptability, not the differential impact of the mindful, reward and regulatory intervention components. Nevertheless, some of our findings offer proof of concept that our intervention components are meeting their intended targets. In terms of mindfulness, participants experienced a significant increase in state mindfulness during physical activity across all intervention conditions. While evidence suggests higher trait mindfulness is

beneficial for physical activity promotion (Chatzisarantis & Hagger, 2007; Sala et al., 2020), the ability to be mindful during physical activity may confer additional unique benefits to physical activity engagement. Mindfulness techniques have been shown to influence physical activity attitudes as physical activity is performed (Sala et al., 2021), and when used before physical activity, mindfulness increases physical activity endurance by increasing awareness of one's bodily sensations, facilitating the adjustment of effort (Salmon et al., 2010). About one-third of participants explicitly noted experiencing increased mindfulness and attention (e.g., focused on movements and effort, not distracted by thoughts or stressors) during physical activity. Additionally, a third of participants noted that the guided imagery increased their ability to focus on physical activity. A sharpened focus and attention before beginning physical activity may have encouraged greater mindfulness during physical activity. These findings suggest that the mindfulness-informed content appears to have promoted mindful practice during physical activity, however additional research with a larger sample is needed to test intervention efficacy, and so we draw this conclusion cautiously.

In regard to targeting the reward and regulatory pathways outlined in the dual-system model, our findings also provide proof of concept that positive associations with physical activity are occurring. Participants reported that they experienced enjoyment during physical activity when using the intervention audio files, and participants rated the intervention content as enjoyable and pleasant to listen to. Almost the entire sample (90%) noted an increase in positive emotions (e.g., pride, achievement, satisfaction, enjoyment) and experienced a more positive mindset (e.g., empowered, change in thinking about physical activity) before and during physical activity after listening to the intervention content. Finally, we found that self-reported satisfaction with physical activity increased from baseline to follow-up. These

findings are encouraging as enjoyment is an important motivator of physical activity maintenance (Williams et al., 2008; 2012) and satisfaction has been noted as an important facilitator for underactive individuals are initiating activity (Baldwin et al., 2013). Further, in combination with the reported increases in exercise motivation and shift in stage of behavioral change, the present findings support the influence of positive physical activity valuations on physical activity behavior change (Rhodes & Kates, 2015; Rhodes et al., 2017) and experimental intervention approaches targeting affective, reward-laden processes (Phipps et al., 2021; Strobach et al., 2020). Of note however, about 10% of sample wide participants described open-endedly that the intervention content did *not* have a significant impact on how much they enjoyed physical activity. As the majority of participants expressed an increase in positive emotions and positive mindset before and during physical activity as a result of the guided imagery, this pattern of findings suggests that there may be underlying differences in how individuals derive enjoyment from physical activity, an important area for future investigation.

Our intervention also included episodic future thinking guided imagery content (Giacobbi et al., 2014; Schacter et al., 2017) for targeting regulatory pathways in the brain. The incorporation of episodic future thinking into a mindfulness-informed guided imagery recording to increase goal-orientation for physical activity is novel and feasibility has not been tested. About 40% of the full sample indicated that the intervention content facilitated clarification of their physical activity goals and intentions. In addition, participants in the episodic future thinking condition, and combined condition (which included episodic future thinking content), tended to describe goal-orientation in more detail during their interview. A subset of participants in both the episodic future thinking (6 of 8) and combined (5 of 8) guided

imagery conditions stated that the imagery strengthened their mental connection between their present self and their future self and the recognition of larger, long-term benefits of physical activity for improving health. Although this qualitative data is from a small sample and should be interpreted with caution, the findings provide proof of concept that the episodic future thinking content is targeting regulatory processes that encourage delay of gratification of immediate impulses in favor of long-term rewards. In combination with earlier reported findings on increased motivation and greater than anticipated rates of physical activity engagement, the present pattern of findings also supports prior research that episodic future thinking prior to physical activity can increase exercise behaviors over a 2-week period (Andersson & Moss, 2011). As empirical evidence purports that regular physical activity is associated with greater valuation of the future (Daughtery & Brase, 2010; Garza et al., 2013), the present findings also provide proof of concept for the feasibility and acceptability of including episodic future thinking in a mindfulness-informed guided imagery intervention targeting physical activity. Replicating and extending the present finds with a larger sample is an essential next step in confirming the benefits of episodic future thinking on physical activity enjoyment and engagement.

One intriguing finding related to the feasibility and acceptability of our integrative mindfulness based guided imagery intervention is the potential for individual differences in preferences to drive which intervention condition would be most beneficial or liked. For instance, two participants, in the positive affect and reappraisal condition and the control conditions, reported a desire to include a focus on goal setting in the guided imagery. Whereas two participants in the episodic future thinking condition described the future-orientation as unhelpful, and that the 6-month future timeframe did not resonate with them. Supporting the

general acceptability of a mindfulness-informed guided imagery approach, participants in the control condition tended to rate the guided imagery as calming and relaxing, with positive feedback regarding ease of use, enjoyment, and physical activity mindfulness all within similar ranges of the target intervention conditions. However, one participant in the control condition found thinking about a routine activity unhelpful. Finally, participants who received the episodic future thinking, positive affect and reappraisal, and control condition guided imagery files each described a need to include components of the guided imagery content present in the *other* conditions to which they were not assigned (i.e., addition of more positive warmth/sympathy to the episodic future thinking condition, and the addition of goal setting to the positive affect and control conditions). This feedback supports our integrative approach as it highlights the need for intervention content that caters to a range of emotional and cognitive processing styles. Yet it also highlights the need for intervention feasibility and acceptability research that incorporates personal preference and needs, a future goal of our research team.

The present study sought to use best practices for increasing the efficacy and effectiveness of health behavior change interventions. The Science of Behavior Change (SOBC) working group at the National Institutes of Health identified the need to design and test integrative, evidence-based approaches to increasing physical activity that expand on decades of health behavior change grounded in theory (Nielsen et al., 2018). The SOBC working group asserts that it is necessary to target and test underlying psychological mechanisms and antecedents in intervention research. Behavior change theories are heterogeneous, but most similarly emphasize the importance of regulatory processes in influencing behavior change (Hennessy et al., 2020). For physical activity, however, evidence has increasingly pointed to the influence of positive affect, habitual, and reward laden

processes for physical activity initiation and maintenance (Hagger, 2020). Overall, the present study contributes to research and addresses SOBC's recommendations for improved intervention design and feasibility testing through an experimental approach that targets regulatory and reward-laden constructs potentially involved in physical activity health behavior change.

While the present study has notable strengths of in terms of design and integrative approach, there are several limitations that should be considered when interpreting results. The sample size is too small for conducting analyses that would compare intervention outcome variables between conditions. The sample size is also too small for capturing a broader range of inter-subject variability, or for detecting nuances in intervention preferences that could affect acceptability or efficacy. While we used industry standard benchmarks similar to Acceptability Intervention Measure (AIM) (Weiner et al., 2017), formally including the AIM with its a priori acceptability benchmarks would have facilitated incorporating our findings into the broader intervention implementation and acceptability field of research. To further leverage a factorial design, future research with an adequate larger sample size may formally incorporate measures such as the AIM and compare the efficacy of the four conditions on physical activity enjoyment and engagement. In addition, physical activity engagement was assessed via self-report rather than via objective methods such as an ActiGraph. Future research testing intervention efficacy should use objective measures of physical activity engagement such as ActiGraphs, smart watch activity trackers, or physiological recordings of physical activity intensity, duration, and exertion. Our sample was also highly educated and limited in diversity, which limits potential generalization to the general population. Additionally, as some participants suggested, our guided imagery were only available in

English. Future research should record the intervention content in other languages such as Spanish to examine feasibility and acceptability in marginalized ethnic groups. Relatedly, feasibility and acceptability should be examined in other specialized populations, such as under resourced individuals living with chronic pain (Garland et al., 2013) and cancer (Zernicke et al., 2013) who may have physical activity limitations but would also benefit from flexible, highly tailorable approaches to increasing physical activity. Finally, there are individual differences that may influence intervention use that were not examined in this study, such as trait mindfulness (Baer et al., 2008; Kharlas & Frewen, 2016) and specific personality traits (Tang & Braver, 2020)—future research incorporating these psychological traits has the potential to inform intervention feasibility, acceptability, efficacy, and intervention personalization.

Despite these limitations, there are multiple strengths of this feasibility and acceptability pilot study. The study presents a novel, online and remotely available guided imagery intervention that integrates mindfulness content with content targeting reward and regulatory pathways of the dual-system model of health behavior (Hofmann et al., 2008). This study also implemented best practice recommendations by the SOBC working group at the National Institutes of Health—we tested overarching feasibility and acceptability of a mindfulness-informed guided imagery intervention and used an experimental approach (Nielson et al., 2018) to obtain proof of concept of the mindfulness, positive affect and reappraisal, and episodic future thinking intervention components. In addition, our design prioritized scalability and accessibility—the intervention is brief, easily accessible online and offline (after downloading to a personal device) and can be used at any point in the day to cue physical activity. Remotely available interventions may have the greatest potential for

scalability to wider populations and may be particularly important for underactive adults seeking to increase their physical activity (Vandelanotte et al., 2007).

Accordingly, we tested the feasibility and acceptability of our novel physical activity enjoyment and engagement intervention in a sample of *underactive* adults. While our sample size limits generalizability and efficacy testing of our intervention conditions, sample wide findings demonstrate increases in state mindfulness during physical activity, an increased positive mindset toward physical activity, increased focus on goals and intentions for physical activity, and increases in physical activity self-efficacy and satisfaction. Finally, the present study illustrates how an integrative intervention approach can provide access to multiple intervention targets in a mindfulness-informed guided imagery format that could be tailored to meet individual needs and preferences. Findings from this study have the potential to address gaps in physical activity intervention research and expand and clarify how mindfulness is integrated into health behavior interventions. Results also suggest novel areas of future research that examine underlying psychological mechanisms and intervention antecedents to increase efficacy rates for physical activity and other health behavior interventions.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

AM and SL designed the study with input from AB and LM. AM and SL applied for human subject IRB approval. AM and SL drafted and revised all intervention content. AM collected Expert and Community Advisory panel feedback. AM oversaw pilot data collection and conducted thematic analysis coding of the interview data. SL oversaw quantitative data analysis. AM and SL drafted the manuscript. LM served as a member of the expert advisory panel. LM and AB provided feedback on drafts of the manuscript.

Funding

Participant incentives were partially funded by a doctoral student award provided through the University of North Carolina Health Psychology Program.

Acknowledgments

We would like to thank members of the Health Psychology Doctoral Advisory Committee for advising this project and providing support: Jeanette Bennett, Ph.D., Michael Turner, Ph.D., Jennifer Webb, Ph.D., Erin Basinger, Ph.D. A special thanks to Shannon Lindsay, B.S. and Cole Jones for their help with this project.

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Table 1. SPIRIT Figure: Schedule of enrolment, intervention, and assessments.

	STUDY PERIOD							
	Recruitment	**Baseline**	**Guided Imagery Use**					**Follow-up**
TIMEPOINT	$-t_1$	t_1	T_2	-	-	-	T_{13}	T_{14}
ENROLMENT:								
Eligibility screen	X							
Informed consent		X						
Allocation		X						
INTERVENTIONS:								
Future Thinking		X	♦	—	—	—	♦	
Positive Affect & Reappraisal		X	♦	—	—	—	♦	
Combined: Positive Affect & Reappraisal		X	♦	—	—	—	♦	
Control		X	♦	—	—	—	♦	
ASSESSMENTS:								
Demographics		X						
Mental Health		X						
Physical Health		X						
Enjoyment with PA			X	X	X	X	X	
Physical Activity Behaviors (duration, intensity, type)			X	X	X	X	X	
Satisfaction with PA		X						X
Mindfulness during PA		X						X
PA Self-Efficacy		X						X
Stages of Behavior Change- PA		X						X
Feasibility Self-Report			X	X	X	X	X	X
Acceptability Self-Report			X	X	X	X	X	X
Semi-structured feedback interview								X

Note. This is a SPIRIT figure that highlights what measures were delivered at each time point for the pilot test phase. PA = Physical activity.

