Exercise-Related Cognitive Errors: Measurement, Validation, and Process

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Abstract

Background. This manuscript-style dissertation is comprised of three studies exploring the concept of exercise-related cognitive errors. Cognitive errors reflect individuals' biased evaluations of context-relevant information. Cognitive errors are verbal statement[s] that suggest ways of evaluating information that reflect errors or biases away from the average or normative evaluation of the same material. The premise behind this program of research is that people do not always make rational decisions regarding their health and that biased information processing can influence how individuals perceive the situations they experience. Consequently, the unhelpful thoughts that result from cognitive errors may make regular exercise engagement more difficult. Each of the studies builds upon the previous in order to advance our understanding of exercise-related cognitive errors (ECEs). The purposes of the three manuscripts were to: (1) create the first ECE measure in the exercise literature, (2) explore how making ECEs relates to exercise adherence cognitions and behaviour, and (3) determine if information processing biases are related to ECEs. **Results**. *Study 1* examined the factor structure of a newly created ECE measure. A 16-item, three-factor model was retained in the final Exercise-related Cognitive Errors Questionnaire's factor structure ($\chi 2$=164.35, df=75, p<.001; RMSEA=.057; CFI=.947; TLI=.915) and had good psychometric properties among an adult sample (*N* = 364). Evidence of the questionnaire's predictive utility was also assessed. For example, ECEs were negatively related to exercise and accounted for additional variance beyond the contribution of past exercise in predicting exercise intention. *Study 2* examined associations between cognitive errors and exercise variables that predict adherence and behavioural patterns among adults. Those reporting high ECEs (*n*=92) exercised less and reported poorer psychological outcomes (e.g., more struggle in making exercise decisions, lower self-regulatory efficacy, lower persistence)

compared to those reporting lower ECEs (*n*=272). All group differences were significant ([*ps*<.001] with large effects). There were also social cognitive and ECE differences between those reporting consistent, inconsistent, and no exercise patterns. These differences reflected medium to large effects across all study variables. *Study 3* examined differences between high and low cognitive error groups on information processed about a relevant exercise decision-making situation. Those in the high ECE group (*n*=29) primarily focused on negative content from the situation (i.e., information that would make exercising more difficult; *p*<.001, *d*=.74), compared to the low ECE group (*n*=109) who had a balanced focus on positive and negative content. Those in the high ECE group reported that they would be less likely to exercise (*p*<.001; *d*=.59) if placed in the situation. Finally, in imagining themselves in the situation, the high ECE group also reported: lower self-regulatory efficacy, lower persistence, more struggle in making exercise decisions, and more difficulty (*p*s<.001; large and very large effect size differences). **Conclusions.** This research represents the first investigation of cognitive errors specific to an exercise context. The three studies represent first-generation research. Their purpose was to broaden our understanding of ECEs. Results from this program of research have provided initial evidence suggesting that ECEs may aid our understanding of faltering exercise and nonadherence. If future investigation experimentally links ECEs to poor exercise adherence, then evidence-based intervention strategies could be employed to modify unhelpful thoughts associated with cognitive errors. Future research expanding the generalizability of the measure and construct are suggested as possible next steps to advance this preliminary research.

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Mom, Dad, you're pretty awesome. You taught me the fundamentals of life. Help others. Say please and thank you. Work hard. Don't be frivolous. Forgive. Unwaveringly, you modelled these things. These are traits people never fail to undervalue, yet are among the most important. Thank you for instilling this in me.

I had no intention to go to a Kinesiology department in Saskatchewan having been trained in Psychology at Windsor. However, an impromptu conversation with the dean of graduate studies, Dr. Jim Frank, resulted in me being put in touch with his colleague from Saskatchewan, Dr. Larry Brawley. I'll be forever grateful to Jim for going out of his way to make that connection.

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War on Drugs.

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Dedication

For physical training is of some value, but godliness has value for all things, holding promise for both the present life and the life to come.

1 Tim 4:8

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List of Abbreviations

AHA – American Heart Association

CE – Cognitive error

CEQ – Cognitive Error Questionnaire

CFI – Comparative fit index

C.I. – Confidence interval

df – degrees of freedom

ECE – Exercise-related cognitive error

E-CEQ – Exercise-related Cognitive Error Questionnaire

PA – Physical Activity

RMSEA – Root mean square error of approximation

SCT – Social Cognitive Theory

SRE – Self-regulatory efficacy

TLI – Tucker-Lewis index

WHO – World Health Organization

1 General Introduction

1.1 Low Prevalence of Physical Activity Engagement Despite its Benefits

The World Health Organization (WHO, 2014) has raised global concern about poor health behaviours that contribute to severe health issues and chronic disease. Physical inactivity positively correlates with numerous health problems such as heart disease, obesity, type II diabetes, depression, and anxiety (Bjornebeckk, Mathe, & Brene, 2005; Duman, Schlesinger, Russell, & Duman, 2008). Physical activity guidelines recommend that adults should engage in 150 minutes or more of at least moderate intensity physical activity per week to attain health benefits (cf. Tremblay et al., 2011). However, behavioural surveillance data suggests that only about 15% of Canadians achieve these recommendations (Colley et al., 2011). Given the numerous benefits to regularly engaging in physical activity and the high prevalence of insufficient physical activity engagement, there is public health impetus to promote healthy behaviours and to help people modify poor ones.

1.2 Failure to Effectively Manage Personal Health Behaviour

Although the benefits of physical activity (referred to hereafter as exercise in the general introduction) are widely known, people are often ineffective at exerting control over their health-related thoughts and behaviours (i.e., failure to quit smoking, poor diet, being physically inactive; Bandura, 2005; Vohs & Baumeister, 2011). Social cognitive models have commonly been used in understanding why people engage in maladaptive health behaviours, despite knowing their risks. Authors of these models purport that peoples' thoughts and behaviour can influence each other; thus, goal directed behaviour is, in part, modified by changing a person's thoughts. Social cognitive models have been used with considerable success in predicting and modifying such health behaviours, like physical inactivity (cf. Artinian et al., 2010; Conner & Norman, 2005). However, Janis (1984) has argued that a major limitation of these models is that

they assume that health-relevant information is processed and acted upon in a rational manner. From this perspective, social cognitive models may fail to capture all factors that might help to understand and predict behaviour. One such example is if some individuals are processing information in a biased manner.

1.3 Biased Thinking and Health Behaviour

Biased thoughts might hinder engagement in good health practices. For example, Anderson and Emery (2014) showed that irrational health beliefs were related to poorer adherence to cardiac rehabilitation. Palascha et al. (2015) demonstrated that eating-specific dichotomous thinking, which is conceptually related to the all-or-nothing biased thinking (e.g., I am going to get fat if I eat even one unhealthy snack), mediated the association between restraint eating and weight regain in a non-clinical sample of adults. Cognitive biases have also been associated with poorer social cognitions regarding health behaviours. For example, they have been related to lower confidence to self-manage one's chronic disease symptoms (Shnek et al., 1997) and body dissatisfaction and body-image quality of life (Jakatdar, Cash & Engle, 2006). This type of biased thinking in the health literature has long been studied within clinical psychology as one psychological process causing and exacerbating depression (Sacco & Beck, 1995). Understanding that conceptualization of biased thinking, called cognitive errors, may provide a useful framework to better understand the relationship between biased thoughts and engagement in poor health practices (e.g., being physically inactive).

1.4 Cognitive Errors

Sacco and Beck (1995) were among the first to examine cognitive errors as biased or irrational thought processes that perpetuated depression. They defined cognitive errors as "systematic errors in the depressed individual's information processing, which reflect the activity of dysfunctional cognitive schemas" (p. 330; also see Study 3 for a brief explanation of schema).

These errors can cause depressed individuals to systematically misinterpret the meaning of events (Lefebvre, 1981). More recently, Mueser, Rosenberg, and Rosenberg (2009) describe cognitive errors as common biased thought patterns that are believed to perpetuate the effects of psychopathological states (e.g., depression, anxiety). They further specify that biased thought patterns are "common logical errors that occur when people draw conclusions about specific events" (Mueser et al., 2009, p.100). However, Mueser et al.'s conception of cognitive errors is not a clear conceptual cognitive error definition because it focuses on the outcome of cognitive errors in clinical populations (i.e., the perpetuation of depression, anxiety) and does not address the possibility that cognitive errors occur in the broader, non-clinical population.

Milman and Drapeau (2012) define *cognitive errors* as,

> "distorted information processes [that] do not consist of thought content…A *cognitive error* refers to a verbal statement that suggests ways of evaluating information that reflect errors or biases away from the average or normative evaluation of the same material" (p.129).

Milman and Drapeau's cognitive error definition is broader, encompassing the possibility that cognitive errors occur in both clinical and non-clinical individuals. Thus, it may be more appropriate for a research program concerned with individuals who exhibit cognitive errors when considering exercise as a lifestyle and health behaviour change. Other cognitive error definitions (e.g., Lefebvre, 1981; Mueser et al., 2009; Sacco & Beck, 1995) are not suitable given their explicit reference to perpetuating psychopathological states.

Catastrophizing is one example of a cognitive error that illustrates cognitively errored thought processing. Catastrophizing thoughts are characterized by having a focus on the extreme or most distressing possible outcome (Drapeau & Perry, 2007). Individuals erroneously make the assumption that they must always think the worst because it is most likely to happen to them.

The following is an example of a catastrophizing reaction in an exercise situation: you have just come off holidays and have not exercised in two weeks. When it comes time to exercise, you think to yourself, "It's been so long since I've exercised that I'm going to be painfully sore for days."

The language used to describe cognitive errors and the thoughts they produce in the mental health literature frequently uses the labels: maladaptive, irrational, negative, or unhelpful. For example, individuals with depression may think that their close friends hate them after not having immediately received a response to a text message. Clinicians may detect a cognitive error as causing this thought and describe this thought as being maladaptive. However, the type of labelling characteristic of psychopathological conditions does not directly translate to the labelling of the thoughts produced by cognitive errors in the exercise context.

Thoughts resulting from cognitive errors in the exercise context might be more appropriately labelled as biased, one-sided thinking because a psychopathology is not being identified and examined. However, research must identify whether cognitive errors specific to the exercise context produce thoughts that are biased in one direction as the Milman and Drapeau model suggests (2012). Thoughts produced by cognitive errors in the exercise context could also be labelled unhelpful as illustrated by the following example. Specifically, if starting or reinitiating physical activity is countered by biased thinking, health promotion advocates might view such thoughts as being unhelpful to the goal of exercising. Given that a goal of this dissertation is to identify and understand the biased thoughts associated with decisions that some people make about exercise and their subsequent actions toward or away from exercise, the labels of biased and unhelpful thoughts will be used throughout the dissertation.

Cognitive errors can have either a positive or negative valence (Milman & Drapeau, 2012). While the discussion of cognitive errors throughout this dissertation concern those with a

negative valence, the existence of the positive side should be acknowledged. However, errors of positive valence are far less common (Milman & Drapeau, 2012). An example of a positively valenced All-or-Nothing cognitive error is, if individuals think that the only way to improve their muscle mass is to lift weights at least seven times per week. Such a cognitive error might lead to negative outcomes like over-exercising.

This brief, general overview introduces the concept of cognitive errors. The dissertation research examines the potential unhelpful nature of cognitive errors within an exercise context. However, to aid understanding through the research process, a construct requires adequate measurement. The first dissertation study describes the development of the first measure of exercise-related cognitive errors (ECEs). Accordingly, the construct is described in more detail in Study 1, where operational definitions are provided to give context to the measure's development. A discussion of the theoretical frameworks under which cognitive errors will be studied within an exercise context is also instructive.

Social Cognitive Theory and Cognitive Errors

The proposed research utilizes complementary perspectives drawn from two areas of psychology: clinical psychology and social psychology. It examines cognitive errors in relation to exercise through a social cognitive lens. Theories of social cognition are commonly used to understand behaviours in health psychology (cf. Conner & Norman, 2005). Social Cognitive Theory (SCT; Bandura, 1997) is one theory that has seen great success in understanding and intervening upon health behaviours like exercise (cf. Luszczynska & Schwarzer, 2005).

