

Methodological overview of a self-determination theory-based computerized intervention to promote leisure-time physical activity[☆]

Heather Patrick^{a,b,*}, Amy Canevello^c

^a Department of Medicine, University of Rochester, Rochester, NY, USA

^b Department of Clinical & Social Psychology, University of Rochester, Rochester, NY, USA

^c Institute for Social Research, University of Michigan, Ann Arbor, MI, USA

ARTICLE INFO

Article history:

Received 10 February 2009

Received in revised form

24 March 2010

Accepted 17 April 2010

Available online 24 April 2010

Keywords:

Computerized intervention

Self-determination theory

Autonomy support

Personal trainers

Physical activity

ABSTRACT

Objectives: To provide a methodological overview of a computerized intervention to promote leisure-time physical activity (PA) and to apply self-determination theory (SDT) to PA initiation to better understand the psychological mechanisms underlying PA frequency, intensity, and duration in previously-sedentary individuals.

Design: Based on SDT, two computerized personal trainers were developed for use with sedentary young adults. One personal trainer was designed to be need-supportive, empathic, and structured while the other was designed to be more controlling, evaluative, and judgmental.

Method: Participants are randomly assigned to work with either the need-supportive or controlling computerized personal trainer. They complete a series of 7 weekly training sessions. In between training sessions, participants complete daily records of PA behaviors and experiences including autonomous self-regulation and perceived competence for PA and PA frequency, intensity, and duration.

Potential contributions: The design of this intervention and its theoretical basis have important implications for advancing the field of exercise science specifically and health behavior change more broadly. Computerized interventions have the benefit of standardizing intervention content as well as reducing clinical contact burden for practitioners. Daily recording procedures reduce the likelihood of retrospective bias and allow for the modeling of (1) daily fluctuations in PA behavior and (2) the psychological mechanisms believed to be involved in PA behavior (e.g., autonomous self-regulation). Finally, as a broad theory of human motivation, SDT is uniquely positioned to offer explanations for the conditions that are likely to promote both the initiation and maintenance of health behavior change.

Published by Elsevier Ltd.

Introduction

Getting people to adhere to an exercise regimen proves a significant challenge to health-care professionals. Research suggests that intensive and repeated counseling, whether from physicians or fitness experts such as personal trainers, can help individuals to become more physically active (Chakravarthy, Joyner, & Booth, 2002). However, research also indicates that individuals rarely adhere to health recommendations, and health behavior change (and maintenance) seem to be particularly

challenged by this failure in follow-through. Having individuals who are more motivated to behave in ways that improve their health and quality of life would be beneficial. An abundance of research on physical activity (PA) suggests that when people are more autonomously motivated to exercise, they are more likely to do so (e.g., Dishman, Sallis, & Orenstein, 1985; Ingledew, Markland, & Medley, 1998). In addition to the challenge of motivating individuals to adhere to health behavior recommendations, practitioners and health systems face increasing demands on time and financial resources. Developing interventions using technology (e.g., computerized practitioners, interactive websites) may be one means by which the clinical contact demands of these intensive interventions can be alleviated, thus improving reach to the broad population at-risk due to physical inactivity and sedentary lifestyle. Here we provide some background on theories of motivation for physical activity, self-determination theory as a particular theory of motivation relevant to health behavior in general and physical activity in particular, and the utility of

[☆] This research was supported by R21 CA 109961 from the National Cancer Institute to the first author while she was at Baylor College of Medicine and, subsequently the University of Rochester.

* Corresponding author at: National Cancer Institute, DCCPS/BRP/HPRB, 6130 Executive Blvd, EPN Room 4076 MSC 7335, Rockville, MD 20852-7335, USA. Tel.: +1 301 435 4589; fax: +1 301 480 2087.

E-mail address: patrickha@mail.nih.gov (H. Patrick).

computerized interventions. We then describe a computerized intervention to promote PA based on self-determination theory.

Theories on motivation for physical activity

Motivation for sports and exercise has been a central area of interest to sport and exercise psychologists and researchers. Historically, motivation for sports has focused on achievement motivation (Atkinson, 1974; Harter, 1978, 1981; McClelland, 1961; Wong & Bridges, 1995), although attention has shifted to participation motivation (Duda, Chi, Newton, Walling, & Catley, 1995; George & Feltz, 1995; Gill, Gross, & Huddleston, 1983; Gould, Feltz, & Weiss, 1985; Kerr, 1997; Roberts & Treasure, 1995). Competitive motivation for physical activity declines as people move from childhood and adolescence into young adulthood, making participation motivation particularly critical during this developmental period (Laakso & Telama, 1981; Telama & Silvennoinen, 1979). In general, physical activity in young adults is low (Leslie, Fotheringham, Owen, & Bauman, 2001; Pinto, Cherico, Szymanski, & Marcus, 1998; Pinto & Marcus, 1995; Woods, Mutrie, & Scott, 1999) and behaviors established in young adulthood lay the foundation for behaviors later in life (Leslie et al., 2001). Thus, developing interventions to increase participation motivation in young adults is essential for increasing physical activity in young adulthood and throughout later life.

Throughout the 1990s research on participation motivation for sports and exercise was guided by three theoretical perspectives: self-efficacy or social cognitive theory, goals theory, and the transtheoretical model. The strength of these theoretical perspectives is that they address important cognitive aspects related to behavior change such as perceptions of competence and perceived readiness for change. However, they do not consider individuals' interest in or desire to perform the behavior or how characteristics of the social environment can facilitate optimal motivation and support perceived competence for recreational physical activity.