Table 2.
Demographics

Demographic Variable	Full Sample *N = 31*	EFT *n = 8*	Pos Affect *n = 8*	Combined *n = 8*	Control *n = 7*
Age *M (SD)*	29.16 (10.66)	28.25 (9.53)	25 (6.95)	31.38 (12.12)	32.43 (13.84)
	N (%)	N	N	N	N
Gender					
Female	19 (61%)	4	5	4	6
Male	11 (35%)	4	3	4	--
Non-binary	1 (3%)	--	--	--	1
Race/Ethnicity					
White	15 (48%)	4	3	4	4
Black	5 (16%)	1	1	1	2
Latinx	4 (12.9%)	1	1	1	1
Asian	4 (12.9%)	2	1	1	--
Middle Eastern	2 (6.5%)	--	2	--	--
Multi Racial	1(3%)	--	--	1	--

Note. N = 31. EFT (Episodic future thinking condition): *n* = 8, Positive affect (Positive affect and reappraisal condition): *n* = 8, Combined (Combined episodic future thinking and positive affect and reappraisal condition): *n* = 8, Control condition: *n* = 7.

Table 3.
Physical Activity Intervention Use Data

	Full Sample	EFT	Positive Affect	Combined	Control
	M (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
Number of GI listens before PA engagement	5.35 (2.99)	4.75 (2.19)	4.0 (1.77)	6.50 (3.82)	6.57 (3.46)
PA duration	4.45 (1.29)	5.03 (1.04)	4.13 (1.18)	4.26 (1.55)	4.40 (1.12)
PA intensity	2.67 (.60)	2.74 (.76)	2.56 (.98)	2.44 (.93)	2.76 (.61)

Note. N = 31. GI = Guided imagery. PA = Physical activity. EFT (Episodic future thinking): *n* = 8, Positive affect (Positive affect and reappraisal): *n* = 8, Combined condition (combined future thinking and positive affect and reappraisal): *n* = 8, Control condition: *n* = 7. Physical activity duration (1 – 7 scale): 1 = *Less than 10 minutes*, 2 = *10 minutes*, 3 = *15 minutes*, 4 = *20 – 30 minutes*, 5 = *30 – 45 minutes*, 6 = *45 – 60 minutes*, 7 = *More than 60 minutes*. Physical activity intensity (1 – 4 scale): 1 = *Not intense*, 2 = *Slightly intense*, 3 = Moderately intense, 4 = *Very intense*. Physical activity enjoyment (Mullen et al., 2011): 7-point Likert scale (1 = *Strongly disagree*, 4 = *Neither agree nor disagree,* 7 = *Strongly agree*).

Table 4.
Self-Report Feedback During Intervention Use

	Full Sample	EFT	Positive Affect	Combined	Control
Feedback	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
I enjoyed listening to the GI.	4.03 (.72)	3.92 (.43)	3.87 (1.01)	4.34 (.75)	3.89 (.53)
I found the GI easy to use	4.47 (.67)	4.41 (.60)	4.38 (.55)	4.55 (.74)	4.58 (.50)
I found the GI helpful.	4.00 (.82)	3.89 (.46)	3.81 (.99)	4.36 (.72)	3.82 (.91)
PA Enjoyment Scale	5.14 (.79)	5.07 (.96)	5.29 (1.00)	5.11 (.53)	5.01 (.69)

Note. $N = 31$. GI = Guided imagery. PA = Physical activity. EFT (Episodic future thinking): $n = 8$, Positive affect (Positive affect and reappraisal): $n = 8$, Combined condition (combined future thinking and positive affect and reappraisal): $n = 8$, Control condition: $n = 7$. These feedback questions were presented with a 5-pt Likert scale (1 = *Strongly disagree*, 5 = *Strongly agree*). Number of survey entries: Full sample = 164 (EFT = 38; Positive affect = 32; Combined = 52; Control = 42). Participant responses for physical activity enjoyment were first summed and then averaged across all entries over the 2-week intervention period. Number of total GI uses before physical activity: Full sample = 164 (EFT = 38; Positive affect = 32; Combined = 52; Control = 42). Physical Activity Enjoyment Scale (Mullen et al., 2011): 7-point Likert scale (1 = *Strongly disagree*, 2 = *Disagree*, 3 = *Somewhat disagree*, 4 = *Neither agree nor disagree*, 5 = *Somewhat agree*, 5 = *Agree*, 7 = *Strongly agree*).

Table 5.
Self-report Feasibility and Acceptability at Follow-up

	Full Sample	EFT	Pos. Aff.	Combined	Control
Feedback Area	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
GI was acceptable	4.65 (.55)	4.62 (.52)	4.50 (.76)	4.62 (.52)	4.86 (.38)
Satisfied with GI	4.26 (.82)	4.13 (.99)	4.25 (1.04)	4.50 (.54)	4.14 (.69)
GI was easy to use	4.90 (.30)	5.00 (.00)	4.88 (.35)	4.88 (.35)	4.86 (.38)
Instructions in GI were clear and easy to follow	4.90 (.30)	4.88 (.35)	4.88 (.35)	4.88 (.35)	5.00 (.00)
Liked having access to GI on phone	4.03 (1.08)	4.25 (.89)	3.38 (1.30)	3.75 (1.04)	4.86 (.38)
Listening to GI was a pleasant experience	4.52 (.68)	4.25 (.89)	4.63 (.52)	4.63 (.52)	4.57 (.78)
Thought about GI during PA	3.77 (1.09)	4.00 (1.07)	3.25 (1.28)	4.25 (.46)	3.57 (1.27)
Would use again for PA	4.06 (1.03)	4.38 (.74)	3.50 (1.41)	4.50 (.54)	3.86 (1.07)
GI changed view of PA	3.58 (1.03)	3.63 (1.06)	3.63 (1.41)	3.62 (.74)	3.43 (.98)
Motivated to increase PA	4.06 (.89)	4.13 (.64)	3.50 (1.31)	4.38 (.52)	4.29 (.76)
Useful in other aspects of life	4.10 (1.04)	3.75 (1.04)	3.87 (1.46)	4.38 (.74)	4.43 (.79)
Other people would benefit to increase PA	4.19 (.98)	4.13 (1.13)	3.88 (1.36)	4.50 (.54)	4.29 (.76)
Other people would benefit to increase enjoyment	4.06 (.89)	4.25 (1.06)	3.63 (1.19)	4.25 (.46)	4.14 (.69)

Note. $N = 31$. GI = Guided imagery. EFT (Episodic future thinking): $n = 8$, Pos. Aff. (Positive affect and reappraisal): $n = 8$, Combined condition (combined future thinking and positive affect and reappraisal): $n = 8$, Control condition: $n = 7$. Participants responded on a 5-pt Likert scale (1 = *Totally disagree*, 5 = *Totally agree*).

Table 6.
Qualitative Feedback on Each Guided Imagery from Semi-structured Feedback Interviews

Qualitative themes	Full Sam.	EFT	Pos. Aff.	Combined	Control
Initial impressions	% (N)	% (N)	% (N)	% (N)	% (N)
I1. Increased focus	32% (10)	16% (5)	9.7% (3)	6.5% (2)	--
I2. Increased motivation	32% (10)	6.5% (2)	9.7% (3)	9.7% (3)	6.5% (2)
I3. Relaxing	23% (7)	--	9.7% (3)	--	12.9% (4)
Delivery method					
D1. No issues and Easy to use	65% (20)	23% (7)	16% (5)	16% (5)	9.7% (3)
D2. Preference for variety	48% (15)	16% (5)	9.7% (3)	9.7% (3)	6.5% (2)
D3. Quicker access	19% (6)	6.5% (2)	3.2% (1)	6.5% (2)	3.2% (1)
D4. Headphones	9.7% (3)	3.2% (1)	--	--	6.5% (2)
D5. Length is ideal	23% (7)	--	16% (5)	3.2% (1)	3.2% (1)
D6. Length not ideal	12.9% (4)	6.5% (2)	3.2% (1)	--	3.2% (1)
D7. Routine/memorized	16% (5)	6.5% (2)	3.2% (1)	6.5% (2)	--
Facilitators to use					
F1. Benefits and change	53% (16)	12.9% (4)	12.9% (4)	12.9% (4)	12.9% (4)
Barriers to use					
B1. No barriers	48% (15)	9.7% (3)	12.9% (4)	16% (5)	12.9% (4)
B2. Time and Schedule	29% (9)	3.2% (1)	9.7% (3)	--	6.5% (2)
B3. COVID-19 Limitations	6.5% (2)	--	--	6.5% (2)	--
B4. Life stressors	12.9% (4)	3.2% (1)	9.7% (3)	--	--
Helpful components					
H1. Voice	35% (11)	6.5% (2)	9.7% (3)	6.5% (2)	12.9% (4)
H2. Increased positive thinking	23% (7)	--	12.9% (4)	9.7% (3)	--
H3. Goal clarification	39% (12)	6.5% (2)	12.9% (4)	19.4% (6)	--
H4. Awareness of future	36% (11)	19.4% (6)	--	16% (5)	--
Unhelpful components					
U1. Nothing unhelpful	48% (15)	9.7% (3)	16% (5)	9.7% (3)	12.9% (4)
U2. Pace and tone	36% (11)	12.9% (4)	9.7% (3)	6.5% (2)	6.5% (2)
U3. Imagery content	9.7% (3)	6.5% (2)	--	--	3.2% (1)
Influence on PA					
PA1. Positive mindset	90% (29)	19.4% (6)	25.8% (8)	25.8% (8)	19.4% (6)
PA2. Mindfulness	32% (10)	12.9% (4)	3.2% (1)	9.7% (3)	6.5% (2)
PA3. Frequency and Intensity	71% (22)	12.9% (4)	25.8% (8)	16% (5)	25.8% (5)
PA4. Motivated by future	23% (7)	12.9% (4)	--	9.7% (3)	--
PA5. No change in enjoyment	32% (10)	9.7% (3)	9.7% (3)	6.5% (2)	3.2% (1)
Generalizability/Improvements					
G1. Post-PA reflection GI	12.9% (4)	--	6.5% (2)	6.5% (2)	--
G2. Inclusive language	6.5% (2)	--	6.5% (2)	--	--
G3. Voices and languages	9.7% (3)	--	3.2% (1)	3.2% (1)	3.2% (1)
G4. Other people would benefit	26% (8)	9.7% (3)	9.7% (3)	6.5% (2)	--
G5. Change GI format	16% (5)	6.5% (2)	6.5% (2)	3.2% (1)	--
G6. Changes to GI prompts	19% (6)	3.2% (1)	9.7% (3)	--	6.5% (2)

G7. Phone reminders	9.7% (3)	--	6.5% (2)	3.2% (1)	--
G8. Would use outside study	65% (20)	9.7% (3)	19% (6)	26% (8)	9.7% (3)

Note. Qualitative themes for each category of feedback are presented here. Full Sam. = Full sample (N = 31). PA = Physical activity GI = Guided imagery. EFT (Episodic future thinking): n = 8, Positive affect (Positive affect and reappraisal): n = 8, Combined condition (combined future thinking and positive affect and reappraisal): n = 8, Control condition: n = 7. Intervention content was described as a "guided imagery" to participants.
Theme descriptions: I1) increased focus for PA, I2) more motivated to complete PA, I3) intervention content as "relaxing," "soothing," and/or "calming." D1) no issues and easy to use and access, D2) Would like different audio files to rotate, D3) Would like quicker access through a mobile phone app, D4) Audio quality better with headphones, D5) Length of the audio file was ideal, D6) Length of the audio file was not ideal: would like to be longer or shorter, D6) Became routine or memorized after 2-3 listens. F1) Began feeling hopeful about change and had noticed the positive benefits of listening to GI. B1) Denied barriers to use and access, B2) Time and/or busy schedule, B3) Limitations due to COVID-19 (e.g., gym closures), B4) Life stressors distracted them. H1) Endorsed voice as "soothing," "encouraging," and that it "sounded like a friend," H2) More positive thinking about themselves and their PA, H3) Opportunity to set intentions and clarify PA related goals, H4) Able to deepen their connection between present moment and future outcomes. U1) Nothing was unhelpful, U2) Pace and tone described as inappropriate: instructions were either too slow or too quick, too many discernible pauses in the audio file, and/or GI was "too calming," U3) Did not like the content of the GI, such as the future focus or routine activity. PA1) Increased positive affect and shift to a positive mindset about PA, PA2) Increased mindfulness, attention, and engagement during PA, PA3) Increased frequency and intensity of PA, PA4) Felt more motivated during their PA from thinking of future outcomes, PA5) GI did not increase or change their level of enjoyment experienced during PA. G1) Desire to have a reflection based GI to listen to after PA, G2) Maintain inclusive language that can apply to the broader population, G3) Different voices and languages (e.g., Spanish), G4) People in their life would also benefit from the GI and find it easy to use, G5) Noted that the GI could be paired with exercise instructions, workout videos, and/or embedded within a group/exercise class, G6) Need for specific changes to the intervention content: Planning statement (e.g., when, where, etc., will you complete physical activity), G7) Mid-day push notification reminders, G8) Would use the GI in everyday life.