Self-efficacy is one of the primary constructs in the agency component of SCT. Self-efficacy beliefs are beliefs about the ability to "organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p.3). Efficacy research has focused on and made a distinction between two broad areas of functioning: efficacy to perform specific tasks

and efficacy for self-regulation. Self-regulatory efficacy (SRE) is concerned with individuals' confidence in their self-regulatory skills and abilities such as self-monitoring, goal setting, scheduling, and preventing relapse. Bandura (1997) suggests that direct experience in performing an action is the strongest way to develop self-efficacy for that action. However, thinking in a manner consistent with cognitive errors may affect the information a person processes during the self-regulation of exercise. Such thinking may interfere with the processing and interpretation of direct experiences (e.g., making errors in logic: Lefebvre, 1981).

Through cognitive errors, the meaning of events can be systematically distorted so individuals consistently construe themselves, their world, and their experiences in a negative or maladaptive way (Lefebvre, 1981). Individuals making cognitive errors may be using biased sources of information to form their self-regulatory efficacy cognitions. In support of this notion, research by Shnek et al. (1997) has demonstrated significant negative associations between the intensity of cognitive errors and self-efficacy for disease self-management.

It seems theoretically tenable to suggest that processing an experience or situation through cognitive errors could have a deleterious effect on the development of personal efficacy for exercise management. For example, individuals could distort their mostly successful performance of an activity (e.g., completing a 5K race) by catastrophizing it as being a complete failure because 100% success was not reached (e.g., they did not finish first), thereby hindering the development of self-efficacy.

Self-efficacy beliefs are important to enacting behaviour. All-or-nothing processing (e.g., focusing only on the negative aspects) as reflected in the example above might elicit a struggle with exercise decisions and affect related self-perceptions. In turn, associated efficacy beliefs may become variable and subsequently result in lapses in behavioural attainments. The presence of unhelpful thought processes, specifically cognitive errors, should have corresponding

relationships with social cognitions such as lower exercise affect, lower self-regulatory efficacy, and a reduction in individuals' willingness towards, and likelihood of, performing a behaviour.

1.5 Purpose of Research Program

The premise underlying this dissertation research is that people do not always make rational decisions that benefit their health. Biased information processing (cognitive errors) can influence how individuals perceive the situations they experience. The unhelpful thoughts resulting from ECE may make regular exercise engagement more difficult. Each of the three studies that follow build upon one another to advance our understanding of ECEs. Determining if biased thinking negatively affects variables that influence the self-regulation of exercise adherence may help to confirm if ECEs occur in relation to everyday exercise environments.

The overarching goal of this novel research program was to determine whether some individuals engage in cognitively errored thinking. At this early stage of research, identifying whether or not individuals think about exercise in cognitively errored ways was the goal. Consideration of the relative impact of different cognitive error factors (e.g., psychopathology literature) was not deemed relevant to the goal of clear identification of the presence of exercise-related cognitive errors.

There were three main purposes of this dissertation. The *first purpose* was to develop the first ECE measure in the exercise literature. Developing and validating a measure offers a practical means to study the ECE phenomena. The *second purpose* was to explore relationships between cognitive errors and adherence cognitions and behaviour. This first-generation research was needed to establish whether exercise-related cognitive errors were negatively related to exercise. Such a relationship would suggest a need for additional research about mechanism and causation. Finally, the *third purpose* was to determine if ECEs were related to processing exercise-related information. While cognitive errors represent biased information processes,

evidence is needed to demonstrate whether individuals who report higher ECEs process information about exercise situations differently than individuals reporting lower ECEs.

Data for Studies 1 and 2 were collected together, but analyzed sequentially. In Study 1, only the ECE measure and exercise variables were used in the measure's development. In Study 2, the developed instrument was used in association with individuals' perceived exercise patterns and social cognitions to answer research questions regarding predictive utility.

In Study 3, a separate investigation was conducted to examine information processing associated with ECEs. All three studies are either published or accepted for publication at the time of this writing. Given their independent publication, there will be some repetition among study introductions. Segues between the studies are provided to transition from one investigation to the next in order for readers to see how they relate to the overall research program. Finally, a general discussion will address their collective contribution to the exercise psychology literature.

1.6 Orientation to the Manuscript-Style Thesis

The reader will note several idiosyncrasies associated with a manuscript style dissertation given it contains published manuscripts. First, the interchangeable use of the terms "physical activity" and "exercise" should be addressed. In the introductions of each study, the prevalence statistics are cited (e.g., use of physical activity when discussing physical activity guidelines). However, throughout the methodology, results, and discussion the term 'exercise' is used to maintain conceptual congruence with the ECE measure.

Second, some detail that might be observed in an unpublished dissertation is not seen in a published manuscript because of journal restrictions on manuscript length. For example, Study 1 omits detail from measure development due to journal restrictions and because the sole purpose of the dissertation was not to satisfy that single objective. To compensate, an appendix of additional information for Study 1 is provided (See Appendix A).

Third, and finally, there is a minor inconsistency in referencing style between manuscripts due to differential requirements of the publishing journals. Manuscripts 1 and 3 used American Psychological Association (APA) reference formatting, whereas Manuscript 2 used Harvard Sage formatting. Harvard Sage is a variant of APA. The most prominent difference between the two is seen in the in-text parenthesized citations, where the full word "and" is used in favor of the "&". To retain the original structure of the papers, we did not modify the manuscript 2 referencing style.

2 Study 1 – Development and Initial Validity of the Exercise-Related Cognitive Errors Questionnaire[1]

2.1 Background

Despite the well-known benefits of regular physical activity engagement, only 15% of Canadians (Statistics Canada, 2013) and 31% of Europeans (World Health Organization, 2015) are sufficiently active to meet exercise guidelines to accrue health benefits. Failing to meet guidelines may in part be the result of failing to effectively self-regulate personal health-related thoughts and behaviours (e.g., being physically inactive; Bandura, 2005; Vohs & Baumeister, 2011). While social cognitive models are useful in understanding health behaviours (cf. Artinian et al., 2010; Conner & Norman, 2005), Janis (1984) has argued that they do not capture all factors that further the understanding of health behaviour. They assume that health information is rationally processed and acted upon.

However, people do not always make rational decisions; biased information processing can influence how individuals perceive the situations they experience. Cognitive errors is one such factor reflecting individuals' biased thinking (Milman & Drapeau, 2012). Taking cognitive errors into account may broaden our understanding of why some individuals fail to regularly exercise. Exercise-related cognitive errors (ECEs) should influence individuals' exercise self-regulation by affecting the information that individuals process in making decisions to engage in planned exercise.

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[1]This manuscript has been published (citation follows). The manuscript formatting has been adjusted from the published article to meet dissertation formatting requirements. Appendix references have been added. The reference section has been removed and amalgamated into one section for the entire dissertation.

Locke, S. R., & Brawley, L. R. (2016). Development and initial validity of the Exercise-Related Cognitive Errors Questionnaire. *Psychology of Sport and Exercise, 23*, 82-89.

2.1.1 Biased Thinking and Health Behaviour

Evidence within the study of health behaviour has demonstrated that biased or irrational beliefs might exacerbate the failure to follow good health practices. They have been related to behavioural failures such as: poor adherence to treatment regimens (Anderson & Emery, 2014; Meichenbaum & Turk, 1987), poor health practices (Christensen, Moran, & Wiebe, 1999), disability status (Smith, Follick, Ahern, & Adams 1986), and excessive or inadequate rest leading to extreme cycles of activity (Moss-Morris & Petrie, 1997; Petrie et al., 1995; Spence, Moss-Morris, & Chalder, 2005). Psychologically, they have been related to lower confidence to self-manage one's chronic disease symptoms (Shnek et al., 1997), body dissatisfaction and weight pre-occupation (Jakatdar, Cash & Engle, 2006). This evidence illustrates that biased or irrational beliefs may distort the processing and interpretation of health-relevant information and be related to subsequent poor health behaviours.

Research regarding negative exercise cognitions might provide another indication that individuals' thinking may be affected by ECEs. Gyurcsik and Brawley (2000) found that negative thinkers had lower self-efficacy, lower exercise intentions, and lower exercise class attendance than did positive thinkers. Subsequent research by Glazebrook and Brawley (2011) indicated a similar pattern among maintenance cardiac rehabilitation participants. Their findings demonstrate the potential presence of negative thoughts, which could be the result of ECEs.

2.1.2 Cognitive Errors.

Irrational thinking has long been studied within the area of depression, conceptualized as biased information processing and thus labelled cognitive errors (Beck 1976; Beck, Rush, Shaw, & Emery, 1979). These errors cause depressed individuals to systematically misinterpret the meaning of events (Lefebvre, 1981) and often result in dysphoric emotions and maladaptive behaviours (Beck, 1976). Milman and Drapeau (2012) define *cognitive errors* as "distorted

information processes [that] do not consist of thought content…*A cognitive error* refers to a verbal statement that suggests ways of evaluating information that reflect errors or biases away from the average or normative evaluation of the same material" (p.129). This definition is broadly operationalized such that cognitive errors are not found exclusively among depressive or anxious individuals.

Milman and Drapeau's definition allows the notion of cognitive errors to be extended to a non-clinical population. It also highlights that cognitive errors are thought processes. Cognitive errors are thought processes that produce unhelpful thoughts. Inasmuch as these information processes are not directly observable, they are identified by the thoughts that they produce. These resultant thoughts are examined to elucidate the specific cognitive error being manifested. The definition also suggests that cognitive errors reflect information processing that differs from the normal or average evaluation. A person with erroneous thinking will interpret certain information in a way that is markedly different from the normal, adaptive processing of the same information among individuals who do not have biased thoughts. Consider the following example to illustrate how a cognitive error might manifest within an exercise context. The "all-or-nothing" ECE might influence individuals to interpret their pre-exercise energy as low and that they can only exert 75% effort. In turn, these individuals may feel that suboptimal effort is not sufficient and thus not make the effort to exercise at all.

2.1.3 Study Purposes and Hypotheses

This investigation had two broad purposes. The first purpose concerned measure development and the second concerned the relationship of cognitive errors relevant to exercise adherence (i.e., criterion-related validity). Background for each follows.

Purpose 1: Measure development. A valid, non-clinical measure is needed if we are to examine whether or not asymptomatic adults process exercise-relevant information in a biased

fashion characteristic of the influence of cognitive errors. Existing measures in psychology and health are developed for other purposes and lack exercise-specificity. For example, the irrational health beliefs scale (Christensen et al., 1999) measures a broad array of biased beliefs, but only one item specific to exercise. Likewise, the behavioural responses to illness questionnaire (Spence, Moss-Morris, & Chalder, 2005) contains only one general exercise item ("I have avoided physical exercise") that represents maladaptive behavioural responses to illness. Current measures are not applicable to the context of exercise for non-clinical individuals.

The first purpose of this study was to create the Exercise-related Cognitive Errors Questionnaire (E-CEQ) as a non-clinical measure of ECEs for adults. We used Lefebvre's (1981) original Cognitive Errors Questionnaire (CEQ) as a model for measure development because it offered a broad perspective on the concept of cognitive errors, had a substantive evidence base, and had a way of presenting items that has demonstrated that cognitive errors can be successfully identified. After item development and refinement, the data were factor analyzed to examine the E-CEQ's factor structure.

Purpose 2: Evidence of criterion-related validity. Biased information processing as reflected by cognitive errors has the potential to influence how individuals perceive the situations they experience. Sources of criterion validity were sought as the second study purpose to provide evidence that the E-CEQ is related to exercise. Four hypotheses (Hyp.) were advanced. First, evidence of convergent validity was examined using Lefebvre's (1981) CEQ and the E-CEQ. A moderate relationship (Hyp. 1) was expected between both measures because both assess conceptually similar, yet distinct, constructs.

Second, the associations between ECEs and planned exercise and exercise intention were examined. Establishing that ECEs can be assessed through a face valid measure represents an initial first step in demonstrating predictive utility in the psychometric process. Based upon

previous exercise research with related concepts (e.g., positive and negative thinkers; Gyurcsik & Brawley, 2000), and the general cognitive errors literature (e.g., Anderson & Emery, 2014), it was hypothesized that (Hyp. 2) ECEs would be negatively associated with planned exercise and exercise intention.