Self-determination theory

Self-determination theory (SDT) provides a comprehensive theoretical framework through which to understand motivated behavior by addressing needs for autonomy and relatedness as well as the need for competence (Deci & Ryan, 1985, 2000). Simply feeling competent is not sufficient to promote optimal motivation (Markland, 1999; Markland & Hardy, 1997). The basic premise of SDT is that human behavior is directed by the primary psychological needs for autonomy, competence, and relatedness (Deci & Ryan, 1985, 1991, 2000, 2002). Autonomy reflects the need to engage in behaviors with a sense of choice or personal endorsement. Competence represents the need to feel optimally challenged and capable of achieving goals and desired outcomes. Relatedness reflects the degree to which an individual feels connected to and understood by others. According to SDT, to the extent that these three needs are met, individuals experience greater autonomous motivation, persistence, and quality of efforts in any given domain.

SDT also focuses on the distinction between autonomous and controlled regulation of behaviors, which reflects the degree to which behaviors are volitional and choiceful, resulting from interest in the behavior relative to behaviors that are the result of pressure and coercion, demand or seduction. This distinction between autonomous and controlled self-regulation of behaviors represents a continuum rather than a dichotomy (Ryan & Connell, 1989). SDT suggests that the social context, in part, determines whether behaviors are regulated in relatively autonomous or controlled ways. When the social context supports individuals' needs for competence, autonomy, and relatedness, they are more

likely to autonomously self-regulate behaviors, and thus more likely to engage in prescribed behavior change.

Need-supportive versus controlling contexts

The concept of need support represents an interpersonal climate in which one (e.g., personal trainer) takes another's (e.g., client's) perspective into consideration, provides relevant information and opportunities for choice, and encourages the individual to accept personal responsibility (e.g., for health behaviors). Need support also includes interactions that involve asking the individual what he or she wants to achieve, encouraging questions, providing meaningful and satisfactory answers to questions, and refraining from judgment or evaluation when obtaining information about past behavior. Thus, need support involves minimal pressure, judgment, and control (Reeve, 1998; Ryan, 1993; Williams, 2002). In contrast, a controlling interpersonal climate involves the use of external (e.g., rewards, punishments, threats or evaluations) and/or internal contingencies (e.g., guilt induction, approval withdrawal) to pressure people into activity (Vansteenkiste, Simons, Lens, Soenens, & Matos, L, 2005). Research has indicated that traditionally, this more controlling style is the approach many practitioners have taken with their patients and clients (Beckman & Frankel, 1984; Kaplan, Greenfield, & Ware, 1989; Marvel, Epstein, Flowers, & Beckman, 1999).

There are three elements crucial to need-supportive contexts: providing a meaningful rationale for the prescribed behavior; acknowledging feelings and perspectives; and emphasizing choice and minimizing control. Results of an experiment in which these elements were manipulated to be relatively need-supportive or controlling demonstrated that, collectively, these facilitating factors were associated with greater internalization and autonomous self-regulation (i.e., integration) for the prescribed behavior (Deci, Eghrari, Patrick, & Leone, 1994). Although this study was not conducted in a personal training setting, it suggests that the contexts in which behaviors are prescribed has an important effect on the extent to which behaviors are internalized. In the domain of sports and exercise, personal trainers are in the unique position to facilitate autonomous motivation for PA by providing contexts that support basic psychological needs, thus enhancing the likelihood of PA engagement, persistence, and enjoyment.

Self-determination and health

SDT has been applied to a variety of health behaviors, including attendance in an alcohol treatment program (Ryan, Plant, & O'Malley, 1995), participation in a weight loss program (Williams, Grow, Freedman, Ryan, & Deci, 1996), adherence to medication prescriptions (Williams, Rodin, Ryan, Grolnick, & Deci, 1998), blood-sugar monitoring (Williams, Freedman, & Deci, 1998), and smoking cessation (Williams, Cox, Kouides, & Deci, 1999; Williams & Deci, 2001; Williams, Gagné, Ryan, & Deci, 2002). Together, findings from these studies suggested that the more autonomously motivated for behavior change participants were, the more successfully they implemented changes recommended by health-care practitioners. These studies also demonstrated the importance of the context in which health information is disseminated from practitioner to patient. When practitioners were need-supportive, patients became more autonomously motivated and felt more competent which, in turn, predicted healthy behavior patterns.

In a related line of research examining the role of other practitioners in motivational processes, SDT research has also focused on the importance of need support from coaches in facilitating autonomous motivation for sports. Undergraduate students in a gymnastics course evidenced more intrinsic interest and greater intentions to persist when they perceived more need support in class (Goudas, Biddle, & Underwood, 1995). Additionally, when coaches were more need-supportive, competitive swimmers

experienced greater autonomous motivation for swimming and were more likely to persist in the sport (Pelletier, Fortier, Vallerand, & Briere, 2001). In a study of competitive gymnasts, parents' and coaches' need support predicted more autonomous motivation for gymnastics (Gagne, Ryan, & Bargmann, 2003). Additionally, gymnasts experienced greater increased positive affect, vitality, and self-esteem after practice as a function of perceiving their coach as need-supportive during practice. Together, these findings suggest the important role that coaches play in facilitating autonomous motivation for sports. Although these findings focused on the role of coaches' need support in athletes' motivation for sports, a similar process may function with personal trainers' need support and clients' autonomous motivation for leisure-time physical activity.