Table 7.
Means and Standard Deviations of Outcome Measures for Full Sample and Conditions

	T1 - Baseline	T2 - Follow-up	
Outcome Measure	M (SD)	M (SD)	Change Difference
PA Stage of Change	2.94 (.68)	3.54 (1.25)	0.6
Future thinking	3.00 (1.07)	3.13 (1.46)	0.13
Positive affect	2.63 (.74)	3.63 (1.30)	1.00
Combined	3.13 (.35)	4.00 (1.00)	0.87
Control	3.00 (.00)	3.43 (1.27)	0.43
PA Self-Efficacy	10.39 (3.53)	12.19 (3.30)	1.80
Future thinking	9.50 (3.21)	12.50 (4.99)	3.00
Positive affect	9.13 (4.02)	11.13 (2.85)	2.00
Combined	12.13 (2.36)	12.88 (2.48)	0.75
Control	10.86 (3.39)	12.29 (2.56)	1.43
Mindfulness in PA	21.94 (4.18)	23.90 (3.64)	1.96
Future thinking	22.89 (4.22)	25.00 (5.18)	2.11
Positive affect	20.25 (5.55)	22.13 (2.36)	1.88
Combined	22.63 (2.97)	24.50 (3.70)	1.87
Control	22.00 (3.83)	24.00 (2.45)	2.00
PA Satisfaction	23.52 (3.97)	25.29 (2.64)	1.77
Future thinking	24.38 (4.17)	27.00 (2.14)	2.62
Positive affect	20.63 (4.27)	24.38 (3.82)	3.75
Combined	25.75 (3.58)	25.12 (1.96)	-0.63
Control	23.29 (1.80)	24.57 (1.51)	1.28

Note. N = 31. PA = Physical Activity. Stage of Change Scale: 1 = pre-contemplation stage (i.e., individual does not intend to take action and could be unaware of the pros of changing their behavior), 2 = contemplation stage (i.e., intending to start the behavior but may still be ambivalent toward changing their behavior), 3 = preparation stage (i.e., ready to act and small steps towards behavioral change and likely believe in the positive outcomes of the behavior), 4 = action stage (i.e., has recently changed their behavior and will be more likely to consider ways to further modify their behavior), 5 = maintenance stage (i.e., has sustained a behavior change and likely works to prevent relapse of negative health behaviors, like remaining sedentary).

CHAPTER 2: MASTER'S THESIS PROPOSAL

2.1 INTRODUCTION

Targeting reward and regulatory pathways to increase physical activity: Development of a guided imagery intervention

Behaviors known to promote good health and prevent negative health outcomes can be difficult to initiate and maintain. One such behavior, physical activity, has been shown to improve health (Rhodes et al., 2017) and well-being across the lifespan (Hyde, Maher, & Elavsky, 2013). For example, strong evidence indicates that physical activity can lower the risk of early death (Arem et al., 2015), coronary heart disease and stroke (Bullard et al., 2015), type 2 diabetes (Reiner, Niermann, Jekauc, & Woll, 2013), breast, colon, and endometrial cancers (Friedenreich, Neilson, & Lynch, 2010), and depression (Mammen & Faulkner, 2013). Physical activity has also been purported to improve psychological health in both clinical (Rosenbaum et al., 2014) and non-clinical populations (Rebar et al., 2015). The federal Physical Activity Guidelines (PAG) specify that for substantial health benefits, adults should engage in 150 minutes of moderate-intensity aerobic physical activity per week, which translates to approximately 30 minutes of aerobic exercise 5 days a week (Department of Health and Human Services [HHS], 2008). Despite federal guidelines and widespread health benefits, low rates of physical activity and high rates of sedentary behavior persist. Recent data from the National Health Interview Survey (National Center of Health Statistics [NCHS], 2018) indicate that 77% of adults 18 and over did not meet the 2008 federal PAG for both aerobic and muscle-strengthening based activities. As increased physical activity reduces a broad range of health risks it is critical to identify ways to facilitate the initiation and maintenance of regular physical activity.

Accordingly, novel and effective interventions are needed to address low rates of physical activity in the United States. Importantly, these novel interventions should address key issues that have arisen in behavior change science and intervention design. These issues, as identified by the National Institutes of Health (NIH) Science of Behavior Change working group, include the tendency for interventions to adopt a narrow focus on effectiveness or efficacy without first testing whether an intervention works by engaging a specific behavior change mechanism (Riddle, 2015). Further, the Science of Behavior Change working group observed that the tendency to conduct separate mechanistic and clinical behavior research is leading to difficulties in applying advances across health behaviors (Riddle, 2015). In addition, many interventions do not address the correlates and determinants that underly physical activity motivations, intentions, and behaviors which, if addressed, could increase their effectiveness. To address these issues, the Science of Behavior Change working group recommends an experimental medicine approach to health behavior and intervention development (see Figure 1) in which intervention development research focuses on identifying causal mechanisms (i.e., putative targets) that underly a health behavior (e.g., physical activity) and targeting those causal putative targets.

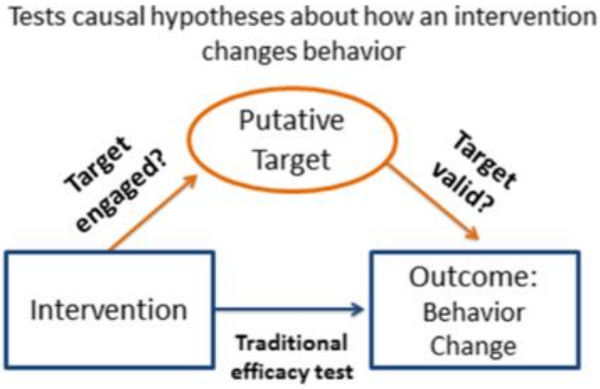

Figure 1. The experimental medicine approach to intervention development involves testing both whether the intervention engages the intended target and whether target engagement leads to desired behavior change outcome. Reprinted from "News from the NIH: Using an experimental

medicine approach to facilitate translational research," by M. Riddle, 2015, Translational Behavioral Medicine, 5, 486-488.

In this proposal we aim to adopt an experimental medicine approach to develop an intervention aimed at increasing positive valuation of physical activity engagement. We begin by reviewing critical constructs relevant to health behavior change theory and then introduce a neurobiological model applicable to physical activity. We then describe how neurobiological models serve to strengthen current conceptualizations of health behavior change. Following this, we identify putative targets that, based on theory and neurobiological models, should influence physical activity, and lastly, we present our intervention designed to activate our putative targets. In sum, our goal with this project is to employ an experimental medicine approach that will merge health behavior change theories and neurobiological models of behavior to develop adjunct interventions that will increase physical activity enjoyment and thereby increase physical activity in sedentary individuals.

Health Behavior Change Theory

Decades of health behavior change research has resulted in considerable progress towards understanding the determinants of health behavior. Although it is beyond the scope of this proposal to review the predominant health behavior change theories, substantiated health behavior change theories include the theory of planned behavior (Fishbein and Ajzen, 1975), transtheoretical model of health (Prochaska & DiClemente, 1983), health action process approach (Schwarzer et al., 2011), protection motivation theory (Rogers, 1975), and social cognitive theory (Bandura, 2001). Common key constructs included (in some form) in the aforementioned theories include: behavioral intention, which represents the motivational factors that influence the likelihood of performing that behavior; outcome expectancies, which describes the link between the behavior and future outcomes; perceived self-efficacy (i.e., beliefs regarding

capabilities to exercise control over challenging demands and over their own functioning), and planning and goal-setting, which are preparatory strategies initiated through mental simulation (Schwarzer, 2011). These theories postulate that the health behavior change constructs of intention and planning will lead to sustained behavioral change and are therefore the target of many health behavior interventions. For example, many individual-level physical activity behavior change interventions have focused on enhancing behavioral intentions as a means of increasing physical activity behaviors (Rebar et al., 2019; Rhodes & Rebar, 2017)—intention is viewed as a lever that can (for example) increase planning and overcome barriers. However, these intervention studies have not been as effective in facilitating behavior change to increase physical activity as anticipated (Rhodes & de Bruijn, 2013; Rhodes & Dickau, 2012).

Intentions are influenced by multiple factors (e.g., self-efficacy, motivation, perceived barriers, perceived benefit/risk) throughout an individual's pursuit for health behavior change (Hagger et al., 2002; Sheeran & Webb, 2016). Importantly, individuals who have successfully initiated a behavior more often than not fail to sustain that behavior over time (Jeffrey et al., 2000; Marlatt & Donovan, 2005; Norman & Conner, 2005) and those who intend to engage often do not actually initiate the behavior (Sheeran et al., 2016; Sweeney & Moyer, 2015; Webb & Sheeran, 2006), despite having intention. In addition, meta-analytic evidence demonstrates that increasing positive intentions to be physically active does not necessarily result in consistent and meaningful changes in physical activity behaviors (Rhodes & Dickau, 2012). Findings from statistical simulations also converge on the conclusion that changing intentions does not guarantee behavior change (Fife-Schaw et al., 2007). Additionally, researchers postulate that for intentions to be effective in guiding behavior, individuals must be aware of their intentions in relation to a goal (e.g., better health status) (Schwarzer, 1992), which may not always be the

case. Strikingly, recent estimates suggest 46% of individuals who are motivated to engage in physical activity do not in fact realize their intentions (Rhodes & de Bruijn, 2013).

This gap between intention and action, known to as the intention-behavior gap, refers to the fact that people do not always achieve what they intend to do regarding health behaviors (Sheeran & Webb, 2016). The intention-behavior gap exemplifies the need for the experimental medicine approach (Riddle, 2015) which would advocate for including the investigation of basic science processes that might further elucidate the nuances of health behavior change. Ultimately, this would contribute to the development of more effective and broadly applicable physical activity interventions. For example, the inclusion of a basic science approach through the incorporation of neurobiological models of health behavior may shed light on the cognitive and emotional factors underlying key health behavior change constructs, such as intention, applicable to increasing physical activity engagement.

Neurobiological Models

One of the most influential neurobiological model of health behavior is the dual-systems model of behavioral control and decision making, which postulate that behavior is the result of processes underlying regulatory and reward pathways in the brain (Hofmann et al., 2008; Lieberman, 2007; Metcalfe & Mischel, 1999; Robinson & Berridge, 2008; Weirs et al., 2007). While earlier research with the dual-systems model has focused on its application to addiction (Wiers et al., 2007), consumer decision making (Shiv & Fedorikhin, 1999), and social behaviors (Strack & Deutsch, 2004), it has emerged as a dominant neurobiological model of health behavior that elucidates the interplay between reasoned judgements and impulsions that underly decision making (Hofmann et al., 2008). The two systems described by the dual-systems model include 1) regulatory, reflective (i.e., future-oriented system) and 2) impulsive, reward laden

(i.e., present-oriented system) cognitive processes that are found to impact decision making and affect related to health behaviors (e.g., Kiviniemi & Duangdao, 2009; Reynolds, 2006). Regulatory and reward pathways outlined in the dual-system model emphasize that structurally different systems of information processing underlie the production of reasoned (i.e., regulated) versus impulsive (i.e., reward laden) forms of behavior (see Figure 2, panel A). A dual-systems approach specifies that reflective information processing occurs through inhibitory control and executive functioning operations that are part of the regulation system in brain that facilitates healthy lifestyle choices (e.g., physical activity behaviors). In contrast, reward information processing often occurs automatically and manifests in impulsive behaviors that have hedonic value which may become maladaptive (e.g., remaining sedentary, high caloric/excessive snacking). Regulatory and impulsive or rewarding forms of behavior are also postulated to derive from distinct regions in the brain, such as the lateral prefrontal cortex and amygdala, respectively (Lieberman, 2007).