Third, with respect to predictive validity, the E-CEQ's utility in predicting number of planned exercise bouts beyond the contribution of the original CEQ was examined to demonstrate the measure's specificity and utility to the exercise context. It was hypothesized that (Hyp. 3) the E-CEQ would account for a significant amount of variance in planned exercise after controlling for the CEQ. Finally, the ECE-Q's utility in predicting exercise intention while controlling for past exercise was examined. Intentions represent proximal goals which motivate and facilitate goal-directed behaviour (cf. Bandura, 1986). ECEs may bias the information that is processed when forming and carrying out these goals. In using ECEs to predict exercise intention, Bandura (1986) reminds us of the dynamic reciprocal nature of behaviour and cognition: past behaviour is a determinant of future beliefs (i.e., proximal goals), which in turn, influence future behaviour. Accordingly, past exercise was controlled as the strongest determinant of exercise intention and future exercise (Sutton, 2004). It was hypothesized that (Hyp. 4) ECEs would account for a significant proportion of variance in exercise intention after controlling for past exercise behaviour.

2.2 Method

Consistent with the investigation purposes of instrument development and the examination of validity, the methods are specific to these goals.

2.2.1 Measure Development

The E-CEQ was created as an exercise-specific cognitive errors measure. It was modelled after Lefebvre's (1981) CEQ measure, which uses item vignettes and a Likert response format to

assess cognitive errors of depression. Vignettes are an effective tool to help examine constructs that might otherwise be difficult to measure overtly (Aguinis & Bradley, 2014; Hughes & Huby, 2002). Recall that cognitive errors are not directly observable and are identified by their resultant thoughts (Milman & Drapeau, 2012). The use of vignette formatting was an apt means of operationalizing ECEs and was selected because it engages participants to think about relevant meaningful contexts (e.g., social interactions, exercise). Other assessment formats do not engage participants in the same way (e.g., narrative rating scale, Drapeau & Perry, 2010; Likert response without vignette items, Spence et al., 2005).

The original CEQ factors demonstrated adequate scale score reliabilities .62 to .94 and criterion-related validity with a number of clinical measures (e.g., pain, depression: Lefebvre, 1981). Factorial validity has been demonstrated in a sample of older adults (Scogin, Hamblin, & Beutler, 1986) and with the German version (Pössel, 2009).

Item scaling. Similar to the original CEQ (Lefebvre, 1981), the E-CEQ instructions requested that participants rate the extent to which they would think in a manner similar to the error reaction in the vignette. Each E-CEQ vignette item was scaled on a 9-point Likert scale ranging from 1 (*not at all like I would think*) to 9 (*exactly like I would think*).

Item content. The general CEQ and cognitive errors literature were used as conceptual guides for the operationalized errors. Drapeau and Perry (2010) describe the following cognitive errors. *Overgeneralization* occurs when "the individual makes a sweeping negative or positive conclusion that goes far beyond the situation" (p.26). *Emotional Reasoning* occurs when, "the individual thinks something must be true because he or she feels and believes it to be true, while ignoring or discounting evidence to the contrary" (p.34). *All-or-Nothin*g occurs when, "the individual views a situation as fitting into one of only two opposing categories, rather than as a mixture or on a continuum between the two" (p.30). *Mental Filter* occurs when, "the individual

pays undue and complete attention to only one aspect of an individual or situation without any acknowledgment of the other sides of the issue which would yield a whole picture" (p.39). *Catastrophizing* occurs when, "one predicts that the future outcome of some situation will be negative without giving consideration to more likely outcomes, which may be less negative" (p.18). *Halo Effect* maybe particularly apt for an exercise/health context in which, bad behaviours are seen as okay if engaging in other good behaviours (e.g., I don't smoke so I don't need to exercise; Boyes, 2013; Cooper, 1981).

Drapeau and Perry's (2010) model suggests that related cognitive errors form conceptually meaningful clusters. Whereas Overgeneralization represents its own unique cluster of errors in drawing conclusions far beyond the immediate situation, the other listed errors fall within the Selective Abstraction cluster. This cluster represents errors in attending exclusively to one particular feature of a situation in the belief that only that feature matters.

Following Drapeau and Perry's (2010) operational definitions, 30 brief vignettes, five for each of the six cognitive errors, were initially created. Each vignette depicted an exercise situation with an accompanying thought reflecting a cognitive error. An example vignette depicting the Overgeneralization ECE reads, "You consider starting an exercise routine, but think to yourself, 'I'm not good at sticking with anything. I'll probably quit after a month so why start'".

The six operationalized errors were selected based on two broad criteria (1) the cognitive error literature about non-psychopathological populations and their errors relative to other health behaviours, and (2) the hypothesized saliency within an exercise context. For the sake of brevity, consider the evidence used in operationalizing Catastrophizing as an example of the use of criteria to illustrate the selection of errors for the E-CEQ. Lefebvre's (1980; 1981) original CEQ, used as a model for the E-CEQ, has demonstrated that both depressed individuals and

individuals with lower back pain report high catastrophizing scores. Drapeau and Perry's (2010) model regards it as a common error of exaggerated negative future predictions. Literature concerning biased health beliefs suggests that catastrophizing biases can affect: chronic fatigue patients' cycles of activity and rest (Moss-Morris, Skerrett, Chalder, & Balwin, 2004), physical activity level of individuals with rheumatoid diseases (Edwards, Bingham, Bathon, & Haythornthwaite, 2006), and non-clinical obese individuals' reactions to failed diet attempts (Jones & Wadden, 2006). Finally, one of the most commonly reported perceived exercise barriers is the lack of time (Glasgow, 2008), a thought that, for some, may be the result of catastrophizing (e.g., "I can't justify exercising because I have so many other things to do.").

Exercise situations needed to be relevant to participants to provide a salient context to depict cognitive errors. For example, participants can place themselves in relevant situations such as joining an exercise class or biking. Less relevant to a majority of participants would be situations like running a marathon or doing parkour. Situation content was also informed by the perceived barriers literature; common exercise barriers (e.g., too busy, fatigued; Glasgow, 2008) were chosen to increase potential salience. Thus, the construction of the vignettes allowed participants to respond to realistic situations in reliable and valid ways even without experience with the situation (Hughes & Huby, 2002).

Two independent raters with psychosocial and physical activity measurement experience used four-point Likert scales to code the vignettes for their (1) exercise realism (1=*completely unrealistic situation* to 4=*completely realistic situation*) and (2) how well each vignette item was operationalized to reflect a specific cognitive error (1=*does not reflect the target error* to 4=*completely reflects the target error*). Raters were provided with a list of operational definitions. Vignette items that did not receive a perfect rating from both raters on either realism or operationalization were re-evaluated and either modified or culled from the list of potential

items. The two raters also provided qualitative feedback on item wording and content to enhance item quality/clarity. This entire item culling, modification, and reiteration process resulted in 24 total items, four items reflecting each of the six different cognitive error types. Of the six items removed from the original 30, two did not match the ECE definition, two did not represent a cognitively errored response, one was too similar to another item, and one was unrealistic. Both the literature review of errored thinking regarding health behaviours and the content examination process just described provided an initial indicant of the items' content validity (DeVellis, 2012).

2.2.2 Participants

Participants (*N* = 364) were *M* = 29.1 years old (*SD* = 11.6, Range = 18 to 72), 81.3% female, 96.1% Canadian, and had an average household income of $40,000 to $59,999. Eighty-one percent were Caucasian (7.1% Asian, 4.2% Aboriginal, 7.7% Other), and 11.4% had a high school diploma or less (36.8% had some college/university, 36.3% had a college diploma/university degree, and 15.5% a post-graduate degree). See Appendix A for more detailed participant demographic information.

2.2.3 Measures

General cognitive errors. The general Cognitive Error Questionnaire (Lefebvre, 1981) consists of 24 items. It is a trait measure which assesses 4 different types of common cognitive errors: catastrophizing, overgeneralizing, personalization, and selective abstraction. Ratings are given on a five-point Likert scale from 0 (*almost exactly like I would think*) to 4 (*not at all like I would think*). An example vignette item reads, "your boss just told you that because of a general slowdown in the industry, he has to lay off all of the people who do your job including you. You think to yourself, 'I must be doing a lousy job or else he wouldn't have laid me off.'" Scale scores were calculated by averaging all 24 items. Scale score reliability was excellent (α = .93; Tabachnik & Fidell, 2007).

Planned exercise. Participants reported their planned moderate and vigorous exercise over a typical week in the past month using a modified Godin Leisure-Time Exercise Questionnaire (GLTEQ; Godin & Shepard, 1985). Specifically, they were asked, "during a *typical week within the past four weeks*, how many times on average did you do the following kinds of exercise for 30 minutes or more during your free time?" Participants reported the number of bouts of moderate and vigorous exercise. This measure has been used previously (e.g., Flora, Brawley, Sessford, Cary, & Gyurcsik, 2015) in published research. The number of planned exercise bouts was chosen because the number and duration of bouts planned in a week requires self-regulation to attain (e.g., requiring conscious efforts to plan, schedule, and carry out) and planned exercise bouts of longer duration are more apt to be recalled and self-reported with greater accuracy compared to short bouts of unplanned activity (Cust et al., 2008). Frequency of planned 30-minute bouts is more likely to influence and thus be more sensitive (i.e., detectable) to the effect of cognitive errors (e.g., decisions to follow through with a planned 30 minute bout or to struggle with planning or adapting its scheduling).

Exercise intention. Cognitive errors should affect intentions (i.e., proximal goals), during the exercise decision-making process. Participants were asked a single item question "how many 30-minute or more bouts of moderate or strenuous exercise do you intend on doing in the next 7 days?" The question was correspondent with the behavioural measure and with goals being a part of the self-regulatory process. This one-item measure has been used in previous research and has demonstrated predictive utility (e.g., Bloomquist, Gyurcsik, Brawley, Spink & Bray, 2008).

2.2.4 Procedure

Following institutional ethics approval, participants were recruited through advertisements on online message boards in Canada (e.g., a university's online bulletin board,

Kijiji®, Craigslist®) and online groups (e.g., Facebook®, Yahoo®). Participating adults gave informed consent and completed an online survey (See Appendix B). Participants were eligible for a draw to win a $50 prepaid Visa® card.

2.2.5 Analytic Plan

Measure development. Exploratory factor analysis (EFA) was conducted with Mplus Version 7.31 (Muthén & Muthén, 1998–2012), using Mplus's robust maximum likelihood estimator (MLR) with a geomin oblique (epsilon = .5) rotation following recommendations by Marsh et al. (2009). MLR estimation is robust to violations of normality (Muthén & Muthén, 1998–2012). The relatively low levels of missing data present at the item-level (2.7% in total) were handled with full estimation maximum likelihood (FIML), the default method implemented in Mplus with the MLR estimator (Graham, 2009).

Estimating the number of factors and model fit. Parallel analysis and computation of model fit indices (i.e., chi square test of exact fit (χ^2), Root Mean Square Error of Approximation (RMSEA; and its associated confidence interval [CI]), the comparative fit index (CFI), and the Tucker-Lewis Index (TLI)) were used to examine the number factors and model fit. Parallel analysis is a Monte Carlo simulation that generates random data to compare eigenvalues obtained from the sample data to eigenvalues obtained from completely random data. The number of factors retained is specified when the eigenvalues obtained from the data are larger than the eigenvalues obtained at random. [2]

Assessment of model fit was based on multiple indicators as per recommendations (cf., Byrne, 2010; Hu & Bentler, 1999). Hu and Bentler (1999) suggest that RMSEA less than 0.06 indicate excellent fit, with best fit approaching 0.00; RMSEA of 0.08 indicate acceptable fit; and RMSEA > 0.10 indicate poor fit. The CFI and TLI range from 0 to 1.0. Values exceeding .90 for

both the CFI and TLI indicate adequate model fit (Byrne, 2005; Hu & Bentler, 1999), however, values greater than .95 are preferable.

Evidence for criterion-related validity. SPSS 20.0 was used for all criterion-related analyses. Recall, this purpose sought to examine relationships between the E-CEQ and other measures in gathering evidence of criterion-related validity. Correlations were examined to analyze hypothesis 1, regarding the relationship between the E-CEQ and the original CEQ, and hypothesis 2, regarding the relationship between the E-CEQ and exercise and exercise intention. Hierarchical multiple regressions (HMR) were conducted to analyze hypotheses 3 and 4. For hypothesis 3, the general CEQ was entered into step 1, followed by the E-CEQ in step 2 in predicting planned exercise bouts. For hypothesis 4, planned exercise was entered into step 1, followed by the E-CEQ in step 2 in predicting exercise intention. Given that exercise was a 7-day retrospective assessment and would serve as a basis for estimating future goals, placing intention as the dependent variable where the intent was amount of exercise over the future seven days was conceptually appropriate (Cohen, Cohen, Aiken & West, 2003).