Self-determination and physical activity

A growing body of research links self-determination to PA adherence. Interest and enjoyment (characteristics of autonomous motivation and self-regulation) as well as competence motives positively predicted number of hours per week spent exercising (Frederick, 1991; Frederick & Ryan, 1993). Other research shows that those who have more autonomous reasons for exercising are more ready to initiate PA and report more positive PA experiences (Mullan & Markland, 1997). Recently, attention has focused on developing interventions based on SDT to promote leisure-time physical activity. Indeed, Edmunds, Ntoumanis, and Duda (2008) tested an SDT-based intervention and found that individuals who experienced greater need support for PA evidenced greater autonomous self-regulation for PA and better attendance in a PA intervention program. Fortier and colleagues (Fortier, Sweet, O'Sullivan, & Williams, 2007) tested an SDT-based intervention to promote leisure-time physical activity through primary care. Participants who worked with an SDT-trained PA counselor evidenced greater perceived need support from practitioners and greater autonomous self-regulation for PA. Importantly, these individuals also evidenced higher levels of PA post-intervention.

Computerized interventions

Although still in its infancy, the past decade has seen an increase in the development of eHealth interventions – interventions that use computer-based programs, web interfaces, personal digital assistants, and, more recently, mobile-phones, to deliver intervention content or to supplement face-to-face intervention interactions (Atkinson & Gold, 2002; Brug, Oenema, & Campbell, 2003; Kroeze, Werkman, & Brug, 2006). The emergence of these technology-based interventions has been, in part, a response to increasing demands on health-care providers and a need to reach broader at-risk populations who may not otherwise engage health professionals, including personal trainers and physical activity counselors. Further, computerized interventions offer several advantages including providing individually-tailored feedback and health information, easier and faster access to information (particularly when these technologies are web- or mobile-phone-compatible), and a degree of anonymity for users who may be hesitant to discuss sensitive health information in face-to-face encounters (Atkinson & Gold, 2002; McKenna & Bargh, 2000; Winzelberg, 1997).

A recent systematic review identified 49 publications (13 PA, 16 dietary behaviors, and 20 weight loss or both PA and diet) published between 2000 and 2005 that included an intervention in which participants interacted with some technology as either the main intervention or some component of the intervention (Norman et al., 2007). Slightly more than half of those studies demonstrated that technology-based interventions were more effective than

a comparison group, slightly less than half indicated no difference between technology-based interventions and a comparison group, and a small number of publications (4) indicated that the comparison group out-performed the technology-based intervention. Although somewhat mixed, this systematic review of some of the earliest technology-based interventions for physical activity, diet, and/or weight loss suggests that in many cases, technology-based interventions perform as well as traditional interventions. Their satisfactory efficacy combined with their potential for reach may result in eHealth interventions having substantial public health impact. Norman et al. (2007) also called on researchers to further the development of eHealth interventions by designing studies that allow for tests of whether these technology-based interventions work through hypothesized theoretical constructs. Thus, more research is needed to develop eHealth interventions that are strongly grounded in theory and can test theoretical mechanisms of behavior change.

Overview and hypotheses

The purpose of this study is to test a self-determination theory-based, computerized intervention to increase leisure-time physical activity among young adults. Based on previous research on the importance of doctors' and coaches' need-supportive interaction style in promoting patients' health behaviors and students' motivation for sports, we hypothesize that participants working with a need-supportive computerized personal trainer will experience greater need support from their trainer compared to those working with a controlling computerized personal trainer (H1). Greater need support will, in turn, predict greater autonomous motivation and perceived competence for PA (H2), which will predict PA behavior including greater PA intentions, frequency, maintenance, and enjoyment (H3). The model derived from these hypotheses is presented in Fig. 1.

The research project

Overview

Participants are between 18 and 30 years and are able to be physically active at recommended levels (at the time of recruitment, US recommendations were 30 min of moderate-to-vigorous activity 3 or more days per week; American College of Sports Medicine, 1995). They are also fairly sedentary in that they engage in leisure-time PA less often than twice a week and have not engaged in leisure-time PA regularly more than twice a week at any point in the past year; most participants did not engage in leisure-time PA at all upon study enrollment. Participants of all ethnicities and both genders are encouraged to participate. To facilitate recruitment of a diverse sample, participants are recruited from one of the most ethnically diverse major research universities in the United States of America with 40.5% Euro-American, 18.3% Asian/Pacific Islander, 17.7% Hispanic, 13.3% African-American, and 7.5% International. The benefit of using an ethnically diverse sample is that it will allow us to test and develop an intervention that is appropriate for a wide range of racial/ethnic groups. At the initial lab session, project staff will address study-related questions and obtain consent.

The intervention

Participants complete an initial lab session, 6 weekly follow-up sessions, and 6 weeks of daily leisure-time PA records. The initial lab session includes a baseline questionnaire to screen eligible participants and to assess leisure-time PA history, motivation and

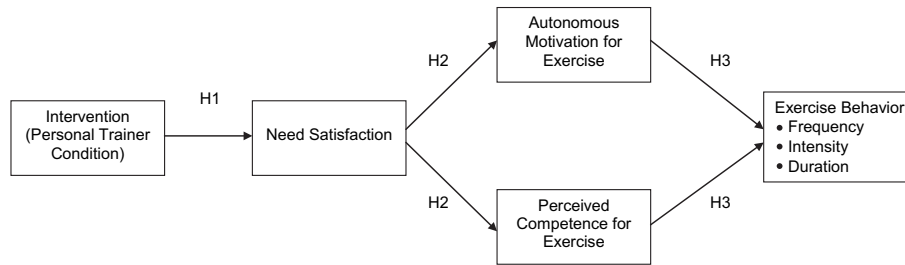


Fig. 1. Hypothesized model for an SDT-based PA intervention.

perceived competence for PA. During the initial lab session participants are randomly assigned to work with either the need-supportive or controlling computerized personal trainer and complete a first session with their trainer which includes computerized interactions about the participants' previous leisure-time PA experiences and current PA goals.