Although each pathway is represented by specific brain regions, both processes have the potential to influence one another by "overriding" the other (See Figure 2, panel B). Neurobiological understandings of health behavior suggest that attempts to restrain and regulate behavior (*high* cognitive effort) have the potential to be overridden by impulsive processes (*high* hedonic or reward impulses). For example, an individual may have a strong impulse to sit and watch television but at the same time be motivated to increase their physical activity levels and improve their health—these signals conflict and according to neuronal research, the stronger signal will determine which behavior is realized (Ochsner et al., 2002). When one signal is weakened (e.g., the reflective signal is weakened due to depleted cognitive resources rendering the person less able to engage in mental simulation or reflective thought) the other signal will

become more dominant and influence behavior more (Hofmann et al., 2008; Lieberman, 2007). Alternatively, when ‘signals’ from dual pathways are aligned and not in conflict, then a behavior is facilitated and is performed with less effort (see Figure 2, panel C). For example, someone who enjoys physical activity and recognizes the long-term benefits will engage in physical activity with greater ease than someone who does not enjoy physical activity but recognizes the long-term benefits. In sum, when the two pathways are in sync, behavior change should occur with greater ease, while when the two systems are incompatible, behavioral change should be more challenging (Hofmann et al., 2008; Strack & Deutsch, 2004) (See Figure 2, panels C and B respectively). Thus, it’s critical to consider both regulatory and reward components of physical activity initiation, enjoyment, and maintenance and interpret physical activity behaviors as a result of influences between automatic impulses and controlled processes.

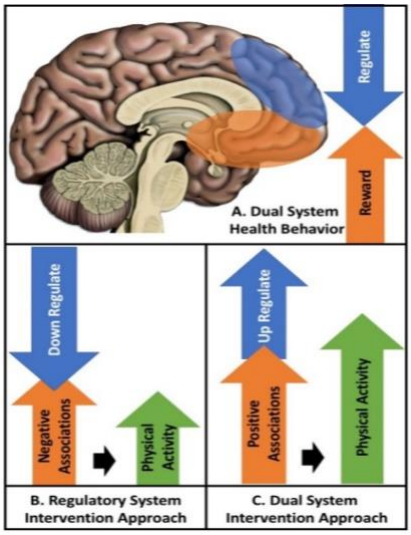

Figure 2. A dual-systems approach will be employed that will serve to increase positive associations with physical activity and increase the balance between both regulatory and reward influences on behavior.

Physical activity and the Regulatory System

Previous research has placed a significant emphasis on the importance of conscious, behavior change correlates (Ekkekakis et al., 2013) included in the regulatory system, such as self-regulatory capacity, self-control, and will-power (Metcalfe & Mischel, 1999). There are several operations included under the umbrella of self-regulatory capacity, including executive functions such as making reasoned judgments and evaluations, putting together strategic action plans for goal-pursuit, and inhibiting or overriding impulses or habits. Regulatory behavioral operations are achieved through relatively slow, controlled processes based on mental and symbolic representations that incorporate rule-based information processing (Smith & DeCoster, 2000; Strack & Deutsch, 2004), and ultimately, are in competition with distinct reward valuation processes, that are more impulsive, involve less inhibitory control, and are associated with unhealthy behaviors (Bechara, 2005; Jasinska et al., 2012; Maher & Conroy, 2016) and decreased propensity for health promotive decision making ability (Wickel, 2017).

Critically, the ability to abstain from gratifying immediate needs and desires (e.g.,

remaining sedentary) is extremely adaptive and enables people to engage in goal-directed behavior to bring about long-term desirable outcomes (e.g., better health status) (Baumeister, 2005; Mischel et al.,1989). Researchers have identified factors underlying self-regulation as important psychological mediators of physical activity intention and adherence (Dishman, 1994), providing support for self-regulatory capacity as a critical component to physical activity behavior change. For example, self-regulatory processes, such as planning, scheduling, and considering future outcomes are shown to positively influence physical activity adherence beyond other factors (Rhodes & Pfaeffli, 2010) and executive function ability (via cognitive tasks) and the ability to set goals are found to increase physical activity self-efficacy and subsequently, engagement (McAuley et al., 2011). Current conceptualizations are that adherence to physical activity constitutes a prime example of a behavior that requires self-regulation and the majority of physical activity interventions have focused on strengthening the regulatory system (Figure 2, panel B), with almost no interventions targeting the rewarding aspects of physical activity. It appears therefore that physical activity interventions have minimally applied the dual-systems model of behavior and may benefit from targeting the reward pathway through increased intrinsic motivation and appraisal of physical activity as rewarding and enjoyable.

Physical Activity and the Reward System

The routes by which affective appraisal mechanisms underlying impulsive and reward behavior (as opposed to general impulsivity) exert an influence on health behavior have received less attention in the health behavior change literature (Hofmann et al., 2008). Recent research suggests that positive affect is a construct central to the reward system, in that individuals in a positive mood are found to rely more heavily on associative networks in long-term memory

activated by reward pathways when processing information (Bolte et al., 2003). The associative networks in long-term memory activated by reward pathways may therefore facilitate the habitualness of physical activity behaviors. Furthermore, evidence posits that a behavior becomes habitual when it relies on the impulse, reward system for information processing and no longer needs to assert cognitive effort through activating executive functions (Smith & DeCoster, 2000). Recognizing the role of the reward pathway in habitual behaviors, researchers have recently theorized that activating the reward system via targeting emotional mechanisms, like positive affect, will have a strong influence on physical activity behaviors (Ekkekakis et al., 2013; Rhodes & Kates, 2015). For instance, recent theory (Upward Spiral Theory of Lifestyle Change; Van Cappellen et al., 2018) posits that experiencing positive affect before and during a health behavior can create nonconscious motives that can grow stronger with time. Taken together, the dual-systems approach postulates that increasing the balance (degree and frequency of neural activation) between both systems, reward and regulatory, while making health behavior decisions (e.g., to be physical active or not) is more likely to be adaptive and result in sustained behavioral change (see Figure 2) (Hofmann et al., 2008).

Intervention Targets: Episodic Future Thinking and Positive Affect

In accordance with the experimental medicine approach and based on evidence from the dual-systems model, our chosen putative targets represent the two neurobiological pathways that are part of a dual-systems model: the regulatory pathway and the reward pathway. To target the regulatory pathway, we will use a process known as episodic future thinking. Episodic future thinking (EFT) is the capacity to imagine personal future events. EFT targets the regulation system, as executive functioning processes are required (Schacter et al., 2017) to mentally visualize a subjective future (Schacter et al., 2017). Also known as prospection (Gilbert &

Wilson, 2007), EFT is central for our ability to delay gratification and withstand short-term impulses in favor of long-term benefits. EFT has been shown to reduce preferences for immediate compared to delayed rewards (Cheng et al., 2012; Lin & Epstein, 2014; Peters & Büchel, 2010). For instance, targeting episodic future thinking has been demonstrated to decrease impulsive, high caloric eating behaviors (Daniel et al., 2013) and cigarettes smoked and cravings in smokers (Stein et al., 2016). Research delving into the mechanisms of EFT suggests that EFT is derived from episodic memory which supports future simulation by allowing people to flexibly retrieve and recombine elements of past experiences into novel representations of events that might occur in the future.

Evidence from thought sampling procedures indicates that episodic future thoughts occur frequently in everyday life and serve a range of functions, including decision making, emotion regulation, intention formation, and planning (Schacter et al., 2017). Importantly, the ability to form internal representations of the future is necessary to facilitate goal-directed actions (Bandura, 2001; Barkley, 2001). From this perspective, internal representations of future consequences and/or outcomes allow people to exert adaptive anticipatory control over their behavior and thereby manipulate, alter, and influence their environments. Furthermore, training in EFT has been shown to reduce temporal discounting rates and health behaviors like and food reinforcement (Sze et al., 2017) and unhealthy snacking (Dassen et al., 2016). To date, no studies to our knowledge have examined the role of EFT in changing physical activity. Yet, prior research illustrating the positive influence of executive function (McAuley et al., 2011) and self-regulatory factors (Rhodes & Pfaeffli, 2010), such as considering behavioral outcomes while goal setting and planning, on physical activity engagement supports a positive association

between EFT and physical activity. Accordingly, our plan is to incorporate EFT into our intervention to target regulatory pathways, thereby increasing physical activity.

To target the reward pathway, on the other hand, we will use positive reappraisal and positive affect processes. Research indicates that the affective changes related to exercise are a critical part of exercise adherence (Sallis & Hovell, 1990; Wankel, 1993) and that when individuals associate enjoyment with the thought of engaging in a health behavior, they are more likely to not only intend to engage in the behavior but are also more likely to actually initiate the behavior (Kiviniemi & Duangdao, 2009). Accordingly, we will highlight positive aspects of physical activity and guide the reframing of perceived negative aspects of physical activity (e.g., physiological effort) to be more positive. For example, physical activity involves physiological signals (e.g., increased heart rate, labored breathing, and sweat) that in other contexts signal danger and incur feelings of discomfort and anxiety. Sedentary individuals may be less able to appropriately label their physiological activity and therefor experience heightened negative arousal during physical activity. Therefore, physical activity may benefit greatly from intervention efforts to increase positive associations with physical activity and reframe the physiological experiences as positive and healthy for the body. Further, positive associations, such as feeling joy or making positive judgements about one's experience with physical activity, can facilitate more habitual behavioral patterns that increase health (Van Capellan et al., 2018; Williams et al., 2008a), like engaging in regular physical activity. Accordingly, our plan is to incorporate positive affect and positive reappraisal into our intervention to target reward pathways, thereby increasing physical activity enjoyment, and subsequently higher levels of physical activity.

Assessment of Intervention Putative Targets

To increase physical activity and to target both systems within the dual-systems model, we will use EFT to target the regulatory pathway and positive affect and reappraisal to target the reward pathway. To measure the putative target of regulatory capacity, we will assess the construct of temporal discounting, a key construct in decision making science that represents an individual's propensity to discount or devalue the future, suggesting a preference for more immediate, smaller rewards (e.g., watching television instead of walking) over future, larger rewards, such as your future health (Bickel & Marsch, 2001). Temporal discounting is regarded as a trans-disease process (McClure & Bickel, 2014), as a sizable body of research has shown that temporal discounting rates are an important predictor or correlate of choice behavior in a wide variety of contexts (Bickel et al., 2017; Story et al., 2014). For instance, high temporal discounting (i.e., high rates of devaluing the future) has been established as a significant predictor for drug use (Petry, 2001a; Reynolds, 2006), alcohol use (Petry, 2001b), tobacco use (Bickel et al., 2008), and eating behaviors (Appelhans et al., 2011), as well as an early life predictor of cognitive development and behavioral choice (Mischel et al., 1989). Temporal discounting has also been explored in the context of physical activity behaviors. For instance, researchers demonstrate that temporal discounting rates are lower (i.e., devaluing the future *less*) among exercisers and that greater temporal discounting (i.e., devaluing the future *more*) and a preference for immediate gains predicts lower exercise adherence and engagement (Daugherty & Brase, 2010; Garza et al., 2013; Tate et al., 2015). As temporal discounting has been linked with physical activity and been identified as a trans-disease process, we will use measures of temporal discounting to assess the impact of the intervention on regulatory pathways.

To measure our putative target of the reward pathway, we will assess positive associations and valuations of physical activity through assessments of positive affect and

physical activity enjoyment and satisfaction. To assess whether we have engaged the reward pathway, we will measure positive affect (Watson et al., 1988) and exercise induced positive emotions (e.g., “revived,” “refreshed”) (Gauvin & Rejeski, 1993). In addition to measuring positive affective states, we will also assess whether the reward pathway is targeted by measuring physical activity satisfaction and enjoyment. For instance, research demonstrates that the predictive effects of physical activity enjoyment and positive affect felt during activity engagement have been demonstrated to hold even among initially sedentary adults at 6- and 12-month follow-up (Williams et al., 2008b; Williams, Dunsiger, Jennings, & Marcus, 2012). Also, feeling satisfied after engaging in physical activity is evidenced to be a significant predictor of adherence and maintenance (Williams et al., 2008a). Accordingly, we will use multiple measures of positive affect and physical activity enjoyment and satisfaction to assess the impact of the intervention on reward pathways.