2.3 Results

2.3.1 Measure Development

Examining multiple factor models. Five of the 24 items were omitted prior to the factor analysis because only 2 to 4% of the respondents (n = 9 to 18) rated the items at or above the scale mid-point (e.g., scoring a 5 or higher on a scale ranging from 1 to 9). This suggested that these vignette items depicted situations that were not sufficiently salient to retain. The five omitted items included one item created to represent Overgeneralization and all four items representing the Halo Effect. Thus, 19 items were factor analyzed. Models containing one through six factors were initially extracted. Parallel analysis suggested one factor. The five-, and six-factor models contained empty factors and were not admissible solutions. The one- and two-

factor solutions had poor fit to the data, while the three and four factor solutions had acceptable fit to the data (see Table 1).

Table 1. *Goodness-of-fit statistics for models examined for the E-CEQ*

# of items	# of factors	Fit Indices						
		Chi-square analyses			RMSEA analysis		CFI	TLI
		χ^2	*df*	*p*	RMSEA	90% C.I.		
19	1	599.231	152	<.001	.090	.082-.098	.799	.774
	2	451.055	134	<.001	.081	.072-.089	.857	.818
	3	296.154	117	<.001	.065	.056-.074	.919	.882
	4	260.632	101	<.001	.066	.056-.076	.928	.878
16	1	324.064	104	<.001	.076	.067-.086	.869	.849
	2	233.769	89	<.001	.067	.057-.077	.914	.884
	3	**164.353**	**75**	**<.001**	**.057**	**.044-.069**	**.947**	**.915**
	4†	108.07	62	<.001	.045	.031-.059	.973	.947

Note: †inadmissible solution containing empty factors. *N* = 364; *E-CEQ: Exercise-Related Cognitive Errors Questionnaire;* RMSEA: root mean square error of approximation; CFI: comparative fit index; TLI: Tucker-Lewis index. Models examined reflect the 19- and 16-item versions of the E-CEQ. Boldface coefficients display the fit indices of the16-item, three-factor retained model.

Large inter-item correlations and modification indices suggested correlated uniqueness between a set of three items (items 1, 10, and 19; .52 < *r* <.61) and between another set of two items (items 6 and 13; *r* =.68). A review of the content from the first set of three items suggested each pertained to being self-conscious about exercising, which represented a clear form of method error variance called parallel wording. A review of the other two items also suggested parallel wording; content for both items pertained to being too busy to exercise. Schweizer (2012) advocates against *post hoc* correlated uniqueness, thus, one item from each set (item 10 and 14) was retained. The authors selected these two clearest items for retention.

Models containing one through four factors were analyzed using the remaining 16 items. Parallel analysis suggested one factor. Model fit for the one-factor solution was poor, while the two- and three-factor solutions had good fit to the data (see Table 1). The four-factor model contained empty factors and was not an admissible solutions. The 16-item, three-factor solution had the best fit to the data, yielded interpretable factors, and was retained as the final model. Table 2 contains standardized factor loadings, item uniqueness, and scale score reliabilities. Appendix C contains a visual depiction of the final model. Based on these results, factor one (items 2, 3, 4, 9, 12, 14, 19; $\alpha = 70$) represents the Catastrophizing cognitive error, factor two (items 5, 6, 7, 8, 16, 18; $\alpha = 84$) represents All-or-Nothing thinking, and factor three (items 11, 12, 14, 15, 16, 17; $\alpha = 83$) represents Mental Filter. The reliability of the overall 16-item E-CEQ was acceptable ($\alpha = .88$).

2.3.2 Evidence of Criterion-Related Validity.

Regarding hypothesis 1, convergent validity with the CEQ (Lefebvre, 1981), there was a moderate-sized, significant positive correlation between the overall scores on the E-CEQ and the CEQ ($r = .406$, $p < .001$), supporting the concurrent relationship between the two measures as related but distinct.

Relative to hypothesis 2, there was a significant negative correlation between the overall E-CEQ score with the number of planned exercise bouts over the past week ($r = -.339$, $p < .001$) and exercise intention ($r = -.373$, $p < .001$). These results indicate that higher levels of self-reported cognitive errors were associated with lower levels of planned moderate to vigorous exercise engagement and lower exercise intentions.

Regarding hypothesis 3 and the prediction of planned exercise bouts, the general CEQ became non-significant ($p > .05$) in the second step of the HMR when the E-CEQ was entered as

a predictor (r^2_{change} = 0.103, p < .001). The E-CEQ contributed the majority of the accounted for variance in planned exercise bouts beyond the contribution of the CEQ. See Table 3 for results.

Table 2. *Standardized factor loadings and uniqueness for the final E-CEQ model*

Abbreviated item description	Factor one λ	Factor two λ	Factor three λ	δ
1. "They must be making fun of me because I'm doing this exercise incorrectly."	-	-	-	
2. "It's been so long since I've exercised that I'm going to be painfully sore for days."	**.46**	.04	.13	.70
3. "I haven't biked in years, I'm going to get way too tired to even be able to finish the ride."	**.53**	.27	-.08	.57
4. "Going that fast is going to really aggravate my medical condition."	**.50**	.00	-.09	.78
5. "Since I'm not going to have the energy to complete my usual routine I'll just start next week."	15	**.69**	.03	.43
6. "I can't justify exercising because I have so many other things to do."	.11	**.67**	.01	.47
7. "I'm going to take the week off because I have no exercise class."	.13	**.50**	.19	.53
8. "I'm never going to be able to achieve that."	.21	**.33**	.30	.56
9. "I shouldn't go play because I am going to injure myself again."	**.48**	-.14	.03	.76
10. "I'm going to feel self-conscious again and people are going to see that I don't know what I'm doing."	-	-	-	
11. "I'm not good at sticking with anything. I'll probably quit after a month so why start."	.17	.16	**.45**	.59
12. "I am not going to because I will be completely tired afterward."	**.34**	-.02	**.41**	.61
13. "There is a lot I still have to do tonight, exercise will really get in the way."	-	-	-	
14. "I'd better not, I know how sore I'm going to be after exercise."	**.35**	.11	**.58**	.44
15. "Exercising is a big drain on all the other fun things I could be doing."	.05	.09	**.71**	.46
16. "I don't really feel excited about it this week, I can start it next week."	-.02	**.54**	**.37**	.41

Abbreviated item description	Factor one λ	Factor two λ	Factor three λ	δ
17. "This is way too hard and no fun, and decide to stop going to the gym."	.09	.27	**.52**	.46
18. "I should just stay home instead of going to the gym today."	.25	**.36**	.25	.55
19. "I feel so uncomfortable that I don't want to go back."	**.32**	.29	.20	.59
Internal reliability (α)	.70	.84	.83	
Factor Correlations				
Factor two	.42			
Factor three	.42	.44		

Note: λ: standardized factor loadings; δ: standardized uniqueness. Items 1, 10, and 13 were omitted from the final measure because of parallel wording between items 1, 10, and 19 (self-conscious about exercising) and items 6 and 13 (too busy to exercise). Recall that items took the form of 2-3 line vignettes, each describing a situation with a cognitively errored response. Items reflect the extent to which the individual thinks similarly to the errored response. For the purposes of brevity only the thought response is presented here. Interested readers should contact the first author for full vignette descriptions. Boldfaced coefficients represent loadings retained for each factor.

Regarding hypothesis 4 and the prediction of exercise intention, past exercise was a significant predictor on step 1. The E-CEQ was a significant predictor ($p < .001$) when added in step 2 in the final model and contributed additional accounted for variance ($r^2_{change} = 0.049$, $p < .001$) beyond the contribution of past exercise. See Table 3 for results.

The total E-CEQ score was used in the foregoing analyses given our initial stage of research. We had no conceptual basis to hypothesize about individual factors. However, to be consistent with the findings from the factor analysis, we also examined the prediction of planned exercise bouts and exercise intention using the three factors as predictors.[2] We entered all three

[2] Review of the study during the publication process required the authors to present the contribution of individual factors to prediction.

factors into step 2 of the prediction model replacing the total E-CEQ score. Regarding the prediction of planned exercise, factors one and two were significant ($p < .05$). The three factors contributed an additional 10.5% ($p < .001$) accounted for variance. Regarding the prediction of exercise intention, none of the three factors were significant as individual contributors to prediction ($p > .05$). Collectively however, the three factors contributed an additional 4.9% ($p < .001$) accounted for variance beyond the contribution of past exercise. See Table 3 for results. We provide additional comment on these findings in the discussion.

Table 3. *Hierarchical multiple regression results for exercise and intention*

Dependent Variable	***F***	***df***	***Adjusted R^2***	**B**	***R^2 Change***
Hypothesis 3: E-CEQ total score					
Step 1	7.83	249	.027**		
CEQ				-.175**	
Step 2	19.12	248	.127***		.103***
CEQ				-.047	
E-CEQ total score				-.346***	
Three E-CEQ factors					
Step 1	7.83	249	.027**		
CEQ				-.175**	
Step 2	9.65	246	.122***		.105***
CEQ				.049	
Factor one				-.171*	
Factor two				-.233*	
Factor three				-.027	

Dependent Variable	*F*	*df*	*Adjusted* R^2	B	R^2 *Change*
Hypothesis 4 – E-CEQ total score					
Step 1	97.85	310	.237***		
Past exercise				.490***	
Step 2	62.92	309	.285***		.049***
Past exercise				.407***	
E-CEQ total score				-.237***	
Three E-CEQ factors					
Step 1	97.85	310	.237***		
Past exercise				.490***	
Step 2	31.12	307	.279***		.049***
Past exercise				.409***	
Factor one				-.051	
Factor two				-.110	
Factor three				-.097	

Note: *p<.05; **p<.01; ***p< .001. CEQ = cognitive errors questionnaire (Lefebvre, 1981). E-CEQ = Exercise-related cognitive errors questionnaire. Hypothesis 3 examined the utility of the E-CEQ beyond the contribution of the original CEQ in predicting the number of planned exercise bouts. Hypothesis 4 examined the utility of the E-CEQ beyond the contribution of past exercise in predicting exercise intention. For consistency sake, we examined predictive models including the overall E-CEQ score and the three individual factors.

2.4 Discussion

The overall purpose of this research was to create and provide validity evidence for a measure operationalizing cognitive errors specific to the exercise context.

2.4.1 Measure Development

The first step in this research involved creating vignette items to reflect ECEs. A number of different steps were utilized to demonstrate that items were content valid and reflected the content domain of exercise-related cognitive errors (DeVellis, 2012). First, the vignette format was modelled after an existing cognitive error measure (Lefebvre, 1981), which was useful for operationalizing ECE, that are, by nature, not directly observable. Second, cognitive error types

and definitions were drawn from a review of the cognitive errors literature (e.g., Drapeau & Perry, 2007; Leahy, 2003; Lefebvre, 1981) and literature demonstrating biased thinking regarding health behaviours (e.g., Anderson & Emery, 2014; Christensen, Moran, & Wiebe, 1999). Finally, the items were examined by two experienced raters in order to present relevant and realistic exercise-related vignettes for items.

The final 16-item E-CEQ consisted of three factors representing Catastrophizing, All-or-Nothing thinking, and Mental Filter cognitive errors. Prior to discussing which items reflect which cognitive error factors, a return to Drapeau and Perry's (2010) cognitive error model is instructive. First, Drapeau and Perry suggest that there may be high degree of similarity between the resultant thoughts produced by cognitive errors from the same cluster. Also, that a resultant thought can be the product of more than one cognitive error. For example, catastrophizing one's expected emotional reaction to a future situation (e.g., if I do vigorous exercise I'm going to hate it) would be the product of Catastrophizing and Emotional Reasoning. A different example is when two errors can produce similar resulting thoughts. For example, individuals might overgeneralize a past experience to cause them to think they will give up a newly started exercise routine. Others could make a Mental Filter error and see only one side of a situation leading to the decision to give up a newly started exercise routine.

Drapeau and Perry's (2010) premises provide a rationale for why items initially designed to assess different cognitive errors could load onto the same factor, particularly when errors are from the same cluster. They also offer explanation of item cross-loadings – the vignette responses may be eliciting more than one error. Regardless, item content for main loadings and cross-loadings has to be interpretable relative to the factor.