Weekly lab sessions

Weekly lab sessions involve completing questions about the past week's leisure-time PA behaviors, motivation and perceived competence for PA using well-validated, psychometrically-sound instruments; "meeting" with a personal trainer (via computer); and completing measures about their perceptions of their personal trainers' need-supportiveness following each training session. The computerized trainer is designed to be interactive and tailored such that the trainer asks specific questions (e.g., "To what extent do you feel you met your PA goals this past week?"); participants provide a response (e.g., using a Likert-type scale), and the computerized trainer responds based on the participant's answer. For example, if the participant provides an answer indicating they feel that they did not meet their PA goals (i.e., ≤ 3 on a 7-point scale), the computerized trainer then asks the participant to identify what barriers the participant feels got in the way of achieving their goals. Participants select from a list of possible barriers those that most closely reflect their experience in the previous week, including an option for "other" with a prompt to specify other barriers the participant dealt with. The intervention also includes voiceover in the scripting to convey a more personal interaction while maintaining the integrity of the intervention. Participants are randomly assigned to receive information and recommendations about PA from their computerized personal trainer in either a need-supportive or controlling manner. Statements from and interactions with the computer-based personal trainer manipulate all three aspects of need support: choice (e.g., "choose whichever one works better for you" versus "do this"); acknowledgement of feelings (e.g., "some people feel intimidated and those feelings are normal" versus "some people feel intimidated, but that's not useful"); and minimal evaluations or judgments (providing recommendations versus telling participants what they should do; Deci et al., 1994). So, in the example above in which participants select barriers that interfered with their being able to reach their PA goals for the week, the computerized trainer responds to the barriers that the participant identified in either a need-supportive or controlling way. Responses are pre-programmed to be specific to participant responses (e.g., if the participant indicates that there wasn't enough time to exercise, the computerized trainer responds to that concern and then proceeds to problem-solve with the participant around that particular barrier). Participants return to the study setting each week for follow-up sessions during which they "meet" with their personal trainer via computer to report on the previous week's PA behavior, address barriers to PA, and make plans for the coming week. Objective measures of height,

weight, and body fat percentage are taken at baseline and the end of the intervention. Participants are compensated \$5 for each weekly session they complete, for a total of \$35 for the full study.

Daily reports on PA

Between weekly lab sessions, participants maintain daily records of their PA behaviors and experiences (e.g., motivation for PA, affect toward PA) using a Personal Digital Assistant (PDA; e.g., Palm). Measures included on the PDA are abbreviated versions of the validated measures used in the weekly assessments. PDAs are programmed with a menu that includes: I am going to exercise; I just finished exercising; and I did not exercise today. On days during which they engage in leisure-time PA, participants complete appropriate measures before (i.e., "I am going to exercise") and after the PA session (i.e., "I just finished exercising"). Pre-PA questions assess PA expectations, motivation, emotion, and vitality. Post-PA questions assess activities completed, motivation, emotion, vitality, physical symptoms, and intentions for exercising the next day. On days participants do not engage in leisure-time PA, they complete measures assessing reasons for not exercising, motivation, emotion, vitality, physical symptoms, and intentions for exercising the next day.

Participants are told that there is no expectation that they will engage in leisure-time PA every day, and that there will be some days when they do not do any leisure-time PA at all. This encourages participants to take rest days as needed and discourages them from fabricating information about a PA session on days when they did not exercise. During the initial lab session, participants are taught how to use the PDAs and complete practice sessions for each of the three sections. PDA data are downloaded during weekly visits but are not integrated within the encounters with the computerized trainer.

The method employed in this intervention is optimal for testing the hypothesized model for several reasons. A computerized personal trainer provides optimal experimental control. The combination of weekly and daily diary data provides an opportunity to test these hypotheses in a particularly interesting and substantive way. For example, data from participants' experiences during their weekly trainer interactions (e.g., need support from one's trainer) may predict subsequent daily motivation, behavior, and PA experience (e.g., emotion during PA). The daily data also allows for tests of pre-PA motivation and its relation to post-PA outcomes. Such daily data can also be "lagged," allowing for a test of how, for example, motivation on one day predicts behavior and experience on subsequent days. Additionally, these data allow for modeling fluctuations in PA motivation and how these fluctuations are, in turn, related to PA behavior.

Advancing the field: potential contributions of this research

In addition to the benefits of the methodology to this particular study and the model that is being tested here, the design of this

intervention and its theoretical basis have important implications for advancing the field of exercise science specifically and health behavior change more broadly. This study also lays the foundation for advancing applications of self-determination theory through new modes of intervention delivery and the potential for methodologically rigorous theory testing.