In sum, consistent with the dual-systems model, physical activity interventions may benefit from leveraging the overactive reward system that has been associated with unhealthy behaviors by enhancing the reward values of healthy behaviors through episodic future thinking and increasing individual positive associations with physical activity. Therefore, the present study aims to target both the regulatory and reward systems by designing a novel intervention that includes EFT (to target the regulatory pathway) and positive affect and positive reappraisal (to target the reward pathway). To assess our regulatory and reward system putative targets we will use temporal discounting and markers of positive associations and enjoyment regarding physical activity, respectively. Through application of a basic science approach of targeting cognitive and emotional factors early in the behavior and decision-making process, we hope to also influence behavior change constructs emphasized in health behavior change theories. For

instance, the present cognitive-emotional targets of regulation and reward should also influence higher level cognitive processes that may serve as moderators or mediators, such as intention, planning and self-efficacy, to also influence the underlying behavioral choice and decision making that contributes to physical activity initiation and maintenance. Therefore, the basic reward and regulatory processes may have multiple testable pathways to influence physical activity that might further elucidate the nuances of health behavior change (e.g., intention-behavior gap) to develop more effective, broad, and applicable physical activity interventions. Accordingly, we now describe the intervention structure and development process we will use to prompt episodic future thinking and positive associations with physical activity.

The Present Study

The overarching goal of the present study is to develop an intervention that targets reward and regulatory pathways with the goal of increasing physical activity. To achieve this goal, we will 1) implement a multistep intervention development process that includes feedback from an advisory panel comprised of field experts and community members, 2) assess the feasibility of delivering the intervention and 3) assess the acceptability of the guided imagery. A secondary exploratory goal of this proposal is to also assess intervention outcomes that are correlates of behavior change, such as stage of behavior change (Prochaska & DiClemente, 1983), self-efficacy (Bandura, 2001), and motivations for engaging in physical activity (Ryan et al., 1997). To develop the intervention, we will first draft initial scripts for the guided imagery, and then collect 1 to 2 rounds of feedback from advisory panel members, in which we address feedback and return the scripts for additional feedback. Once the advisory panel members feedback has been sufficiently incorporated and final scripts agreed upon, the guided imagery will be piloted with a convenience sample to assess delivery and initial use rates. Notably, to apply an

experimental medicine approach while assessing the differential and combined effects of regulatory and reward targets, the guided imagery intervention will be comprised of three conditions that will focus on specific pathways of the dual-system model, and a control. Specifically, we will develop four intervention scripts, one which targets the regulatory pathway via EFT, a second which targets the reward pathway using positive affect and reappraisal, a third which targets both the regulatory and reward pathways using a combination of EFT and positive affect. Finally, a control condition will be developed to assess the impact of the aforementioned intervention conditions.

To assess feasibility of delivering the intervention, we will assess number of times participants each use the imagery, delivery method ease of use, and whether there is variability in use (e.g., type and length of physical activity, location, timing of using imagery). To assess the acceptability of the guided imagery we will collect qualitative feedback via semi-structured interviews from participants. Finally, we will address our secondary exploratory goal of examining the effects of the intervention on correlates of behavior change by assessing between group differences on stages of behavior change, motivations for physical activity, and self-efficacy measures. Through these efforts we hope to yield three viable intervention conditions and a control condition that will be able to be tested in a future clinical trial with sedentary individuals.

2.2 PROPOSED METHOD

Guided Imagery Development

To target positive affect and episodic future thinking, scripts will be created for each of the four proposed guided imagery conditions: 1) EFT only, 2) positive reappraisal of physical activity only, 3) EFT and positive reappraisal of physical activity, and 4) neutral episodic recent

thinking about unrelated event (control condition). Initial scripts will be developed by the researcher and based on language from positive episodic future thinking induction tasks, positive mood induction scripts, mindful meditation exercises, and existing guided imagery scripts from a previous study focusing on healthful eating (Levens et al., 2019). After initial development, scripts will be sent to an advisory panel comprised of approximately 3 sedentary community members and 3 experts in fields of mindfulness, health promotion, physical activity/exercise, guided imagery interventions, positive affect, or health behavior change. Efforts will be made to find experts with overlapping expertise in the aforementioned fields. Advisory panel members will provide feedback through a survey delivered via Qualtrics and via a phone conference. Feedback will then be incorporated and revised scripts sent back to experts for a second round of feedback.

Advisory panel members will be asked to provide their overall feedback for each script as well as comment on specific aspects of the script, such as the content of imagery and whether script induces positive associations with physical activity and EFT, as well as their perceived impact of the guided imagery script on physical activity and correlates of behavior change. We anticipate collecting 1 to 2 rounds of feedback to reach scripts that will be ready for initial piloting.

Guided Imagery Content

While we anticipate that the content of the guided imagery will shift and evolve based on input from advisory panel members, below are the starting point content themes for each condition.

Episodic Future Thinking Condition. This condition will invite participants to consider themselves in the future after participating in three months of regular physical activity. The

imagery will reference improved health but will not include explicit prompts to the positive benefits and outcomes associated with physical activity. This condition will be three to five minutes long.

Positive Affect and Reappraisal Condition. To impact positive affect related to engaging in physical activity, individuals will be invited to think of positive feelings and associations surrounding physical activity. They will be asked to imagine themselves appreciating the experience and challenge of physical activity and bring awareness to positive aspects of engaging in physical activity, such as physical and mental health benefits, and reframe the negative aspects of physical activity. This condition does not invite individuals to consider themselves in the future, rather the focus will be to increase positive affect and associations regarding physical activity in the present moment or more generally. This guided imagery condition will be approximately three to five minutes long.

Episodic Future Thinking and Positive Affect and Reappraisal Condition. This condition will include the same positive affect and reappraisal imagery as previously described; however, it will also incorporate EFT. Participants will be invited to think about a physical activity goal they have for the future and then participants will be invited to think in detail of a future, ideal version of themselves who has regularly engaged in physical activity and met their goals. They will be asked to envision the journey they took to become this ideal version of themselves, how they would look and feel after three months on this journey, and the positive effects physical activity has had on them. This guided imagery exercise will be approximately five minutes long.

Episodic Recent Thinking Control Condition. This condition will include no positive affect or EFT content. Instead, the condition will include control content for both the positive

affect and reappraisal condition and the EFT condition: neutral affect and episodic recent thinking. Employing the same approach as prior episodic future thinking studies (e.g., O'Neill, Daniel, & Epstein, 2016; Stein et al., 2016), individuals will be asked to think back to an event or activity that occurred one week ago and to imagine themselves during this event or doing this activity. To make sure that participants don't choose a positive recent event (which would confound the control) participants will be guided to imaging a routine behavioral event that is not identified as regularly positive. They will be asked to imagine it as vividly and with as much detail as possible. This condition will be three to five minutes long.

Participants

Recruitment. Participants will be individuals from the UNC-Charlotte community through email, flyers, and word of mouth. The aim is to recruit 6 participants for each guided imagery condition, resulting in a final sample size of $N = 24$. Interested participants will be directed to a Qualtrics survey that will determine eligibility. Eligible participants will be asked to provide their contact information for scheduling their intake session. At their intake session, participants will be consented for the full study, complete a battery of questionnaires, receive their randomized audio recording and be trained on how to access and use the imagery audio file, and schedule their final feedback session.

Eligibility. Inclusion criteria include: over the age of 18, fluent in English, individuals who do not meet physical activity guidelines (HHS, 2008) (i.e., engage in physical activity less than 30 minutes/five days a week), possession of a cellular device for intervention delivery (via audio file), and the capacity to engage in physical activity (access to a gym, or safe walking or running path). Exclusion criteria include diagnosis of a medical condition that limits their ability to engage in at least 20 minutes of a physical activity a day.

Randomization. Randomization will be achieved using a random number generator that will generate a repeated randomized order of all four conditions, which will be set prior to the participant's intake session. Participants will be randomized at their intake session before they will be provided with training on using the guided imagery audio file. The randomization will be blind such that the participant will be unaware that there are multiple intervention conditions.

Procedures. First, interested participants will be emailed a brief online survey to determine eligibility. Once eligibility is determined, participants will be scheduled for their intake session that will take place in the Levens Emotion and Cognition Lab. At the intake session, participants will first provide informed consent and then complete a battery of questionnaires. Following the questionnaire, participants will be assigned their intervention condition by the research based on a predetermined repeated randomized order of all four conditions. Participants will be blinded to their condition. At the intake session, participants will be provided their audio file of the guided imagery. Participants will next be trained in intervention use and provided guidelines on how to implement the imagery given their respective condition. For instance, a participant in the control condition (episodic recent thinking) will be directed to think of something neutral while listening to the imagery, such that the training session at intake will ensure participants understand the meaning of neutral and do not think about emotionally evocative scenarios while listening to the imagery. Alternatively, those in the episodic future thinking and positive affect and reappraisal condition will be encouraged to consider specific goals related to physical activity and their health and how they might envision themselves as healthier and enjoying exercise. After the training session is complete participants will be shown how to access/log their mood and affect following use (see Figure 3 for measures). The audio file and post-imagery assessment questions will be accessible via an online survey link

sent to the participant's email that will also contain instructions and guidelines for using the imagery. In addition to being provided instructions and access to intervention components, participants will be scheduled for their follow-up session that will take place in the lab approximately two weeks after their intake session.

During the two-week intervention period, participants will be directed to listen to their guided imagery audio file before engaging in their chosen physical activity (e.g., during warm-up). Participants will be directed to do the following: listen to the imagery right before engaging in their physical activity (framed as a warm-up exercise), use headphones to listen to the imagery if in a public space, subsequent physical activity should last a minimum 20 minutes, and complete the post-intervention assessment following their physical activity. Participants will also be instructed to use the imagery at least twice but are encouraged to use it as many times as they would like. There are no restrictions placed on what activity participants can engage in, however, they will be provided examples (e.g., walking uphill on a treadmill for 30 minutes) in the instructions attached to the imagery audio file and asked to describe their activity in the post-intervention assessment. Given that the audio file will be accessible on their cell phones and this is not always ideal for completing questionnaires, participants will be directed to complete the post-intervention use questionnaire by the end of the day the day the imagery is listened to. After completing their physical activity, participants will access their post-intervention use questionnaire survey via a link that they are sent during the intake session. The post-intervention use questionnaire assesses details about the activity they chose to engage in and includes measures of physical activity related positive affect. The post-intervention questionnaire should take 2-3 minutes to complete.

After the two-week period, participants will return to the lab to complete a follow-up session that will include an online questionnaire with putative target assessments for temporal discounting and physical activity related positive affect, follow-up exploratory measures, and self-report questions eliciting feedback on the guided imagery. Following this, participants will be asked to provide consent to be audio recorded for a brief interview. The interview will be conducted by the researcher, take place in quiet room, and will last no longer than 15 minutes. The interview will be semi-structured and include predetermined, open-ended questions to elicit qualitative feedback data on their experience with the guided imagery intervention. The purpose of the interview is to provide greater context on acceptability of the intervention. Interviews will be transcribed, and a coding analysis process will occur to elucidate themes. After the interview is complete, participants will be debriefed and provided compensation of a $25 gift card or 3 hours of research credits for those enrolled in the UNCC Psychology participant pool system (SONA). Participants who use the guided imagery more than twice will receive an additional $10 as an incentive. Please see Appendix A for a flow chart of procedures for this phase of the study.

Measures

Demographics. As part of a larger battery of questions, participants will be asked to self-report their age, biological sex assigned at birth, gender identity, racial and ethnic identity, educational background, and household income.

Putative Target Assessment Measures

Satisfaction with Physical Activity. Satisfaction with physical activity will be measured with an eight-item scale that was developed for a previous study (Tsafou et al., 2015) that demonstrates excellent internal consistency ($\alpha = .90$). This scale extends previous one-item assessments of satisfaction (Baldwin et al., 2013; Finch et al., 2005) and assesses satisfaction

with the outcomes of physical activity and the engagement in (i.e., during) physical activity. The scale begins with the statement "When I am doing physical activity" followed by the items "I am satisfied with the results of/I am satisfied with/I enjoy/I feel good when I have done/I notice positive results if I have done physical activity," "Physical activity has many advantages," and "I find physical activity nice/difficult." Responses are selected on a 5-point Likert scale (1 = *Totally agree*) to (5 = *Totally disagree*) and summed, in which higher scores indicate greater levels of satisfaction with physical activity. This measure will be assessed at baseline, during intervention use, and follow-up.

Enjoyment with Physical Activity. Enjoyment with physical activity will be measured with the Physical Activity Enjoyment Scale- 8 item version (PACES; Mullen et al., 2011). On this scale, respondents are asked to rate 8 items that assess how they feel in the moment about their physical activity engagement (e.g., "It's very gratifying") using a 7-point Likert scale (1 = *Strongly disagree*, 7 = *Strongly agree*). This scale demonstrates excellent internal consistency (*a* = .93), convergent and divergent validity, and invariance across group and longitudinal samples (Mullen et al., 2011). This measure will be assessed at baseline, during intervention use, and follow-up.