Factor one has five main item loadings and two cross-loaded items (see Table 2), which represent exaggerated predictions of future outcome associated with the Catastrophizing

cognitive error. Factor two has six main item loadings, which represent viewing a situation as being either black or white which is associated with the All-or-Nothing error. Factor three has five main item loadings and one cross-loading, which represent paying attention to only one aspect of a situation which is associated with the Mental Filter error. Three interpretable cross-loadings were retained in the final model.

2.4.2 Evidence of Criterion-Related Validity

The moderate-sized association between the E-CEQ and Lefebvre's (1981) general CEQ measure suggest that the two scales are measuring some similar but not identical content and are an indicant of convergent validity. Evidence for predictive validity was demonstrated through the relationship and significant proportion of variance accounted for in exercise bouts by the E-CEQ in comparison to the CEQ's non-significant prediction. Together these two findings provide additional support for content validity (i.e., relevance and realism of E-CEQ items rather than CEQ items in predicting physical activity).

The significant association between the E-CEQ with frequency of exercise bouts and with exercise intention also helped to provide preliminary support for the hypothesized negative relationships. That is, those with high ECE scores also reported engaging in fewer weekly bouts of exercise and expressed lower exercise intentions. These findings are congruent with previous health research demonstrating that biased thinking was associated with maladaptive health behaviours (e.g., poor adherence to treatment regimens; Anderson and Emery, 2014). The findings support the idea that ECEs are related to the frequency of self-regulated, planned exercise engagement.

The hypothesis that ECEs would account for a significant proportion of variance in exercise intention beyond the contribution of past exercise was confirmed. This examination also heeds the recommendation of Weinstein (2007) that controlling for past exercise experience,

a known determinant of social cognitions, avoids overestimation of their relative predictive utility. The demonstrated utility to predict future intention beyond that of past exercise contributes to the predictive validity evidence for the E-CEQ.

The total score was used in the initial analyses because there was no theoretical or conceptual reason why any one E-CEQ factor should account for more variance than another. At this stage in the research, our main purpose was to establish the relationship. However, for consistency sake with the factor analysis, we also used a predictive model including the three factors. The accounted for variance using all three factors as predictors in the second step was not markedly different from that accounted for when the total scale score was used. While the overall scale score may have more power and utility in examining associations, distinct factors representing individual cognitive errors require further examination in future research to determine their usefulness in identifying ECEs that may be countered through intervention (e.g., cognitive reframing; Leahy, 2003).

The relationships examined evidence of the E-CEQ's utility and addressed recommendations by Messick (1987) about a measure's validation being an ongoing process through investigations testing its utility. The criterion-related validity demonstrated is an important initial step in the validation process, as it speaks to the potential usefulness of the E-CEQ's overall score in understanding low exercise engagement.

2.4.3 Limitations

Given that this research reflects the beginning of the ECE measurement validation process, it is important to identify limitations. First, the current sample was collected online and is one of convenience, which cannot be considered as representative of the adult population. The study sample contained few older adults (over 65 years old), was mostly Caucasian, and from Canada. Additional validation with diverse samples will be necessary before the measure can be

considered to more broadly generalize to other populations. Second, the use of additional raters (e.g., 5 or more total raters; Lynn, 1986) concerning the face validity and exercise specificity would have provided additional confidence regarding content-validity. It has been suggested that more raters guards against change agreement (Dunn, Bouffard, & Rogers, 1999). However, this potential limitation may be attenuated by the strict criteria about item acceptability (i.e., only those with perfect ratings by both raters) used in the present study. Third, while the E-CEQ predicted exercise and adherence variables, this evidence is cross-sectional and should be interpreted as such. The importance of this finding is consistent with being an initial step in the validation process as one study cannot satisfy all the goals associated with the larger ongoing process of validation.

2.4.4 Implications and Future Research

Cognitive errors have been primarily examined as a part of depressive or anxious pathology in mental and physical health studies. A new contribution of this study to the literature is the use of the concept and measure of cognitive errors to investigate individuals' perceptions about their own exercise experience. The E-CEQ was developed with the notion that inactive to minimally active healthy adults make cognitive errors regarding exercise decisions. A form of valid assessment that is specific to an exercise context and salient to how respondents perceive the exercise context was needed versus measures borrowed from the cognitive errors literature. Responses to the more specific E-CEQ instrument indicated that the measure was not redundant with the more general measure (CEQ).

There are three primary research directions regarding the ongoing process of demonstrating reliability and validity evidence. First, test-retest reliability should be examined relative to the stability of E-CEQ scores across multiple measurement time points. This will also help to understand the temporal nature of ECEs. Second, relative to factorial validity, data from

additional samples is a future research goal in order to examine the factor structure via confirmatory factor analysis (Cudeck & MacCallum, 2007).

Third, ECEs are a phenomenon operationalized to reflect biased exercise-related thought processing. Recall that the E-CEQ is a measure designed to detect those individuals who selectively attend to only certain aspects of situations. Such errors are not observed in the majority of individuals, as Milman and Drapeau's (2012) model suggests that cognitive errors do not reflect normative attention to and processing of contextual information. Future research needs to determine if this bias reflects faulty information processing about exercise.

Following suggestions by Milman and Drapeau (2012), we would expect that individuals making ECEs would process exercise-relevant information in a biased manner which would differ from individuals who process information normally. Quasi-experimental research would allow us to examine whether ECEs, as measured be the E-CEQ, are related to one-sided information processing. For example, individuals with low E-CEQ scores may differentially attend to negative and limited information in making an exercise decision as compared to those with high E-CEQ scores.

This study was the first to create and validate a measure of cognitive errors specific to exercise-relevant thoughts for healthy adults. The steps taken to examine different forms of validity helped provide a platform (a) to continue to study this phenomenon and (b) from which to continue the validity process through ongoing investigation of the E-CEQ.

2.5 Segue between Studies 1 and 2

A logical step that follows from instrument development is to begin examining relationships between the construct of ECEs and key theoretical variables related to exercise adherence. If ECEs affect individuals' processing of exercise–related self-regulatory information, then some relationship should be evident between ECEs, self-regulatory social cognitions, and exercise-related behaviours. As mentioned previously, Social Cognitive Theory is a useful framework for understanding the regulation of, or the failure to regulate, health behaviours like exercise (Bandura, 1995; Luszczynska & Schwarzer, 2005). Self-regulatory skills are necessary for maintaining regular exercise (Vohs & Baumeister, 2011) and are integral components of cognitive behavioural intervention concerning dieting and exercising for cardiovascular risk factor reduction (Artinian et al., 2010). Examining a construct like ECEs in relation to self-regulatory social cognitions may expand our understanding of the failure to regulate regular exercise. For instance, thinking in a manner consistent with cognitive errors should be related to variables that concern the biased self-reflection people initiate when making decisions about exercising. The *first* and main purpose of Study 2 was to examine these relationships.

A *second* purpose of Study 2 was to examine individuals' perceptions of their exercise consistency in relation to ECEs and self-regulatory cognitions. Investigating ECEs in relation to individuals' perceptions of the pattern of exercise they believe they execute (e.g., consistent, inconsistent, no exercise pattern) might illuminate whether ECEs are related to individuals' personal views of specific behavioral patterns and their associated social cognitions. Cognitive errors are theorized to have an intermittent effect on behaviour. Thus, making an ECE may result in unhelpful thoughts, but these thoughts may not always lead some individuals toward exercise non-adherence. On the other hand, to the extent that stronger ECEs reinforce a pattern

of unhelpful thinking, individuals' perceptions of their exercise might tend towards "being erratic" or being a "non-exerciser". For this reason, a measure like perceived consistency might better reflect the effect of ECEs on individuals' estimates of their pattern of exercise than its direct impact on exercise adherence.

3 Study 2 – Perceptions of exercise consistency: Relation to exercise-related cognitive errors and cognitions[3]

3.1 Background

Many individuals fail to exert effective control over their health-related thoughts and behaviours (e.g., erratic attempts to quit smoking; multiple and varied attempts at dieting; not being regularly active; Vohs and Baumeister, 2011). Some are challenged by public health guidelines that regular exercise adherence should be at least five or more days of the week of 30 minutes of moderate to vigorous physical activity (PA; Haskell et al., 2007). Despite such widely recognized health knowledge, only about 15% of Americans adhere to physical activity guidelines (United States Department of Health and Human Services, 2008).

3.1.1 How People Define Their Own Adherence

Public health prescriptions about the amount of activity needed to bring about health benefits stress "regular" exercise; and this externally defined standard is specified to be most days of the week. However, do people actually focus on this standard when they consider themselves as being regularly active? What factors are associated with individuals' perceptions of their own patterns of exercise? Studies of exercise identity would suggest that individuals of similar identity strength could view themselves as having a consistent pattern of exercise, while differing in the absolute frequency or volume of exercise (cf. Strachan et al., 2010). For example, some individuals perceived themselves as consistent exercisers if they exercised twice

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[3]This manuscript has been published (citation follows). The manuscript formatting has been adjusted from the published article to meet dissertation formatting requirements. Appendix references have been added. The reference section has been removed and amalgamated into one section for the entire dissertation.

Locke, S. R. & Brawley, L. R. (2015). Perceptions of exercise consistency: Relation to exercise-related cognitive errors and cognitions. *Journal of Health Psychology*. 1-11. doi: 10.1177/1359105315611956

a week while others exercised six days a week and viewed themselves as regular. Both groups may see themselves as adherent to exercise. In other words, it is individuals' perceptions of their exercise regularity that helps to define their view of themselves as adherent, not some externally defined standard.

Interesting findings have emerged regarding the regulation of regular exercise engagement. Gyurcsik et al. (2002) compared consistent and inconsistent exercisers and found that inconsistent exercisers had more negative acute exercise thoughts, struggled more with these thoughts, and had lower self-efficacy for coping with these thoughts. Karoly et al. (2005) also found such self-regulatory differences between regular and irregular exercisers. These related constructs appear to suggest that there may be important social cognitive differences between individuals who differ in their perceived pattern of weekly exercise.

3.1.2 Influence of Cognitive Errors and Biases

Social cognitive models are useful in understanding health behaviour; however, Janis (1984) has argued that social cognitive models do not capture all factors that further our understanding of health behaviour. These models assume that health-related information is rationally processed and acted upon. However, biased information processing can influence how individuals perceive the situations they experience. Cognitive errors is one such factor that affects individuals' rational thinking. Taking cognitive errors into account in addition to known social-cognitive factors may broaden our identification of the psychological differences associated with the patterns of exercise that people believe they execute. As well, inclusion of a factor like cognitive errors may assist or clarify individual differentiations that go hand-in-hand with social cognitive differences associated with exercise adherence.

Cognitive errors are distorted information processes that are manifested by verbal statements. These statements reflect ways in which individuals' evaluate information that

indicate errors or biases rather than the average or normative evaluation of the same material (Milman and Drapeau, 2012). To illustrate the nature of cognitive errors, consider Drapeau and Perry's (2010) definition of the following cognitive errors as defined in their cognitive error assessment manual. *Emotional Reasoning* occurs when, "the individual thinks something must be true because he or she feels and believes it to be true, while ignoring or discounting evidence to the contrary". *Mental Filter* occurs when, "the individual pays undue and complete attention to only one aspect of an individual or situation without any acknowledgment of the other sides of the issue which would yield a whole picture".

While cognitive errors have been studied predominantly in psychopathological individuals (Drapeau and Perry, 2010; Lefebvre, 1981), initial research has shown that a non-clinical sample of exercisers report thinking in cognitively-errored ways in exercise situations. That is, 60% of participants agreed with thinking in a manner consistent with at least one of four exercise-related cognitive errors (ECEs: Locke & Brawley, 2015a). Although cognitive errors have received limited attention in regard to exercise adherence, literature concerning biased processing of other health behaviours is instructive.

Evidence suggests that biased or irrational beliefs might exacerbate the engagement of poor health practices and have been found to be related to: poor treatment adherence (Anderson and Emery, 2014), poor self-management during cardiac rehabilitation (Christensen, Moran, and Wiebe, 1999), lower confidence to self-manage chronic disease symptoms (Shnek et al., 1997), and excessive or inadequate rest leading to extreme cycles of activity (Spence et al., 2005). As well, Palascha et al. (2015) demonstrated that eating-specific dichotomous thinking, a form of the all-or-nothing cognitive error, mediated the association between restraint eating and weight regain in a non-clinical sample of adults. Collectively these findings indicate that cognitively-errored thinking can be detected relative to health-related factors among many individuals, not

just those with a mental health problem. Findings indicate that such errors may be distorting the processing and interpretation of health-relevant information.