Benefits of a computer-based intervention

Standardization and tailoring

One of the many advantages of a computer-based intervention is its capacity to standardize treatment. To date, much of the research applying SDT to health behavior in general and leisure-time activity in particular has relied on training groups of practitioners to deliver intervention content in need-supportive ways. Although the purpose of this training is to attempt to standardize across practitioners, it is not as precise as what can be obtained through interactive technology that incorporates standardized need-supportive tailoring. Computerized interventions also provide flexibility to tailor interventions to an individual's needs and experiences throughout the process of adopting a new health behavior. Importantly, computerized interventions have the capacity for wide dissemination, which is critical to reaching the population at-risk for various chronic diseases (e.g., cardiovascular disease, diabetes, and various cancers) due to a sedentary lifestyle. Computerized interventions are also likely to be more cost-effective than time-intensive trainings and intervention content.

Theoretical advances

Perhaps one of the most interesting implications of this research is the translation of SDT-based face-to-face interventions into a more standardized, cost-effective mode of delivery through the use of computer technology. Whether technology can be sufficiently tailored to convey key need-supportive elements such as empathy and relatedness is a critical issue that should be borne out empirically, and this trial will provide initial evidence to that end. That the crucial elements of SDT-based interventions could be delivered through the use of modern technology would provide additional evidence for the flexibility of the theory (i.e., that theory-consistent interventions can be delivered through various means both human and technological) and would suggest new avenues for research in a variety of health settings and with a range of practitioners.

Another advantage of computer-based interventions is the potential for researchers to isolate elements of interventions to determine which elements are critical to promoting desired health behavior change. For example, while SDT posits that there are several characteristics of need-supportive contexts, no empirical research has examined which of these characteristics of need support is most crucial to facilitating the process of internalization, the function served by each element, or whether all elements are necessary for internalization. Although the current research will test the conglomerate of need-supportive characteristics (e.g., asking the individual what he or she wants to achieve, refraining from judgment or evaluation when obtaining information about past behavior), this technology has the potential to isolate certain aspects of the need-supportive context (e.g., providing a menu of options) to better understand how these elements serve to facilitate internalization and optimal motivation.

Potential for translational research

The method employed here also has potential implications for translational research. Despite the efficacy of randomized-controlled trials and the relative cost-effectiveness of interventions, many interventions developed through randomized-controlled

trials are not effectively translated (Westfall, Mold, & Fagnan, 2006). There are numerous barriers to translating research into practice. They include the estimated 17 years it takes for only 14% of new scientific discoveries to enter daily clinical practice (Balas & Boren, 2000; Westfall et al., 2006). In addition, interventions to promote physical activity require extended clinical contact to be efficacious (Goldstein, Whitlock, & DePue, 2004; Maciosek et al., 2006). This presents a problem for clinicians attempting to motivate change and for individuals attempting to make these changes.

By using web- or software-based treatments, individuals could easily access information about PA recommendations and PA programs. Recent data from Nielsen/Net Ratings indicate that more than 80% of American households are connected to the internet through broadband or standard dial-up, suggesting the vast potential reach for such interventions in the US. Additionally, these computerized treatments could be used in conjunction with face-to-face meetings with practitioners and personal trainers to make better use of that time and to develop more comprehensive and efficacious interventions. Recent meta-analyses and systematic reviews have also suggested that computer-based interventions for PA can successfully change targeted health behaviors and are in many cases as efficacious as face-to-face meetings (e.g., Portnoy, Scott-Sheldon, Johnson, & Carey, 2008; Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). However, little research to date has been theory-driven, with a focus on the psychological mechanisms that may explain behavior change. Thus, this research represents an important first step to developing an efficacious, theory-based treatment program for promoting PA among individuals not meeting recommendations for frequency, intensity, and duration of PA.

Benefits of daily recording procedures

Daily recording procedures represent a paradigm for studying ongoing experiences, as they naturally occur. These methods provide detailed, accurate, and multifaceted information about behavior in its natural context (Reis & Gable, 2000). Participants monitor and report their behaviors and experiences according to schedules and formats defined by the investigator. In the current research, participants will provide daily reports on their PA behaviors via PDAs. Because participants record information each day regardless of whether or not they engage in leisure-time PA and, ideally, immediately after PA (in the case of post-PA questions), retrospection biases are substantially diminished, providing more accurate accounts than traditional self-report or recall methods (Reis & Gable, 2000). Daily recording procedures provide extremely rich data, allowing us to establish the frequency, intensity, and duration of PA behavior and to test hypotheses about the effects of personal trainer's need support on PA behavior as they naturally occur. Daily recording procedures allow researchers to (1) identify the conditions under which processes operate (e.g., how does the interaction style of computerized personal trainers affect participants' daily motivation for PA without the presence of the trainer), (2) unconfound within-person processes from individual differences (e.g., how do daily variations in motivation for PA predict PA behavior, independent of individual differences in motivation for PA), (3) examine how individuals change over time (e.g., how day to day changes and experiences predict later behaviors and outcomes) and (4) establish phenomena outside the laboratory or clinical context (e.g., PA perceptions and experiences as they naturally occur).