Positive Affect. State positive affect will be measured with the Positive Affect and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). This scale assesses positive and negative affect using emotion words in which participants are asked to rate the extent to which they have felt the listen emotion in a specified time period (e.g., within the last hour). It consists of ten positive emotion words, attentive, interested, alert, excited, enthusiastic, inspired, proud, determined, strong and active, and ten negative emotion words, such as ashamed, nervous, and irritable. Respondents are asked to rate their emotions on a 5-point Likert

scale (1 = *Very slightly or not at all*, 5 = *Extremely*). The scores are generated by adding each category of responses so that there are separate scores for positive and negative affect. Scores will vary along the scale of 10 – 50, with lower scores indicating low (positive or negative) affect and higher scores indicating high (positive or negative) affect. Both positive and negative affect scales demonstrate strong internal consistency, ranging from alpha reliabilities of .86 to .90 for positive affect and from .84 to .87 for negative affect. This measure will be assessed at baseline, during intervention use, and follow-up.

Physical Activity Induced Emotions. In addition, positive affective judgements regarding physical activity will also be assessed using the Exercise-Induced Feeling Inventory (EFI; Gauvin & Rejeski, 1993). Participants will be asked to respond on a 5-point Likert scale (1 = *Do not feel*, 5 = *Feel very strongly*) to indicate the extent to which each word describes how they feel at this moment in time. This scale contains twelve words used to describe feelings one might encounter after engaging in a physical activity, which include refreshed, fatigued, calm, enthusiastic, relaxed, energetic, happy, tired, revived, peaceful, worn out, and upbeat. Each word is evidenced to load onto four factors that are described as separate subscales: revitalization, tranquility, positive engagement, and physical exhaustion. Each subscale is adding to create a total score for that category. Each scale in the EFI demonstrates good internal consistency (a = .72 - .91) and overall strong psychometric properties (Gauvin & Rejeski, 1993). This measure will be assessed during intervention use.

Temporal discounting. To target self-regulatory capacity, the minute monetary temporal discounting (TD) task (Bickel et al., 2017; Koffarnus & Bickel, 2014) will be administered. During the minute TD task participants answer five questions about their preference to receive specific monetary rewards over time (now versus later). Across consecutive trials, participants

are presented with a fixed set of choices between smaller, immediate rewards and larger, delayed rewards ($1000 in three weeks or $500 now) with the temporal distance being adjusted at each trial (now, 4 days, 1 week, 3 months, 2 years, etc.). The five questions are taken from a list of 64-item pairs with differential money and time options. The questions adjust based on the participants prior response to identify the participant's delay discounting rate. For example, the participant selects which option they would rather have "$500 now" or $1000 in 3 weeks". If the "$1000 in 3 weeks" is selected, the next question will feature the same monetary reward at a more distant time (i.e., $1000 in 1 year). Whereas if the "$500 now" option is selected, the next question will feature the $1000 reward at a more proximal time (i.e., "$500 now" or "$1000 in 1 day"). In this way the reward amount or time will be titrated to identify the rate (i.e., k-value) at which the participant discounts monetary rewards over time. The TD rate will be calculated for each participant and then compared across intervention condition as a between subject variable, and as a within subject repeated measure variable comparing the effect of the guided imagery. This measure will be assessed at baseline, during intervention use, and follow-up.

Intervention Feedback

Acceptability. To assess intervention acceptability, data will be collected at the intervention follow-up session via a semi-structured interview with the researcher as well as self-report questions included in the follow-up questionnaire. Self-report questions included in the follow-up questionnaire will assess similar themes described below and will complement the qualitative data collected via interviews. Prior to beginning the semi-structured interview, participants will first provide consent to be audio recorded and if the participant does not consent to be audio recorded, then the researcher will take detailed notes during the interview. The researcher will conduct a semi-structured interview to assess participants' overall experience

with the guided imagery, likelihood of using the guided imagery in their day to day life, likelihood of guided imagery precipitating behavioral change, expected magnitude of change from using the guided imagery for physical activity, as well as any suggested improvements. During the interview, participants will also be asked open-ended questions relating to putative targets, such as if the guided imagery increased their confidence in engaging in physical activity or if their attitude about physical activity has changed. Interviews will be audio recorded and transcribed and coded for relevant themes.

Feasibility. To assess intervention feasibility, data will be collected via self-report measures on frequency of use (i.e., number of times the participant plays the guided imagery), as well as type, duration, and intensity of the physical activity engaged in after listening to the guided imagery. Feasibility data will be collected through open-ended questions during the interview but will primarily be collected through an online survey that participants will be asked and reminded to complete within a reasonable time frame (no more than 24 hours) after listening to the imagery and completing a physical activity.

Exploratory Measures.

Physical Health. To assess for physical health concerns, a physical health checklist adopted from a previous study (Holman et al., 2008) will be employed. Participants will respond "yes" or "no" to a list of health conditions diagnosed by a health professional, included in three subscales: 1) cardiovascular-related (e.g., stroke, high blood pressure), 2) metabolic (e.g., metabolic syndrome, type 2 diabetes), and 3) other conditions (e.g., autoimmune disorders). Each subscale can be added (*yes* = 1, *no* = 1) to create a total score for each category of illness. Participants will also have an open-ended response option to include conditions not listed. This measure will be included in the baseline questionnaire (see Table 1).

Mental Health. Similarly, presence of mental illness will be assessed using a similar checklist adapted from Holman and colleagues (2008) longitudinal health study. Participants will respond "yes" or "no" to whether they have a current mental health condition diagnosis. Examples of listed mental health conditions include post-traumatic stress disorder, eating disorders (e.g., bulimia, anorexia, binge-eating disorder, etc.), post-traumatic stress disorder, and mood disorders (e.g., major depression, dysthymia, bipolar disorder, etc.). Each item can be added (*yes* = 1, *no* = 1), with higher scores representing more mental health concerns diagnosed by a heath professional. This measure will be included in the baseline questionnaire (see Table 1).

Physical Exercise Self-Efficacy. Perceived self-efficacy has been noted as a driving force for forming intentions to exercise and maintaining the practice over an extended period (McAuley, 1992). Health Action Process Approach (Schwarzer, 2001) based on social-cognitive theory (Bandura, 1997) suggests that self-efficacy is important at both phases of behavior change, behavioral intention and actual behavior. Correlated with physical exercise intention (r = .33) and physical activity behavior six months later (r = .39). To measure exercise self-efficacy, the Self Efficacy for Exercise Scale (Resnick & Jenkins, 2000), which is a 9-item questionnaire in which participants are prompted to respond to the following statement, "How confident are you that you could exercise if…" with a 10-point Likert scale (0 = *Not confident*, 10 = *Very confident*). Example items include "You felt pain when exercising" and "You were too busy with other activities." Total scores are calculated by summing each response, such that a higher score indicates higher self-efficacy for exercise. This scale demonstrates excellent internal consistency (a = .92). This measure will be assessed at baseline and follow-up (see Table 1).

Mindfulness in Physical Activity. Mindfulness in Physical Activity (MFPA; Tsafou et al., 2015) is a scale designed to measure state mindfulness during physical activity that demonstrates good internal consistency ($\alpha = .84$). The questionnaire begins with the statement "When I am doing physical activity" followed by six items. The items include "I am not distracted by thoughts and emotions," "I am aware of what I am doing," "I am focused on what I am doing," "I notice what I am doing right now," "I am fully absorbed in it," and "I am feeling OK with what I am doing." Responses are selected on a 5-point Likert scale (1 = *Totally disagree*) to (5 = *Totally agree*) and summed, in which higher scores represent greater levels of mindfulness during PA. This measure will be included in the baseline and follow-up session questionnaire (see Table 1).

Physical Activity Behavior. Physical activity behaviors will be measured via the 31-item International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) that asks about three levels of activity undertaken during leisure-time (walking, moderate, and vigorous). Physical activity expends energy; therefore, a metabolic equivalent (MET) is a commonly used unit for describing an individual's energy expenditure. Each level of activity is weighted by its energy requirements defined in METs to yield a score in MET-minutes. The number of MET-minutes per week is computed by multiplying the MET score of an activity level by the minutes performed and the number of days per week. The three activity levels will be summed, yielding a total physical activity score. Reliability and validity testing indicate that this measure has acceptable psychometric properties and is suitable for national population-based studies of physical activity participation (Brown, Trost, Bauman, Mummery, & Owen, 2004; Craig et al., 2003). Higher scores on this measure indicate greater levels of physical activity in MET-minutes per week. This measure will be included in the baseline questionnaire (see Table 1).

Stage of Physical Activity Behavioral Change. To assess stage of behavioral change, a previously validated measure (Romain et al., 2012) based on the Transtheoretical Model of Behavioral Change (Prochaska & Diclemente, 1983). This approach has been widely used in health behavior change research (e.g., Bridle et al., 2005). Accordingly, research demonstrates that the stage of behavioral change an individual is in when attempting to initiate, change, and maintain a behavior informs whom interventions are most effective for and how best to tailor interventions (e.g., Kim, 2008). Participants will be asked to respond to "yes" or "no" to the following questions which each represent a different stage of health behavior change, 1) "Do you currently engage in regular physical activity?," 2) "Do you intend to engage in regular physical activity in the next 6 months?," 3) "Do you intend to engage in regular physical activity in the next 30 days?" and 4) "Have you been regularly physically active for the past 6 months?". Regular physical activity is qualified as at least 30 minutes a day for 4 days of the week. Such that, if they answer "no" to questions 1 and 2, they will be classified as being in the precontemplation (i.e., individual does not intend to take action and could be unaware of the pros of changing their behavior), if they answer "no" to questions 1 and 3, but "yes" to question 2, they were considered to be in contemplation (i.e., individual is intending to start the behavior but may still be ambivalent toward changing their behavior). If they answered "no" to question 1, but "yes" to question 3, they will be classified as being in preparation (i.e., individual is ready to act and small steps towards behavioral change and likely believe in the positive outcomes of the behavior). If they answer "yes" to question 1, but "no" to question 4, they are considered to be in the action stage (i.e., individual has recently changed their behavior and will be more likely to consider ways to further modify their behavior) and if they answer "yes" to questions 1 and 4 then they are considered to be in the maintenance stage (i.e., individual has sustained a behavior

change and likely works to prevent relapse of negative health behaviors, like remaining sedentary). This measure will be included in the baseline and follow-up questionnaire (see Table 1).

Motives for Physical Activity. Motives for physical activity will be assessed via the Motives for Physical Activities Measure – Revised (MPAM; Frederick & Ryan, 1993). This is a 23-item scale in which participants respond to items corresponding to the following prompt "I exercise or engage in physical activity because…" on a 7-point Likert scale (1 = *Not at all true for me*; 7 = *Very true for me*). This measure includes five subscales that capture different motivations for physical exercise, which include items that assess exercise for purposes of enjoyment, competence, appearance, fitness, and social reasons. Corresponding items for each subscale will be averaged, in which higher scores for each subscale demonstrate higher levels of motivation to exercise for that domain. Each subscale of the MPAM has demonstrated good reliability (e.g., $\alpha \geq .87$; Frederick & Ryan, 1993; Ryan et al., 1997). This measure will be included in the baseline and follow-up questionnaire (see Table 1).

2.3 PLANNED DATA ANALYSIS

Because the primary goal of this proposal is to develop and test a novel guided imagery intervention for use in a future clinical trial, analysis will focus on feasibility, acceptability, and preliminary putative target comparisons across conditions.

Feasibility. The primary focus of feasibility data is to examine and describe if and how participants use the guided imagery. Feasibility data will be described through frequencies and percentages by each guided imagery condition. Data on number of times the participant plays the guided imagery, type, duration, and intensity of the physical activity engaged in after listening to

the guided imagery will be described for each condition and assessed for trending differences using a between-subjects ANOVA.

Acceptability. The primary focus of acceptability data is to examine and describe participant perceptions of the imagery and the likelihood of the intervention's usefulness for engaging sedentary individuals in the general public in more physical activity. Self-report acceptability questions completed during the follow-up session will be presented as descriptive statistics (i.e., mean, frequencies, percentage, and response range) and compared across intervention conditions using a between-subjects ANOVA to assess for mean differences in acceptability ratings. Semi-structured interviews conducted at the follow-up session will be recorded and transcribed verbatim using NVivo transcription software. First, each interview transcript will be read through in their entirety. Deductive coding will take place, such that categories of responses will be based on questions presented during the interview (e.g., likelihood of continued use). Initial themes for each category of feedback content will be established. After establishing the first round of initial coded themes, recurring themes will be identified, coded, and revised. Lastly, a final round of thematic coding will occur to establish the most salient and reoccurring themes that will be presented. Presentation of intervention feedback data will be centered around participants' overall experience with the guided imagery, likelihood of using the guided imagery in their day-to-day life, likelihood of guided imagery precipitating behavioral change, expected magnitude of change from using the guided imagery for physical activity, as well as any suggested improvements.