3.1.3 Influence of Social Cognitions

Self-regulatory efficacy is a central part of the agency component of Bandura's (1986) social cognitive theory (SCT) and is concerned with individuals' confidence in their skills and abilities to self-monitor, goal set, schedule, and prevent relapse. These skills are necessary for individuals to persist with regular exercise (Bandura, 1986; Woodgate et al., 2005). According to SCT, exercisers mastering a regular, consistent schedule of physical activity should develop stronger self-regulatory efficacy beliefs than those individuals who exercise on an irregular and inconsistent basis (Bandura, 1997). Consequently, those who have lower self-regulatory efficacy should struggle in making the decision to engage in exercise, and should perceive regular engagement as more difficult (Bandura, 1997). Research supporting these predictions has been reported by Jung and Brawley (2010) with university students and by Glazebrook and Brawley (2011) with patients in cardiac rehabilitation.

Examining cognitive errors relative to social-cognitive responses of people who view themselves as regularly active, irregularly active, and not active may provide clues about why social cognitive reactions to exercise vary in different reports in the literature (e.g., Conner and Norman,2005; Hagger et al., 2002; Jung and Brawley, 2010).

3.1.4 Purpose and Hypotheses

Based upon the aforementioned literature, our first purpose was to examine differences in ECEs and social-cognitive beliefs about exercise relative to how individuals' perceive their pattern of exercise (e.g., regularity: consistent, inconsistent). It was hypothesized that those who perceive themselves as being consistent exercisers will report lower levels of ECEs than those perceiving themselves as being more inconsistent. Based on Bandura's (1986) social cognitive

theory as well as the social-cognition and exercise literature, the following hypothesis is advanced. Individuals perceiving an inconsistent pattern of exercise will report lower levels of self-regulatory efficacy and anticipated persistence to carry out planned exercise, as well as greater decisional struggle, and perceived difficulty of exercise management.

For our second purpose, we examined whether the strength of ECEs was related to social cognitions. Specifically, we hypothesized that those with high levels of ECEs would report lower self-regulatory efficacy and persistence, and higher decisional struggle and perceived difficulty in managing exercise.

3.2 Method

3.2.1 Participants and Recruitment

N = 364 adults consented and completed an online questionnaire (See Appendix D). This was the same sample of participants as was used in Study 1. Participants were *M* = 29.1 (*SD* = 11.6, Range = 18 to 72) years old, and 81.3% female, 96.1% Canadian, and had an average household income of $40,000 to $59,999. Eighty-one percent were Caucasian (7.1% Asian, 4.2% Aboriginal), and 11.4% had a high school diploma or less (36.8% had some college/university, 36.3% had a college diploma/university degree, and 15.5% a post-graduate degree). The study had approval from a university research ethics board. Participants were recruited through advertisements on online message boards (i.e., a university's online bulletin board, Craigslist®, Kijiji®) and online groups (i.e., Facebook®, Yahoo®). Participants were eligible for a draw for a chance to win a $50 prepaid Visa® card.

3.2.2 Measures

Demographics. Participants were asked to provide information about their gender, age, education, household income, country of residence, and ethnicity.

Exercise-specific cognitive errors. The Exercise-Related Cognitive Errors Questionnaire (E-CEQ: Locke & Brawley, 2015a) assesses cognitive errors that occur in relation to exercise and within an exercise context. The 16-item version of the E-CEQ represents the degree to which an individual believes that his/her thoughts are consistent with ECEs, which are based on a model of cognitive errors described by Drapeau and Perry (2010). Items took the form of very short vignettes (i.e., depicting a cognitively distorted response to an exercise situation). An example item reads, "You consider starting an exercise routine, but think to yourself, 'I'm not good at sticking with anything. I'll probably quit after a month so why start'". Participants responded to items on a nine-point Likert scale ranging from 1 (not at all like I would think) to 9 (exactly like I would think). Scores above the scale mid-point (5) indicate that an individual is thinking in a manner consistent with an ECE. The E-CEQ was reliable in the current study (α= .88). Initial content, factorial, and predictive validity has been presented (Locke and Brawley, 2015a). The overall scale mean was used in the first analyses examining exercise pattern differences. In the second set of analyses examining differences between high and low ECE groups, the E-CEQ was dichotomized at the scale mid-point (i.e., those above and below 5).

Planned physical activity. As a check on whether actual behaviour corresponded with the *pattern of exercise* individuals perceived, a recall estimate was obtained. Participants reported the number of *planned* 30-minute bouts of moderate and vigorous PA in which they engaged during the past week using a modified Godin Leisure-Time Exercise Questionnaire (GLTEQ; Godin and Shepard, 1985). The validity of the alteration to the scale (30-minute bouts) has been established in an adult sample (Amireault and Godin, 2012). The number of planned PA bouts was chosen because the number and duration of bouts planned in a week requires self-regulation to attain (i.e., requiring conscious efforts to plan, schedule, and carry out)

and frequency of planned 30-minute bouts might be more sensitive (i.e., detectable) to the effect of cognitive errors (i.e., decisions to follow through with a planned bout requiring 30 minutes or struggle with planning and adapting the scheduling of that 30 minutes).

Physical activity pattern. This one item, five-option ordinal measure asked participants to "select the description that best describes your pattern of exercise over the past four weeks." Five response choices were provided: (1) exactly same for the past four weeks, (2) the same for 3 of the 4 weeks, (3) different for 2 of the 4 weeks, (4) all four weeks were different, and (5) no exercise over the past month. An example was given for each item to increase understanding and response accuracy. Using pattern (1) above as an example: the response option read as, "my planned exercise frequency and duration were *exactly the same* for all four of the weeks (e.g., you completed the same planned activities each week for about the same amount of time)." Examining perceptions of exercise consistency over the course of a month may provide insight into the pattern that individuals believe characterizes their adherence. This measure was used as a five-option, categorical variable in the analyses.

Self-regulatory efficacy (SRE). Participants' confidence in their ability to manage their planned exercise was assessed using an 8-item measure (Cronbach's alpha = .93) pertaining to behaviours necessary to self-regulate exercise over the next two weeks (e.g., scheduling exercise, planning exercise sessions, overcoming barriers that may interfere with exercise; Jung and Brawley, 2010). An example item read, "over the next 2 weeks, how confident are you that you can arrange your weekly schedule in order to do your exercise no matter what?". Items were assessed using a confidence scale ranging from 0% (*not at all confident*) to 100% (*completely confident*) and were in accordance with recommendations in the literature (Bandura, 1997; McAuley and Mihalko, 1998; Woodgate et al., 2005). The overall scale mean was used in all analyses.

Anticipated persistence. Participants' persistence with carrying out their planned exercise was assessed using a 4-item scale (Cronbach's alpha = .94) ranging from 1 (*little or none*) to 9 (*as much as it takes*). The scale was modified from the original scale (Jung and Brawley, 2010) and adapted to concern cognitive errors. The item instructions cued participants to recall their responses from the E-CEQ. An example item reads, "how much are you willing to persist in order to carry out planned exercise and maintain your current exercise frequency for the next week, given you were experiencing some of the unhelpful thoughts?". The overall scale mean was used in all analyses.

Perceived difficulty. Participants' perception of how difficult it would be to carry out their planned exercise when experiencing a cognitive error was assessed using a 1-item Likert scale ranging from 1 (*not at all difficult*) to 9 (*extremely difficult*). The item instructions cued participants to recall their responses from the E-CEQ. Participants were asked to, "rate the degree to which you believe that it would be difficult to carry out planned exercise when you have unhelpful thoughts (ECEs)". This scale was a modified version of the original scale (cf. Jung and Brawley, 2010) to specifically reference difficulty when individuals experienced ECEs.

Decisional struggle. Participants' perception of the amount of struggle ECEs caused them in making exercise decisions was assessed. Again, item instructions cued participants to recall their responses from the E-CEQ. Participants were asked to indicate how much ECEs made them struggle with their decision to exercise on a scale ranging from 1 (*no struggle*) to 9 (*tremendous struggle*). This scale was a modified version of the original scale (Gyurcsik et al., 2002) to specifically reference struggle when individuals experienced ECEs.

3.2.3 Analytic Plan

Prior to conducting all main statistical analyses, univariate and multivariate assumptions were managed (Field, 2013). Recall that purpose one involved examination of differences

between consistent and inconsistent exercisers on ECEs and social cognitive variables. Two hypotheses were specified. First, a Welch's ANOVA (Welch, 1951) with a *post-hoc* Games-Howell test (Field, 2013) was conducted to examine differences in reported level of ECEs between participants who self-categorized themselves to one of the five different level of response about exercise consistency. Given this self-categorization results in groups of different size, procedures appropriate to examine groups of unequal size and different variances for the various dependent variables were needed. Both Welch's ANOVA and Games-Howell *post hoc* tests do not assume equal variances and group sizes (Field, 2013), produce lower type I error (Frost, 2014), and were appropriate for the current data. To assess the second hypothesis, a MANOVA with follow-up Welch's ANOVAs was conducted to examine the social cognitive and MVPA differences between the five exercise pattern groups. A Bonferroni correction was applied to the alpha level ($\alpha = .01$ [.05/5]) to account for type I error in conducting five Welch's ANOVAs (Field, 2013).

To examine the second purpose, a MANOVA with four Bonferroni corrected ($\alpha = .0125$ [.05/4]; Field, 2013) follow-up Welch's ANOVAs were conducted to examine the differences between participants with high and low levels of reported ECE on four key theoretical variables related to PA adherence. The E-CEQ was dichotomized between participants indicating they thought in a manner consistent with ECEs (i.e., higher level of ECEs, above the scale median of 5; $n = 89$) and those who did not think this way (i.e., lower level of ECEs, below the scale median of 5; $n = 260$). For all analyses, omega squared (Ω^2) effect sizes are presented and represent the magnitude of relationship. An omega squared of .01 represents a small effect, .06 represents a medium effect, and .14 represents a large effect (Field, 2013).

3.3 Results

3.3.1 Differences Between Perceived Exercise Pattern Groups

ECE level. Relative to hypothesis 1, there was an overall significant difference between the five exercise pattern groups on expressed level of ECE (Welch's $F(4, 357) = 17.53$, $p < .001$, $\Omega^2 = .16$). Means for the five exercise pattern groups are presented in Table 4. The results of the Games-Howell *post-hoc* indicated that individuals perceiving themselves as having more inconsistent patterns reported greater levels of cognitive error than did individuals who reported more consistent patterns of exercise. There were no significant differences in ECEs between groups 1, 2, and 3 (i.e., more consistent pattern groups); group 4 (i.e., inconsistent – no perceived pattern) had significantly ($p < .05$) higher levels of ECEs than groups 1 to 3; and group 5 (i.e., no exercise) had significantly higher level of ECEs than group 4 ($p < .05$), and groups 1 to 3 ($p < .001$).

Social cognitions. The omnibus MANOVA comparing individuals with different exercise patterns on social cognitive variables was significant ($F(16, 1248.00) = 6.721$, Pillai's Trace = .317, $p < .001$, *partial* $\eta^2 = .079$). However, the assumption of equality of the covariances was violated as Box's test was significant ($p < .001$). MANOVA is not robust to such violations, especially when group sizes are unequal, thus, interpreting the omnibus results with caution is suggested. Thus, to account for the violation, follow-up univariate Welch's ANOVAs were used (Field, 2013). These were significant indicating differences between the exercise pattern groups on the four social cognitive variables: self-regulatory efficacy (Welch's $F(4, 108.65) = 24.9$, $p < .001$), persistence (Welch's $F(4, 113.50) = 7.23$, $p < .001$), decisional struggle (Welch's $F(4, 114.21) = 10.39$, $p < .001$), and perceived difficulty (Welch's $F(4, 108.16) = 21.54$ $p < .001$). See Table 4 for means and univariate effect sizes. The direction of the means tends to follow what was observed in the ECE comparison. Specifically, means

reflect the differences between those perceiving that they have some pattern of consistent, planned physical activity and those self-categorizing themselves to inconsistent or no exercise groups.