To date, much of the research on physical activity has been retrospective. Indeed, many physical activity questionnaires assess "usual" physical activity or physical activity over the previous week, month, or year (e.g., 7-Day Physical Activity Recall (Sallis et al.,

1985)); Minnesota Leisure-Time Physical Activity Questionnaire (Taylor et al., 1978). The self-generated global assessments required by these types of questionnaires may be influenced by the processes of encoding, storage, retrieval, and evaluation of experiences (Kahneman, Fredrickson, Schreiber, & Redelmeier, 1993; Visser, Krosnick, & Lavrakas, 2000). Daily recording procedures address these limitations in that participants record information as it occurs. Self-report biases are minimized when participants respond to concrete, specific questions close in time to the event (Schwarz & Sudman, 1996; Wentland, 1993). Although daily recording procedures are still self-reports, and are thus not free of biases, daily recording protocols characterize ongoing experience more accurately than do global self-reports (Conrath, Higgins, & McClean, 1983; Menon, 1997; Penner, Shiffman, Paty, & Fritzsche, 1994; Reis & Gable, 2000). Additionally, because daily recording procedures involve reporting information for a period of days, these data are better able to identify stable patterns of behavior compared to data from single situations or assessments, which may be influenced by atypical or random factors.

Strengths of the SDT approach: mechanisms for change and maintenance

Finally, much debate has come about in recent years on the theoretical and empirical distinction between health behavior change and maintenance (Rothman, 2000). One of the primary strengths of SDT in its applications to health behavior is that it speaks to the underlying mechanisms that may be responsible for both behavior change and maintenance. Specifically, SDT speaks to the importance of motivation, or psychological energy, and its role in energizing or initiating behavior. SDT also addresses the importance of competence, which research in a variety of domains has demonstrated to be critical for behavior change. However, SDT goes to the next level by also delineating the circumstances that are likely to promote behavior maintenance. That is, through the process of internalization, individuals come to adopt behavior changes as their own, integrating them within broader values and larger sense of self. Thus, the behavior becomes part of the individual and not just part of the intervention context, thus increasing the likelihood that behavior change will be sustained. Although the scope of the current research is limited to behavior change initiation, an emerging body of research provides empirical support for the role of SDT process in behavior maintenance (Williams, Niemiec, Patrick, Ryan, & Deci, 2009). More research is needed to examine how individuals move through the process of internalization into a state of maintained health behavior.