Putative Target Assessment. First, descriptive statistics will be calculated for putative target measures (i.e., temporal discounting, positive affect, physical activity induced feelings, satisfaction, and enjoyment) at each point of assessment (i.e., baseline, during use of the

intervention, and follow-up), including demographics and other self-report measures. Given the current proposed sample size for each intervention condition (n = 6), it is not likely that we will be able to detect or infer statistical significance, yet we hope through these preliminary analyses to detect preliminary "proof of concept" differences that could be conferred and expanded upon in a future clinical trial. Accordingly, a principal component analysis will first be conducted with related positive association measures, such as enjoyment and exercise induced emotions, to determine if variables are in fact independent or related in some way. Finally, we will conduct a between between-subjects ANOVA controlling for baseline measures for each putative target (regulatory and reward).

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CHAPTER 3: ADDITIONAL RESULTS

3.1 ADDITIONAL DEMOGRAPHIC DATA

Table 8.
Additional Participant Demographics.

Demographic Variable	Full Sample	EFT	Pos Affect	Combined	Control
	N = 31	*n = 8*	*n = 8*	*n = 8*	*n = 7*
Income					
≤ $24,999	9 (29%)	2	3	3	1
$25,000 – 75,000	10 (32%)	3	2	1	4
> $75,000	12 (39%)	3	3	4	2
Occupational Status					
Full time student	16 (51%)	5	5	4	2
Employed full-time	12 (38%)	3	1	4	4
Employed part-time	3 (9%)	--	2	--	1
Educational Status					
Some college	15 (48%)	3	4	4	4
College degree	6 (19%)	2	3	--	1
Grad/professional	10 (32%)	3	1	4	2
Mood/anxiety disorder	14 (45%)	4	4	2	3
High blood pressure	2 (6.5%)	1	--	1	1
Pre-diabetes	3 (9.7%)	2	1	--	--
Obesity	9 (29%)	3	2	2	3
Type 2 Diabetes	1 (3.2%)	--	--	--	1

Note. *N* = 31. Mood/anxiety disorder = participants self-reported ‘Yes’ or ‘No’ to a checklist of conditions that have been diagnosed by a medical professional; 5 of the 14 participants endorsed being diagnosed with both an anxiety and a mood disorder. Physical Health = participants self-reported ‘Yes’ or ‘No’ to a checklist of conditions that have been diagnosed by a medical professional.

3.2 POSITIVE AND NEGATIVE AFFECT

Table 9.
Positive and Negative Affect at Baseline and Follow-up.

	T1 - Baseline	T2 - Follow-up	
	M (SD)	M (SD)	Change Difference
Positive Affect			
Full sample	22.97 (4.24)	24.65 (5.60)	+1.68
Future thinking	23.50 (5.68)	25.25 (5.26)	+1.75
Positive affect	22.25 (3.65)	24.50 (6.85)	+2.25
Combined	24.50 (3.38)	25.00 (5.29)	+0.50
Control	21.43 (4.04)	23.71 (5.91)	+2.28
Negative Affect			
Full Sample	23.19 (3.75)	24.74 (5.48)	+1.55
Future thinking	24.13 (5.08)	26.63 (4.47)	+2.50
Positive affect	21.75 (2.96)	23.75 (5.34)	+2.00
Combined	23.63 (4.10)	26.13 (6.15)	- 0.50
Control	23.29 (2.43)	22.14 (5.73)	- 1.15

Note. N = 31. GI = Guided imagery. Future thinking (Episodic future thinking): *n* = 8, Positive affect (Positive affect and reappraisal): *n* = 8, Combined condition (Combined future thinking and positive affect and reappraisal): *n* = 8, Control condition: *n* = 7. Participants responded on a 5-pt Likert scale (1 = *Totally disagree*, 5 = *Totally agree*) to the 20-item PANAS measure to assess positive and negative affect. Responses were summed and scores could range from 10-50, with higher scores indicative of greater positive and negative affect in the past 2-weeks. Positive affect: Enthusiastic, Determined, Active, Inspired, Attentive, Alert, Proud, Strong, Excited, Interested. Negative affect: Jittery, Ashamed, Scared, Guilty, Hostile, Irritable, Nervous, Upset, Distressed, Afraid.

Conclusion

In all, participants experienced an increase in positive affect over the 2-week intervention period. Participants in the Positive affect and reappraisal condition experienced the greatest increase, which is appropriate given that is the primary target of that condition. The Combined condition experienced the least amount of increase in positive affect. This in line with the data that suggest the Combined condition also experienced a decrease in physical activity satisfaction

from baseline to follow-up. Data also suggest that participants experienced an increase in negative affect from baseline to follow-up as well, with the exception of the Combined and Control conditions that experienced a *decrease* in negative affect. Overall, results indicate that participants tended to experience an increase in affect across the board and that the Positive affect and reappraisal intervention content may have had a specific influence of increasing positive affect for participants assigned to this condition.

3.3 PHYSICAL ACTIVITY EMOTIONS DURING INTERVENTION USE

Table 10.
Physical Activity Induced Emotions During Intervention Use.

	Full Sample	EFT	Positive Affect	Combined	Control
Feedback	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)	*M* (SD)
Revitalization	6.40 (2.02)	6.49 (1.98)	5.87 (2.93)	6.67 (1.89)	6.59 (1.11)
Tranquility	5.76 (2.49)	6.03 (2.37)	6.52 (2.80)	4.74 (1.65)	5.75 (3.14)
Pos. engage	6.23 (2.24)	6.39 (2.11)	5.63 (2.99)	5.71 (2.11)	6.65 (.91)
Phys. exhaust.	5.44 (3.01)	5.84 (2.62)	5.95 (3.13)	4.63 (3.38)	5.34 (3.32)

Note. $N = 31$. GI = Guided imagery. PA = Physical activity. EFT (Episodic future thinking): $n = 8$, Positive affect (Positive affect and reappraisal): $n = 8$, Combined condition (combined future thinking and positive affect and reappraisal): $n = 8$, Control condition: $n = 7$. Pos. engage = Positive engagement. Phys. exhaust. = Physical exhaustion. The Exercise-Induced Feeling Inventory (EFI; Gauvin & Rejeski, 1993) was included to measure physical activity related affect experienced immediately following physical activity ("Please indicate the extent to which each word described how you felt in the moment right after engaging in physical activity."). The EFI consists of a 5-point response scale (1 = *Do not feel*; 5 = Feel very strongly) and four separate subscales, in which each subscale is summed, with scores ranging 3 – 12 (higher scores represent greater levels of that emotion category): Revitalization (refreshed, revived, energized), Tranquility (calm, relaxed, peaceful), Positive engagement (upbeat, enthusiastic, happy), and Physical exhaustion (worn-out, tired, fatigued).

Conclusion

Results suggest that participants on average tended to experience revitalization related emotions such as refreshed, revived, and energized following their physical activity, with the Combined condition experiencing the highest of all conditions (.16 higher than the sample average). Importantly, participants on average also experienced emotions suggestive of positive physical activity engagement, which is in line with outcome findings that stage of change increased from baseline to follow-up. Participants endorsed emotions related to physical exhaustion which may be an area to be targeted in future physical activity interventions.

3.4 MOTIVATIONS FOR PHYSICAL ACTIVITY

Table 11.
Motivations for Physical Activity at Baseline and Follow-up.

	T1 - Baseline	T2 - Follow-up	
Motivation	M (SD)	M (SD)	Change Difference
Enjoyment			
Full sample	30.26 (8.70)	34.30 (5.22)	+3.80
Future thinking	32.13 (9.11)	36.87 (4.61)	+4.74
Positive affect	26.63 (7.60)	32.25 (4.60)	+5.62
Combined	32.50 (9.37)	34.13 (6.94)	- 1.37
Control	29.71 (9.07)	33.86 (4.06)	+4.51
Social			
Full Sample	16.71 (6.70)	16.35 (7.27)	- 0.36
Future thinking	17.88 (3.98)	19.25 (8.51)	+1.37
Positive affect	18.50 (9.20)	16.13 (8.20)	- 2.37
Combined	14.13 (6.45)	14.25 (5.55)	+0.12
Control	16.29 (6.63)	15.71 (6.92)	- 0.58
Fitness			
Full Sample	29.84 (3.82)	29.00 (1.65)	- 0.84
Future thinking	29.38 (4.80)	29.75 (0.71)	-0.37
Positive affect	29.88 (3.94)	27.88 (2.10)	- 2.0
Combined	29.38 (4.78)	28.88 (2.03)	- 0.50
Control	30.17 (3.35)	29.57 (0.54)	- 0.60
Appearance			
Full Sample	31.74 (7.73)	30.29 (7.01)	- 1.45
Future thinking	33.88 (5.69)	34.50 (1.77)	+ 0.62
Positive affect	29.13 (11.98)	24.88 (10.48)	- 4.25
Combined	30.50 (5.48)	30.00 (5.07)	- 0.50
Control	33.70 (6.05)	32.00 (4.16)	- 1.70
Competence/Challenge			
Full sample	29.32 (8.81)	28.03 (6.91)	- 1.29
Future thinking	31.25 (9.25)	32.75 (3.78)	+ 1.50
Positive affect	29.12 (8.34)	25.88 (6.13)	- 3.24
Combined	30.13 (9.00)	28.38 (7.40)	- 1.75
Control	26.43 (9.83)	24.71 (8.10)	- 1.72

Note. N = 31. GI = Guided imagery. Future thinking (Episodic future thinking): n = 8, Positive affect (Positive affect and reappraisal): n = 8, Combined condition (Combined future thinking and positive affect and reappraisal): n = 8, Control condition: n = 7. Participants responded on a 5-pt Likert scale (1 = *Totally disagree*, 5 = *Totally agree*) to the Motives for Physical Activity Measure (MPAM) is a 30-item questionnaire with a 7-point Likert scale (1 = *Not at all true for me*, 7 = *Very true for me*) that assesses different categories of motivations for physical activity (Frederick & Ryan, 1993). The five motives are: (1) Fitness (Score range: 5-35), which refers to being physically active out of the desire to be physically healthy and to be strong and energetic; (2) Appearance (Score range: 6-42), which refers to being physically active in order to become more physically attractive, to have defined muscles, to look better, and to achieve or maintain a desired weight; (3) Competence/Challenge (Score range: 7-49), which refers to being physically active because of the desire just to improve at an activity, to meet a challenge, and to acquire new skills; (4) Social (Score range: 5-35), which refers to being physically active in order to be with friends and meet new people; and (5) Enjoyment (Score range: 7-49), which refers to being physically active just because it is fun, makes you happy, and is interesting, stimulating, and enjoyable. Responses for each subscale are summed.

Conclusion

This table presents participants' physical activity motivations at baseline and follow-up assessment periods. This variable was exploratory for this study and yielded interesting results. Importantly, participants tended to experience an increase in motivations from baseline to follow-up for physical activity due to enjoyment related reasons, with the greatest increase for the Positive affect and reappraisal condition participants and a decrease in these motivations for the combined participant group (note high standard deviations at baseline and follow-up). This finding is in line with other results that indicate varied positive and negative feedback and results for the Combined condition. At baseline, participants on average had mostly appearance related physical activity motivations which decreased at follow-up for all conditions except for participants in the Episodic future thinking condition. Results also indicate that participants tended to experience a decrease in fitness and competence/challenge related motivations, whereas findings regarding social motivations for physical activity remain mixed. In sum, the guided imagery may have a potentially strong influence on increasing enjoyment related

motivations for physical activity and perhaps decreasing appearance related motivations which may be less sustainable and less beneficial for mental health and sustaining behavior change.