Planned MVPA bouts. This check was to determine if pattern differences corresponded to self-reported PA differences using a validated recall measure. The Welch's ANOVA was significant (Welch's $F(4, 113.9) = 37.6$, $p < .001$) indicating that there was a PA difference between exercise pattern groups on their self-reported MVPA. The Games-Howell *post-hoc* tests revealed that those perceiving no pattern of regular exercise engagement reported engaging in significantly fewer bouts of planned MVPA than the three most consistent exercise pattern groups. These three groups did not significantly differ from each other.

Table 4. *Comparison of variable means and standard deviations for the five PA pattern groups*

Variables	*Effect Size* (Ω^2)	PA Pattern Groups *Mean*(*SD*)					*Post-hoc* between-group differences
		1 (*n* = 46)	2 (*n* = 65)	3 (*n* = 51)	4 (*n* = 162)	5 (*n* = 38)	
Exercise-related cognitive errors (ECEs)	.16***	3.04(1.58)	3.04(1.22)	3.54(1.47)	4.20(1.43)	5.29(1.55)	1, 2, 3 < 4 < 5
Self-regulatory efficacy (SRE)	.23***	71.92(21.9)	66.50(20.0)	52.15(23.18)	42.71(22.9)	33.25(29.0)	1, 2 > 3, 4 > 5
Perceived difficulty	.08***	5.86(2.2)	5.70(1.90)	5.94(2.07)	6.68(1.82)	7.46(1.80)	1, 2, 3, 4 < 5
Decisional struggle	.11***	5.28(2.0)	5.50(1.91)	5.67(1.96)	6.67(1.86)	7.30(1.94)	1, 2, 3 < 4, 5
Anticipated persistence	.21***	6.51(2.8)	6.34(1.66)	5.65(1.90)	4.60(1.52)	3.60(2.2)	1, 2, 3 > 4 > 5
Planned MVPA bouts	.31***	7.12(7.69)	6.46(4.53)	6.76(6.80)	3.24(3.53)	0(0)	1, 2, 3 > 4 > 5

Note: ***$p < .001$. Interpreting the *post-hoc* differences, "1, 2, 3 < 4 < 5" for example, indicates that group 5 is significantly larger than group 4; both 4 and 5 significantly larger than groups 1, 2, and 3. SRE ranged from 0 to 100. All other scales ranged from 1 to 9. Patterns of physical activity over the past four weeks; 1 = the pattern did not change over the past four weeks; 2 = same pattern three of four weeks; 3 = same pattern for two of four weeks; 4 = no exercise pattern; 5 = did not exercise. Ω^2 effect size conventions (Field, 2013): small = .01, medium = .06, large = .14. *Post-hoc* group differences assessed using Games-Howell correction.

3.3.2 Differences Between High and Low ECE Groups

Recall that this was the first group comparison based upon the new ECE variable. The omnibus MANOVA comparing individuals with higher and lower levels of ECEs on social cognitive variables was significant ($F(4, 312.00) = 29.81$, Pillai's Trace = .277, $p < .001$, *partial* $\eta^2 = .277$). However, the assumption of equality of the covariances was violated as Box's test was significant ($p < .001$). MANOVA is not robust to such violations, especially when group sizes are unequal, thus, investigators should be cautious interpreting this omnibus result. Consequently, the four follow-up univariate Welch's ANOVAs were used to examine the four social cognitive variables because they account for Box's test violations (Field, 2013). The Bonferroni-corrected ANOVAs ($\alpha = .0125$) were significant, demonstrating differences between those with high and low ECEs on the four social cognitive variables: self-regulatory efficacy (Welch's $F(1, 135.31) = 107.16$, $p < .001$), persistence (Welch's $F(1, 235.84) = 77.81$, $p < .001$), decisional struggle (Welch's $F(1, 208.09) = 68.91$, $p < .001$), and perceived difficulty (Welch's $F(1, 150.52) = 51.69$ $p < .001$). See Table 5 for means and univariate effect sizes. Those who reported higher levels of ECEs (i.e., above the ECE scale median) had lower self-regulatory efficacy to manage exercise, lower anticipated persistence, higher perceived difficulty to exercise, and more struggle with making the decision to exercise in comparison to those reporting lower levels of ECEs. See Appendix F for a correlation table of study variables.

Table 5. *Group comparisons between those reporting high and low exercise-related cognitive errors*

Variables	Effect Size (Ω^2)	Exercise-related cognitive errors			
		Lower level		Higher level	
		n	*Mean(SD)*	*n*	*Mean(SD)*
Self-regulatory efficacy	.25***	243	58.46(23.1)	78	28.32(22.1)
Anticipated persistence	.18***	260	5.61(1.9)	89	3.93(1.9)
Perceived difficulty	.13***	259	5.95(2.0)	89	7.61(1.3)
Decisional struggle	.16***	257	5.77(2.0)	89	7.45(1.5)

Note: ***p<.001. Ω^2effect size conventions (Field, 2013): small = .01, medium = .06, large = .14. Relative to the groups, lower level = below the scale median; higher level = equal to or above scale median. When making cognitive errors, higher ECE level participants are less efficacious, less persistent, perceive more difficulty with regular exercise, and struggle more with decisions about exercise.

3.4 Discussion

This theoretically-driven study examined two related research question to better understand (1) psychological differences between individuals with varying perceptions of personal exercise consistency, and (2) social cognitive differences between those who do and do not make exercise-related cognitive errors.

3.4.1 Perceptions of Exercise Patterns

Individuals' self-definitions as being consistent exercisers may be observed in the way they describe the pattern of their behaviour and which may, in part, reflect the various psychological factors motivating their self-regulation and exercise decisions. However, some individuals who struggle with regular exercise or do not exercise at all may be affected by how they think about exercise and exercise information. If the nature of their thinking is somehow biased or negatively one sided, such as "I can't do anything right with exercise; I feel it takes me more time and effort than I can afford", do they see PA through a different lens than others?

We investigated if cognitive errors were associated with perceptions of consistent and inconsistent exercise patterns and with social-cognitive beliefs associated with exercise patterns.

We found that those who perceived themselves as having more consistent exercise patterns reported lower levels of ECE than those who perceived their patterns as inconsistent. Those not exercising at all expressed the highest levels of ECEs. These findings support the relationships between biased thinking and health behaviours found in the health literature (e.g., dichotomous thinking and weight regain; Palascha, 2015).

We also observed social cognition differences between individuals who perceive their exercise as consistent or inconsistent. Those who perceived themselves as consistent reported more adaptive social-cognitive outcomes (e.g., higher SRE, lower struggle) than those who perceived themselves as being inconsistent. The magnitude of the effects was medium to large, which suggests that meaningful and robust social cognitive differences exist between the PA pattern groups. This supports findings by Karoly et al. (2007) and Strachan et al. (2010) who noted that perceptions of being an irregular exerciser might reflect participants' negative beliefs about their self-regulatory abilities. Overall, those who self-categorized as having partly or fully consistent patterns of exercise expressed social cognitions of similar strength. Differences only emerged when the former groups of participants were contrasted with those perceiving no consistent pattern. The latter individuals reported significantly weaker social cognitions, and still worse were those reporting no exercise.

3.4.2 Social Cognitive Differences Between ECE Groups

Compared to those who reported weak ECEs, those expressing stronger ECEs reported lower SRE to manage exercise, lower persistence with exercise management, higher perceived difficulty to exercise, and more decisional struggle. The magnitude of effects was large, which suggests that meaningful and robust social cognitive differences exist between the two groups. The observed social cognitive differences suggest that those who reported thinking in cognitively errored ways also expressed social cognitions at a level less than advantageous for the self-

regulation of exercise (Bandura 1986; 2005). In other words, in the face of challenges to carrying out that exercise, their adherence would be likely to suffer. ECEs could be one variable to help us better understand why individuals fail to exert control over their regular exercise participation.

Bandura (1997) has suggested that biased self-appraisals, like self-deception, can cause individuals to misconstrue their performances and improperly filter efficacy-relevant information. In line with this suggestion, it could be that ECEs affect social cognitions, because they are partly the constructions of *processing self-relevant information*. For example, the emotional reasoning cognitive error may lead individuals to have a unilateral focus on their negative affective state associated with not following through on planned exercise. In turn, when self-reflecting about not exercising, individuals may interpret this as a failed mastery experience, leading to lower confidence to manage their exercise (sources of efficacy: cf. Bandura, 1997). While this speculation is based upon the premises of the agency aspect of SCT, a causal investigation would help to verify its validity. Our example simply illustrates one ECE and SRE relationship based upon Bandura's (1997) notion that the development of efficacy beliefs can be affected by erroneous thinking.

3.4.3 Strengths

A new contribution of this study to the literature is the use of the concept and measure of cognitive errors to investigation of individual's perceptions of their own exercise adherence. The use of the E-CEQ in conjunction with the agency aspect of social cognitive theory provides insight about the psychological correlates of these adherence perceptions. The findings also provide additional evidence of the E-CEQ's utility and addresses recommendations by Messick (1987) about a measure's validation being an ongoing process through investigations testing its utility.

A second strength is that the investigation was based upon the agency aspect of SCT (Bandura, 1986). Individuals with varying perceptions of exercise consistency were differentiated, in part, by social cognitions important in the regulation of exercise (Bandura, 1986). Findings support Bandura's (1997) idea that inconsistent mastery experience (i.e., irregular or no exercise) is related to a lower sense of self-regulatory efficacy and associated cognitions. They appear to agree with his idea that the development of personal efficacy may be influenced by cognitive errors which selectively filter sources of efficacy information when individuals reflect on their behaviour.

3.4.4 Limitations

Our study was designed to examine whether there were differences between those who make and do not make ECEs and those who perceive themselves as being consistent or inconsistent exercisers. The findings are preliminary. The cross-sectional nature of the data limits us to conclusions about relationships. Desirable next steps are investigations about the dynamic nature of the relationships between SRE, ECEs, perceptions of exercise regularity, and exercise behaviour. Such causal investigations are exemplified by research questions such as: Does the presence of ECEs cause individuals to limit their exercise? Does it function as a pre-intentional process and indirectly affect SRE?

3.4.5 Implications and Future Research

As Bandura (1997) explains, individuals can form strong SRE beliefs based on how they perceive the mastery of their adherence even if their perceptions do not match externally defined criteria of behavioural adherence. In other words, perceiving oneself as being a regular exerciser may be more important than meeting exercise guidelines in developing strong efficacy beliefs. Those who are not meeting guidelines, but view themselves as being regularly adherent to

exercise may not see a need change and may be resistant to intervention. This is an important consideration relative to public health persuasion to increase activity (cf. Latimer et al., 2009).

ECEs are a phenomenon that may negatively impact exercise-related cognitions. However, future research needs to determine if ECEs reflects faulty information processing about exercise. That is, to determine if those making ECEs attend to negative and limited exercise information in making exercise decisions, which differs from individuals who process information normally. Examining this type of biased information processing is in line with cognitive error conceptualizations (Milman and Drapeau, 2012) and would help to validate the E-CEQ as a measure of exercise-related cognitive errors. Quasi/experimental research would allow us to examine whether ECEs, as measured be the E-CEQ, are related to one-sided information processing.

3.5 Segue between Studies 2 and 3

Studies 1 and 2 have provided evidence to suggest that cognitive errors are related to exercise and self-regulatory cognitions. Those reporting higher ECE scores exercised less, perceived themselves as exercising more inconsistently, and reported self-regulatory cognitions unlikely to enable adherence. These findings were commensurate with the ideas underlying the cognitive errors model (Milman & Drapeau, 2012) and spoke to the predictive utility of the E-CEQ measure. However, additional evidence regarding the link between making ECEs and detection of information processing biases characteristic of cognitive errors is needed to help strengthen the inferences based upon the cognitive errors model as applied to the exercise context. Examining differences among higher and lower ECE individuals with respect to the exercise information to which they attend and interpret would provide additional evidence of construct validity. Study 3 seeks to examine whether individuals who score higher on the E-CEQ measure also process information in biased ways.