References

- American College of Sports Medicine. (1995). *Physical activity and public health guidelines*.
- Atkinson, J. W. (1974). The mainstream of achievement-oriented activity. In J. W. Atkinson, & J. O. Raynor (Eds.), *Motivation and achievement* (pp. 13–41). New York: Halstead.
- Atkinson, N. L., & Gold, R. S. (2002). The promise and challenge of eHealth interventions. *American Journal of Health Behavior*, 26(6), 494–503.
- Balas, E. A., & Boren, S. A. (2000). *Yearbook of medical informatics: Managing clinical knowledge for health care improvement*. Stuttgart, Germany: Schattauer Verlagsgesellschaft mbH.
- Beckman, H., & Frankel, R. (1984). The impact of physician behavior on the collection of data. *Annals of Internal Medicine*, 101(5), 692–696.
- Brug, J., Oenema, A., & Campbell, M. (2003). Past, present, and future of computer-tailored nutrition education. *American Journal of Clinical Nutrition*, 77(Suppl.), 1028S–1034S.
- Chakravarthy, M. V., Joyner, M. J., & Booth, F. W. (2002). An obligation for primary care physicians to prescribe physical activity to sedentary patients to reduce the risk of chronic health conditions. *Mayo Clinic Proceedings*, 77, 165–173.
- Conrath, D. W., Higgins, C. A., & McClean, R. J. (1983). A comparison of the reliability of questionnaire versus diary data. *Social Networks*, 5, 315–322.
- Deci, E. L., Eghrari, H., Patrick, B. C., & Leone, D. (1994). Facilitating internalization: the self-determination theory perspective. *Journal of Personality*, 62(1), 119–142.
- Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Publishing Co.
- Deci, E. L., & Ryan, R. M. (1991). A motivational approach to self: integration in personality. In R. Dienstbier (Ed.), *Nebraska symposium on motivation. Perspectives on motivation, Vol. 38* (pp. 237–288). Lincoln, NE: University of Nebraska Press.
- Deci, E. L., & Ryan, R. M. (2000). The “what” and “why” of goal pursuits: human needs and the self-determination of behavior. *Psychological Inquiry*, 11, 227–268.
- Deci, E. L., & Ryan, R. M. (2002). Overview of self-determination theory: an organismic dialectical perspective. In E. L. Deci, & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3–36). Rochester, NY: University of Rochester Press.
- Dishman, R. K., Sallis, J. F., & Orenstein, D. R. (1985). The determinants of physical activity and exercise. *Public Health Reports*, 100, 158–171.
- Duda, J. L., Chi, L., Newton, M. L., Walling, M. D., & Catley, D. (1995). Task and ego orientation and intrinsic motivation in sport. *International Journal of Sport Psychology*, 26, 40–63.
- Edmunds, J., Ntoumanis, N., & Duda, J. L. (2008). Testing a self-determination theory based teaching style in the exercise domain. *European Journal of Social Psychology*, 38, 375–388.
- Fortier, M. S., Sweet, S. N., O’Sullivan, T. L., & Williams, G. C. (2007). A self-determination process model of physical activity adoption in the context of a randomized controlled trial. *Psychology of Sport and Exercise*, 8, 741–757.
- Frederick, C. M. (1991). An investigation of the relationship among participation motives, level of participation, and psychological outcomes in the domain of physical activity. Unpublished doctoral dissertation. University of Rochester.
- Frederick, C. M., & Ryan, R. M. (1993). Differences in motivation for sport and exercise and their relations with participation and mental health. *Journal of Sport Behavior*, 16, 124–146.
- Gagne, M., Ryan, R. M., & Bargmann, K. (2003). Autonomy support and need satisfaction in the motivation and well-being of gymnasts. *Journal of Applied Sport Psychology*, 15, 372–390.
- George, T. R., & Feltz, D. L. (1995). Motivation in sport from a collective efficacy perspective. *International Journal of Sport Psychology*, 26, 98–116.
- Gill, D. L., Gross, J. B., & Huddleston, S. (1983). Participation motivation in youth sports. *International Journal of Sport Psychology*, 14, 1–14.
- Goldstein, M. J., Whitlock, E. P., & DePue, J. (2004). Planning committee of the addressing multiple behavioral risk factors in primary care project. Multiple behavioral risk factor interventions in primary care. *American Journal of Preventive Medicine*, 27(2S), 61–79.
- Goudas, M., Biddle, S., & Underwood, M. (1995). A prospective study of the relationships between motivational orientations and perceived competence with intrinsic motivation and achievement in a teacher education course. *Educational Psychology*, 15, 89–96.
- Gould, D., Feltz, D., & Weiss, M. (1985). Motives for participating in competitive youth swimming. *International Journal of Sport Psychology*, 16, 126–140.
- Harter, S. (1978). A model of intrinsic mastery motivation in children: individual differences and developmental change. In A. Collins (Ed.), *Minnesota symposium on child psychology* (pp. 215–255). Hillsdale, NJ: Erlbaum.
- Harter, S. (1981). Effectance motivation reconsidered: toward a developmental model. *Human Development*, 21, 34–64.
- Ingledeu, D. K., Markland, D., & Medley, A. R. (1998). Exercise motives and stages of change. *Journal of Health Psychology*, 3, 477–489.
- Kahneman, D., Fredrickson, B. L., Schreiber, C. A., & Redelmeier, D. A. (1993). When more pain is preferred to less: adding a better end. *Psychological Science*, 4, 401–405.
- Kaplan, S. H., Greenfield, S., & Ware, J. E. (1989). Assessing the effects of physician–patient interactions on the outcomes of chronic disease. *Medical Care*, 27 (Suppl. 3), S110–S127.
- Kerr, J. H. (1997). *Motivation and emotion in sport reversal theory*. East Sussex, UK: Psychology Press Ltd.
- Kroeze, W., Werkman, A., & Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine*, 31, 205–223.
- Laakso, L., & Telama, R. (1981). Sport participation in Finnish youth as a function of age and schooling. *Sportwissenschaft*, 1, 28–45.
- Leslie, E., Fotheringham, M. J., Owen, N., & Bauman, A. (2001). Age-related differences in physical activity levels of young adults. *Medicine and Science in Sports and Exercise* 255–258.
- McClelland, D. (1961). *The achieving society*. New York: Free Press.
- McKenna, K. Y. A., & Bargh, J. A. (2000). Plan 9 from cyberspace: The implications of the Internet for personality and social psychology. *Personality and Social Psychology Bulletin*, 4, 57–75.
- Maciosek, M. V., Coffield, A. B., Edwards, N. M., Flottenmesch, T. J., Goodman, M. J., & Solberg, L. I. (2006). Priorities among effective clinical preventive services. *American Journal of Preventive Medicine*, 31(1), 90–96.
- Markland, D. (1999). Self-determination moderates the effects of perceived competence on intrinsic motivation in an exercise setting. *Journal of Sport & Exercise Psychology*, 21, 351–361.
- Markland, D., & Hardy, L. (1997). On the factorial and construct validity of the intrinsic motivation inventory: conceptual and operational concerns. *Research Quarterly for Exercise and Sport*, 68(1), 20–32.
- Marvel, K. M., Epstein, R. M., Flowers, K., & Beckman, H. B. (1999). Soliciting the patients’ agenda: have we improved? *Journal of the American Medical Association*, 281, 283–287.