APPENDIX A: CONCLUSIONS AND FUTURE DIRECTIONS

The primary goal of this study was to develop a physical activity intervention that integrates components associated with health behavior change: mindfulness, guided mental imagery, and reward (positive affect and reappraisal) and regulatory (episodic future thinking) constructs. This study is the first to test a newly developed, integrated, remote delivery physical activity intervention in a pilot sample of 31 physically underactive participants from the Charlotte community. This is a first step in what is meant to be a larger, iterative, and ongoing process to test a reward and regulatory, mindfulness-informed guided imagery approach to health behavior change. Importantly, the present study aimed to address suggestions from the Science of Behavior Change working group (Nielsen et al., 2018) that intervention designs should target underlying mechanisms involved in health behavior change. To test the feasibility and acceptability of this intervention we collected data on intervention use and adherence, sample-wide changes in outcome variables, and participant feedback data via self-report and a semi-structured interview.

Our intervention use data found that participants across all four conditions listened to the guided imagery audio file before physical activity an average of 5.35 time, which was about 2.5 times more than the minimum requirement of 3 uses. Given that this is a sample of underactive adults, these findings suggest that this integrative intervention may help individuals reach physical activity guidelines (150 minutes of moderate physical activity each week), and that it may be accessible enough to be beneficial for a range of individuals. Specifically, participants on average rated the guided imagery as acceptable, pleasant to listen to, easy to use and access, and that they were satisfied with the guided imagery. Participants' self-report data from baseline to follow-up also demonstrated a sample-wide increase in physical activity stage of change

(average increase of 0.6, contemplation to preparation stage), positive affect, mindfulness during physical activity, satisfaction with physical activity (apart from the Combined condition), and physical activity self-efficacy.

Overall, results suggest that mindfulness-informed guided imagery targeting positive affect and reappraisal and episodic future thinking may be effective for not only improving the experience of physical activity, and thus helping to bridge the intention-behavior gap (Sheeran & Webb, 2016), but also for increasing the frequency and intensity of physical activity in underactive adults. Interestingly, this intervention was delivered during the COVID-19 pandemic, which may have conferred a unique intervention testing context. It is possible that future studies testing this intervention may yield different findings outside the context of a global health pandemic.

Further, many individuals are chronically physically underactive physically, which can have detrimental effects on a range of health conditions. There remains a strong need to develop health behavior change interventions that target underlying mechanisms, such as positive affect and reappraisal, to increase an intervention's ability to target theory constructs such as self-efficacy, attitudes, and stages of change. One overarching goal of this study is to continue to refine and build on present findings to improve the existing guided imagery content and test this intervention with a larger sample. Building on this present study, one promising future direction is to explore *for whom* the intervention works best for and determine strategies for increasing its acceptability within the general population. This intervention is scalable and therefore has the potential to reach individuals in many contexts to increase population physical activity levels. The intervention could be easily accessed online, via auditory streaming platforms or mobile applications; It could stand alone, or function as an ancillary intervention that is combined with

other healthcare and/or clinical treatments. For example, the present intervention has potential to be remotely delivered (via audio file with instructions) to a larger, more diverse sample of underactive adults in both rural and urban settings. Increasing the reach and improving the inclusivity of health behavior interventions is important for meeting physical activity and health goals—the present intervention has the capacity for these critical growth areas and applications.

With multiple mechanistic combinations, future research with a larger sample size could identify individual preferences in accessibility and feasibility for some intervention combinations over others (e.g., positive affect and reappraisal only vs. a combined version that includes episodic future thinking), supporting personalized medicine approaches to increasing physical activity. Feedback data from specialized populations could also be collected to facilitate physical activity in groups with unique barriers. For instance, although the general population consists of a large proportion of underactive adults, there are also specialized populations that could benefit from creative approaches to maintaining or increasing physical activity, such as individuals living with chronic illnesses, chronic pain and/or physical limitations, and individuals living with mental health conditions that make it difficult to engage in regular physical activity (e.g., Depression).

A future study could also test how to improve the personalization of the guided imagery approach. For instance, research regarding the success of tailorable, online-based health behavior change interventions suggests the importance of maintaining flexibility and identifying methods for individualizing approaches (Gonot-Schoupinsky & Garip, 2019; Lustria et al., 2013). Additionally, given that self-determination theory (Deci & Ryan, 2012; Sheeran et al., 2020) implicated in health behavior change literature emphasizes the role of autonomy in sustaining health behavior change, it is important to identify ways to emphasize the individual's role and

choice in their health behavior engagement. Such that participants could choose which audio recording best fits their motivational needs for the day, or route could be identified for personalization of the recordings. Finally, research could explore how the integrative approach and intervention content used in the present study could be expanded to other health behaviors, such as sleep and nutrition. In sum, the present study yielded exciting initial findings and acceptability of a novel approach to increasing physical activity, with multiple potential future directions. As we refine and test our integrative intervention in a larger sample, we will identify next steps that advance our overarching goal of developing a scalable and accessible intervention that targets reward and regulatory mechanisms to support physical activity engagement in a broad range of individuals and groups.

APPENDIX B: GUIDED IMAGERY SCRIPTS

1. Episodic Future Thinking Condition

Beginning

Begin by getting into a comfortable position

First, take a deep breath in and… exhale fully … continue breathing deeply, releasing any tension in your body as you exhale…. Next, take a slow breath and focus on how your body feels as you breathe…

notice the natural rhythm of your breath, and continue breathing evenly in this way…. (transition)

Prompt Future thinking/Future self

Now, take a moment to create a picture in your mind of a future ideal version of yourself—a future version of yourself who is healthy, strong and embodies what you strive for... Take a moment to think about this future version of yourself that is healthier and fulfilled.

Cue convo w/ experimenter and begin thinking of journey to future, ideal self

Now, as you picture this ideal version of yourself… imagine the journey you take toward your future self… imagine that on this journey you are being physically active…moving your body…accomplishing goals, and becoming stronger, more focused, and healthier…

Future goal thinking

Now, take a moment to think about the physical activity goals you are striving for.

Select a physical activity to do today and imagine yourself doing this physical activity.

Think about how the steps you take today are getting you closer to accomplishing your goals. Today is a part of this journey to becoming this future, ideal version of yourself. Attach no evaluations to your journey…it is your own.

Now, 6 months have passed on your journey. Imagine that you have accomplished one of your physical activity goals.

Where might you be? .. … How do you feel? …Picture who might be around you...

…Perhaps you are doing activities now that you could not before… perhaps these activities take less effort now that you are more active

try to stay with this image of your future self in 6 months … Hold it in your mind.

It's ok if your mind wanders just return to this vision of yourself, as you carry it with you to today…. *(transition)*

Ending

Now…bring your attention back to the present. Awaken your muscles so you can continue on your journey and ready them for activity…

2. Positive Affect and Reappraisal Condition.
Beginning

Begin by getting into a comfortable position

First, take a deep breath in and… exhale fully … continue breathing deeply, releasing any tension in your body as you exhale…. Next, take a slow breath and focus on how your body feels as you breathe…

notice the natural rhythm of your breath, and continue breathing evenly in this way…. (transition)

Cues convo w/ experimenter and positive thinking of PA

Now, Create a picture in your mind of a healthy body that is radiating positivity. This body has strong muscles and a vital heartbeat. It feels energized and positive.

Now, imagine yourself being physically active and building energy within your body. Select a physical activity to do today and imagine yourself doing this physical activity. Think of how doing this physical activity will expand your physical capabilities. Think about the positive benefits of this activity for you… how it might enable you to do more than you could before, and make your daily life feel more enjoyable…

Build on this and take a moment to imagine yourself doing this activity as vividly as you can… imagine your body moving…

Reframe physical aspects as challenge

What sensations are you feeling as your body moves? Is your heart beating faster, harder?…Do you feel your muscles contracting?…. as your effort increases, your breathing and physical sensations may intensify. Your body might feel warm…you might feel fatigued…you may want to label this experience as bad, or uncomfortable—recognize that this is an arbitrary label.

…Rather, the increase in sensations can be a good thing… your body is responding to the challenge you are giving it and becoming stronger, healthier, energized…

Attach no evaluations to your physical activity journey. Through your effort you are increasing your strength and physical capabilities, making the next time you exercise easier, and more familiar….

Satisfaction from finishing PA

Now, imagine that you've finished your activity and you feel satisfied, accomplished, confident, and energized… let this feeling build …. breathe in this feeling, and exhale any fears and hesitations you have…

(transition) Stay and experience this satisfaction for a few more moments. Carry this feeling and vision with you and use it to motivate you today.

Ending

Now…bring your attention back to the present. Awaken your muscles so you can continue on your journey and ready them for activity…

3. Episodic Future Thinking and Positive Affect and Reappraisal (Combined) Condition. ***Beginning***

Begin by getting into a comfortable position

First, take a deep breath in and… exhale fully … continue breathing deeply, releasing any tension in your body as you exhale…. Next, take a slow breath and focus on how your body feels as you breathe…

notice the natural rhythm of your breath, and continue breathing evenly in this way…. (transition)

Prompt Future thinking/Future self

Now, take a moment to create a picture in your mind of a future ideal version of yourself—a future version of yourself who is healthy, strong and embodies what you strive for... picture in your mind a healthy body that is radiating positivity. This body has strong muscles and a vital heartbeat. It feels energized and positive.

Take a moment to think about this future version of yourself that is healthier and fulfilled.

Cue convo w/ experimenter and begin thinking of journey to future, ideal self and bring in positive affect and reappraisal

Now, as you picture this ideal version of yourself… imagine the journey you take toward your future self… imagine that on this journey you are being physically active…moving your body…accomplishing goals, and becoming stronger, more focused, and healthier…

Imagine yourself being physically active and building energy within your body. Select a physical activity to do today and imagine yourself doing this physical activity. Think of how doing this physical activity will expand your physical capabilities. Think about the positive benefits of this activity for you… how it might enable you to do more than you could before, and make your daily life feel more enjoyable…

Build on this and take a moment to imagine yourself doing this activity as vividly as you can… imagine your body moving…

What sensations are you feeling as your body moves? Is your heart beating faster, harder?…Do you feel your muscles contracting?…. as your effort increases, your breathing and physical sensations may intensify. Your body might feel warm…you might feel fatigued…you may want to label this experience as bad, or uncomfortable—recognize that this is an arbitrary label.

…Rather, the increase in sensations can be a good thing… your body is responding to the challenge you are giving it and becoming stronger, healthier, energized…

Attach no evaluations to your physical activity journey. Through your effort you are increasing your strength and physical capabilities, making the next time you exercise easier, and more familiar….

Future goal thinking

Now, take a moment to think about the physical activity goals you are striving for.

Think about how the steps you take today are getting you closer to accomplishing your goals. Imagine that you've finished your activity and you feel satisfied, accomplished, confident, and energized… let this feeling build …. breathe in this feeling, and exhale any fears and hesitations you have… …Today is a part of this journey to becoming this future, ideal version of yourself.

Now, 6 months have passed on your journey. Imagine that you have accomplished one of your physical activity goals.

Where might you be? .. … How do you feel? …Picture who might be around you...

…Perhaps you are doing activities now that you could not before… perhaps these activities take less effort now that you are more active. Stay and experience this satisfaction for a few more moments.

try to stay with this image of your future self in 6 months … Hold it in your mind. Carry this feeling and vision with you and use it to motivate you today.

It's ok if your mind wanders just return to this vision of yourself, as you carry it with you to today…. *(transition)*

Ending

Now…bring your attention back to the present. Awaken your muscles so you can continue on your journey and ready them for activity…

4. Episodic Recent Thinking Control Condition.

Beginning

Begin by getting into a comfortable position

First, take a deep breath in and exhale fully … continue breathing, releasing any tension in your body as you exhale…. Next, take a slow breath and focus on how your body feels as you breathe…

notice the natural rhythm of your breath, and continue breathing evenly in this way … (transition)

Recall of recent event (cues convo w/ experimenter)

Now, gently direct your focus to a moment that you remember from last week… imagine a moment where you were doing a simple activity, an activity that you do every day and that does not require much effort ……. think about the routine activity you selected. What activity are you doing?

Recognize how this simple activity is a part of your day and the purpose it has.

Imagine event….

Once you have this activity in mind… hold on to whatever image you have of the moment…imagine that you are replaying this memory of this activity in your mind from start to finish……

imagine the details as vividly as you can…

what are you doing? …..what is around you?..... how does your body feel?..... What position is your body in?…. what movements are you making?

if your mind wanders, it's ok…just gently bring your focus back to the memory… perhaps the sense of simplicity of this activity brings a sense of normalcy, or predictability…

inhale and hold briefly with the image of the activity in your mind… exhale and bring your focus back to your body… follow the breath in your body and bring awareness to the moment, to what's around you

Ending

Now…bring your attention back to the present. Awaken your muscles so you can continue on

your journey and ready them for activity…