- Menon, G. (1997). Are the parts better than the whole? The effects of decompositional questions on judgments of frequent behaviors. *Journal of Marketing Research*, 34, 335–346.
- Mullan, E., & Markland, D. (1997). Variations in self-determination across the stages of change for exercise in adults. *Motivation and Emotion*, 21, 349–362.
- Norman, G. J., Zabinski, M. F., Adams, M. A., Rosenberg, D. E., Yaroch, A. L., & Atienza, A. A. (2007). A review of e-Health interventions for physical activity and dietary behavior change. *American Journal of Preventive Medicine*, 33, 336–345.
- Pelletier, L. G., Fortier, M. S., Vallerand, R. J., & Briere, N. M. (2001). Associations among perceived autonomy support, forms of self-regulation, and persistence: a prospective study. *Motivation and Emotion*, 25, 279–306.
- Penner, L. A., Shiffman, S., Paty, J. A., & Fritzsche, B. A. (1994). Individual differences in intrapersonal variability in mood. *Journal of Personality and Social Psychology*, 66, 712–721.
- Pinto, B. M., Chericco, N. P., Szymanski, L., & Marcus, B. H. (1998). Longitudinal changes in college students' exercise participation. *College Health*, 47, 23–27.
- Pinto, B. M., & Marcus, B. H. (1995). A stages of change approach to understanding college students' physical activity. *Journal of the American College of Health*, 44, 27–31.
- Portnoy, D. B., Scott-Sheldon, L. A. J., Johnson, B. T., & Carey, M. P. (2008). Computer-delivered interventions for health promotion and behavioral risk reduction: a meta-analysis of 75 randomized controlled trials. *Preventive Medicine*, 47, 3–16.
- Reeve, J. (1998). Autonomy support as an interpersonal motivating style: is it teachable? *Contemporary Educational Psychology*, 23(3), 312–330.
- Reis, H. T., & Gable, S. L. (2000). Event-sampling and other methods for studying everyday experience. In H. T. Reis, & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 190–222). New York: Cambridge University Press.
- Roberts, G. C., & Treasure, D. C. (1995). Achievement goals, motivational climate, and achievement strategies and behaviors in sport. *International Journal of Sport Psychology*, 26, 64–80.
- Rothman, A. J. (2000). Toward a theory-based analysis of behavioral maintenance. *Health Psychology*, 19, 64–69.
- Ryan, R. M. (1993). Agency and organization: intrinsic motivation, autonomy and the self in psychological development. In J. Jacobs (Ed.), *Nebraska symposium on motivation: Developmental perspectives on motivation*, Vol. 40 (pp. 1–56). Lincoln, NE: University of Nebraska Press.
- Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization: examining reasons for acting in two domains. *Journal of Personality and Social Psychology*, 57(5), 749–761.
- Ryan, R. M., Plant, R. W., & O'Malley, S. (1995). Initial motivations for alcohol treatment: relations with patient characteristics, treatment involvement and dropout. *Addictive Behaviors*, 20, 279–297.
- Sallis, J. F., Haskell, W., Wood, P., Fortmann, S. P., Rogers, T., Blair, S. N., et al. (1985). Physical activity assessment methodology in the five-city project. *American Journal of Epidemiology*, 121, 91–106.
- Schwarz, N., & Sudman, S. (1996). *Answering questions: Methodology for determining cognitive and communicative processes in survey research*. San Francisco: Jossey-Bass.
- Taylor, H. L., Jacobs, D. R., Shucker, B., Knudsen, J., Leon, A. S., & DeBacker, G. (1978). A questionnaire for the assessment of leisure time physical activities. *Journal of Chronic Diseases*, 31, 741–755.
- Telama, R., & Silvennoinen, M. (1979). Structure and development of 11- to 19-year-olds' motivation for physical activity. *Scandinavian Journal of Sports Science*, 1, 23–31.
- Vansteenkiste, M., Simons, J., Lens, W., Soenens, B., & Matos, L. (2005). Examining the motivational impact of intrinsic versus extrinsic goal framing and autonomy-supportive versus internally controlling communication style on early adolescents' academic achievement. *Child Development*, 2, 483–501.
- Visser, P. S., Krosnick, J. A., & Lavrakas, P. J. (2000). Survey research. In H. T. Reis, & C. M. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 223–252). New York: Cambridge University Press.
- Wentland, D. J., Portillo, C., Holzemer, W. L., Slaughter, R., & McGhee, E. M. (2004). The effectiveness of web-based vs. non-Web-based interventions: a meta-analysis of behavioral change outcomes [Electronic version]. *Journal of Medical Internet Research*, 6. Retrieved August 21 2009 from www.jmir.org/2004/4/e40/.
- Wentland, E. J. (1993). *Survey responses: An evaluation of their validity*. New York: Academic Press.
- Westfall, J. M., Mold, J., & Fagnan, L. (2006). Practice-based research—"Blue Highways" on the NIH roadmap. *JAMA*, 297(4), 403–406.
- Williams, G. C. (2002). Improving patients' health through supporting the autonomy of patients and providers. In E. L. Deci, & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 233–254). Rochester, NY: University of Rochester Press.
- Williams, G. C., Cox, E. M., Kouides, R., & Deci, E. L. (1999). Presenting the facts about smoking to adolescents: the effects of an autonomy supportive style. *Archives of Pediatrics and Adolescent Medicine*, 153(9), 959–964.
- Williams, G. C., & Deci, E. L. (2001). Activating patients for smoking cessation through physician autonomy support. *Medical Care*, 39(8), 813–823.
- Williams, G. C., Freedman, Z. R., & Deci, E. L. (1998). Supporting autonomy to motivate glucose control in patients with diabetes. *Diabetes Care*, 21(10), 1644–1651.
- Williams, G. C., Gagné, M., Ryan, R. M., & Deci, E. L. (2002). Facilitating autonomous motivation for smoking cessation. *Health Psychology*, 21, 40–50.
- Williams, G. C., Grow, V. M., Freedman, Z. R., Ryan, R. M., & Deci, E. L. (1996). Motivational predictors of weight loss and weight-loss maintenance. *Journal of Personality and Social Psychology*, 70(1), 115–126.
- Williams, G. C., Niemiec, C. P., Patrick, H., Ryan, R. M., & Deci, E. L. (2009). The importance of supporting autonomy in facilitating long-term tobacco abstinence. *Annals of Behavioral Medicine*, 37, 315–324.
- Williams, G. C., Rodin, G. C., Ryan, R. M., Grolnick, W. S., & Deci, E. L. (1998). Autonomous regulation and adherence to long-term medical regimens in adult outpatients. *Health Psychology*, 17(3), 269–276.
- Winkelberg, A. (1997). The analysis of an electronic support group for individuals with eating disorders. *Computers in Human Behavior*, 13, 393–407.
- Wong, E. H., & Bridges, L. J. (1995). A model of motivational orientation for youth sport: some preliminary work. *Adolescence*, 30, 437–449.
- Woods, C. B., Mutrie, N., & Scott, M. (1999). More students, more active, more often: exercise behavior change in a student population. *Journal of Sports Sciences*, 17, 70.