4 Study 3 – Making One-Sided Exercise Decisions: The Influence of Exercise-Related Cognitive Errors[4]

4.1 Background

Exercise-related cognitive errors (ECEs) represent biased processing of exercise-relevant information. Preliminary evidence has demonstrated that ECEs are associated with lower physical activity (PA) levels and weaker adherence cognitions (e.g., lower self-regulatory efficacy; Locke & Brawley, 2015b). One gap in this literature is understanding whether individuals who make ECEs selectively process information about exercise situations. That is, do individuals who report thinking in cognitively errored ways demonstrate actual biased information processing? The type of processing associated with cognitive errors differs from individuals who do not make cognitive errors. The latter individuals have a more balanced consideration of situational information (i.e., not selectively one-sided). Examining the influence of ECEs on individuals' information processing would shed light on whether stronger ECEs could affect the information which individuals attend in an exercise situation as well as their decisions about exercise. Some background about how individuals process information generally, and with respect to cognitive errors is instructive.

4.1.1 Processing Information and the Use of Schemas

Schemas are used to help individuals process and filter incoming information (cf., Bargh & Chartrand, 2000; Thorndyke & Hayes-Roth, 1979). Schemas, or how people mentally

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[4]This manuscript is under review (citation follows). The manuscript formatting has been adjusted from the published article to meet dissertation formatting requirements. The future directions section has been removed and amalgamated into the general discussion. Appendix references have been added. The reference section has been removed and amalgamated into one section for the entire dissertation.
Locke, S. R., & Brawley, L. R. (accepted with revisions). Making One-Sided Exercise Decisions: The Influence of Exercise-Related Cognitive Errors. *Journal of Health Psychology*.

represent and view the world, are mental structures that classify and categorize information (White & Carlston, 1983). For example, when you think about exercising, a mental representation is activated that might be related to lifting weights or jogging on a treadmill. When faced with a decision or judgment in an ambiguous or uncertain situation, individuals use schemas to help organize and clarify ambiguity. They also draw on schemas to aid in "filling in the blanks" in the case of missing information. For example, when a friend asks if you want to go to the gym to exercise, your schema of exercise might cause you to think that you are going to be doing an aerobic workout, whereas your friend might intend weight training.

4.1.2 Biased Processing: Exercise-Related Cognitive Errors

Although schemas can assist in our completion of missing information to clarify an entire conceptual idea, they can give rise to cognitive errors (Beck, Rush, Shaw, & Emery, 1979; Drapeau & Perry, 2010). Milman and Drapeau (2012) define *cognitive errors* as "verbal statement[s] that suggest ways of evaluating information that reflect errors or biases away from the average or normative evaluation of the same material" (p.129). There are a number of key points to highlight from Milman and Drapeau's (2012) cognitive error definition relative to how information is processed.

First, cognitive errors are *thought processes*. They represent biased information processing that results in biased thoughts. Inasmuch as these are information processes that are not directly observable, they are identified by the thoughts that they produce. These thoughts are then examined to identify the specific cognitive error being manifested.

Second, the definition suggests that cognitive errors reflect information processing that differs from the normal or average evaluation. A person with errored thinking will interpret information in a way that is markedly different from the normal, adaptive processing of the same information among individuals who do not have biased thoughts. Finally, cognitive errors will

cause a person to process information in a biased or distorted manner. For example, an innocuous situation will be systematically misinterpreted by individuals who make cognitive errors. In turn, this leads to maladaptive emotional, cognitive, and/or behavioural responses.

In their cognitive errors review, Hertel and Mathews' (2011) suggest that such errors can contribute to attentional and interpretational information processing biases. Attentional processing biases concern the propensity to process specific information when interpreting social situations. For example, individuals may attend to only one aspect of the situation (positive or negative tone), while ignoring or diminishing information about the other aspect. Interpretational biases concern the processing of normal or ambiguous stimuli in a biased manner. For example, individuals who may only exercise with a friend might view exercising without that partner as too motivationally daunting and not worthy of consideration. Attention to other information or possibilities is not given. By contrast, individuals not making a cognitive error may perceive multiple ways of continuing exercise (e.g., call another friend, exercise on your own) and attend to this information.

To illustrate cognitive errors' effect on information processing, consider Drapeau and Perry's (2010) definition of the *Mental Filter* cognitive error defined as when "the individual pays undue and complete attention to only one aspect of an individual or situation without any acknowledgment of the other sides of the issue which would yield a whole picture" (p. 39). We might expect individuals making this error to display the attentional and interpretational biases described by Hertel and Mathews (2011) in processing exercise-relevant information. Given that only one-sided information about a situation is processed, these errors should also be related to individuals' adherence-related cognitions (e.g., self-regulatory efficacy, intentions) when making decisions or judgements about exercise.

4.1.3 ECEs Relation to Social Cognitions

Self-regulatory efficacy (SRE) is a central part of the agency component of Bandura's (1986) social cognitive theory. It is concerned with individuals' confidence in their self-regulatory skills and abilities such as self-monitoring, goal setting, scheduling, and preventing relapse. Individuals who make cognitive errors may be using biased sources of information to form their self-regulatory efficacy cognitions. For example, such one-sided processing (e.g., focusing only on the negative aspects) might elicit a struggle with exercise decisions and may affect related self-perceptions. These situational problems raise self-regulatory challenges, and those with weaker SRE beliefs tend to falter with subsequent action (Bandura, 1997). Thus, individuals with higher levels of ECEs may also exhibit lower SRE, greater perceived struggle with exercise decisions, and less anticipated satisfaction with an associated experience.

4.1.4 Purpose and Hypotheses

The first purpose of this study was to examine the effect of ECEs on the nature of information that individuals process from an exercise decision-making situation described in a vignette. We compared individuals with greater and lesser levels of ECEs with respect to their thoughts and reactions about the vignette, which served as indicants of which information was attended to and interpreted. As per the conceptualization of cognitive errors, those who do not think in a cognitively-errored manner should attend to a balanced proportion of facilitating and hindering content, whereas those who make cognitive errors should disproportionately attend to the hindering content. First, it was hypothesized that those with high ECEs will focus on a greater amount of hindering exercise content from the scenario than their counterparts. Second, when examining the overall tone of participants' thoughts (i.e., positive or negative), those with high ECEs will express a more negative valence compared to low ECE individuals.

Our second study purpose was to understand how participants would respond to the vignette relative to making the decision to exercise. Participants were asked to place themselves in the vignette and explain whether or not they would decide to exercise. Previous findings have demonstrated that those who make ECEs struggle more in making exercise decisions, and have lower PA intentions and engagement (Locke & Brawley, 2015b). Accordingly, it was hypothesized that those with higher ECEs would be more likely to decide *not to* exercise than low ECE individuals.

ECE groups were also compared with respect to participants' social cognitions after placing themselves in the exercise vignette. Given Bandura's (1997) notion about the importance of greater self-regulatory efficacy in response to situational challenges, individuals with greater and lesser ECEs should express social cognitive differences when placing themselves in the exercise scenario. It was hypothesized that individuals with high ECE would see the exercise decision in the vignette as being more difficult, have corresponding lower self-regulatory efficacy for exercising in that context, and struggle more with their exercise decisions than their low ECE counterparts.

4.2 Method

4.2.1 Participants

Adults (N = 138) aged 18 and older (M = 27.2, SD = 10.5) participated in the study. Participants were 76.8% female (23.2% male), 46.4% single (20.3% married, 29.7% in a relationship but not married, and 3.6% divorced). Concerning education, 52.2% had some university or college, 43.5% had at least a college diploma or university degree, and 4.3% had no college or university. About one-third of the sample worked full-time, one-third part-time, and one-third were not employed. The average household income bracket was between $40,000 and

$59, 999. Ethnic distribution was 81.8% Caucasian, 7.2% East Asian, 2.8% Native/Metis, and 8.2% other/unknown.

4.2.2 Measures

Exercise-specific cognitive errors. The Exercise-Related Cognitive Errors Questionnaire (E-CEQ; Locke & Brawley, 2016) assesses cognitive errors that occur in relation to exercise and within an exercise context. The 16-item E-CEQ represents the degree to which an individual believes that his/her thoughts are consistent with ECEs. Factorial and content validity has been presented (Locke & Brawley, 2016). The conceptual foundation for errors is a model described by Drapeau and Perry (2010). Items took the form of very short vignettes (i.e., depicting a cognitively distorted response to an exercise situation). An example item read, "You consider starting an exercise routine, but think to yourself, 'I'm not good at sticking with anything. I'll probably quit after a month so why start'". Participants responded on a nine-point Likert scale by answering the extent to which this thinking is like theirs. The response scale ranged from 1 (*not at all like I would think*) to 9 (*exactly like I would think*). The overall E-CEQ score was dichotomized at the scale mid-point (i.e., those above and below 5). Scores above the scale mid-point (5) indicate that an individual is thinking in a manner more consistent with an ECE. The internal consistency of the measure was acceptable ($\alpha = .90$, Tabachnik & Fidell, 2007).

Thought listing. Thought listing is a procedure used to capture information that an individual processes during a given task. Participants were asked, "please list up to 5 thoughts that you had while reading the scenario." The thought content was thematically coded and processing biases were examined. Thought listing has been used in previous research examining implicit thoughts while reading health-related advertisements (Berry, McLeod, Pankratow, & Walker, 2013; Pankratow, Berry, & McHugh, 2013).

Response to the exercise scenario. Participants responded to an open-ended question, "if you were put in this scenario, how would you respond (e.g., what would you think/do)? Please explain". This question was designed to elicit behavioural and cognitive responses to being placed in the exercise situation described in the scenario. The phrasing of the question was designed to avoid leading the respondent in a response direction (e.g., toward positive/negative responses).

Self-regulatory efficacy for planned exercise (SRE-P). Participants' confidence in their ability to manage their planned exercise was assessed using an eight-item measure pertaining to behaviours necessary to self-regulate exercise over the four weeks depicted in the scenario (e.g., scheduling exercise, planning exercise sessions, overcoming barriers that may interfere with exercise; Jung & Brawley, 2010; Shields & Brawley, 2007). An example item from this scale was, "over the month depicted in the scenario, how confident are you that you can arrange your weekly schedule in order to do your exercise no matter what?". Items were assessed using a confidence scale ranging from 0% (*not at all confident*) to 100% (*completely confident*) and were in accordance with recommendations in the literature (Bandura, 1997; McAuley & Mihalko, 1998; Woodgate, Brawley, & Weston, 2005). Internal consistency was excellent ($\alpha = .95$; Tabachnik & Fidell, 2007). The overall scale mean was used in the analyses.

Self-regulatory efficacy for facing cognitive errors (SRE-CE). Four SRE items based upon the same measurement recommendations and conceptual bases as cited above were used to assess participants' confidence in their ability to regulate their exercise when they were thinking in a manner consistent with cognitive errors (e.g., similar to facing a challenge/obstacle; Gyurcsik, Bray, & Brittain, 2004). Participants were asked to recall their most unhelpful thoughts reported in the E-CEQ when responding to the four SRE-CE items and then rate their efficacy in overcoming such thoughts when they were considering exercising during the exercise

scenario. The 4-item SRE-CE measure had excellent internal consistency (Cronbach's alpha = .95; Tabachnik & Fidell, 2007). The overall scale mean was used in the analyses.

Perceived difficulty. Participants' perception of how difficult it would be to carry out their planned exercise when experiencing a cognitive error was assessed using a 1-item Likert scale (Jung & Brawley, 2013) ranging from 1 (*not at all difficult*) to 9 (*extremely difficult*). The item preamble cued participants to recall their responses from the E-CEQ. Participants were asked to, "rate the degree to which you believe that it would be difficult to carry out planned exercise when you have unhelpful thoughts".

Decisional struggle. Participants' perception of the amount of struggle ECEs caused them in making exercise decisions was assessed using a one-item Likert scale (Gyurcsik & Brawley, 2002; Gyurcsik & Estabrooks, 2004) ranging from 1 (*no struggle*) to 9 (*tremendous struggle*). The item preamble cued participants to recall their responses from the E-CEQ. Participants were asked, "how much do these thoughts make you struggle with your decision to exercise?"

Message quality checks. Checks on the quality of the description of the exercise situation described in the vignette was assessed. Consistent with other studies in the exercise literature using message and vignette description checks (e.g., Pankratow et al., 2013), participants responded to six items assessing their ability to (1) relate to and (2) understand the situation in the vignette, its, realism for both (3) hindering and (4) facilitating content, as well as its (5) readability and (6) believability. Each check was individually examined as an indicant of message quality. An example item read, "the problem scenario was easy to read." Items were scaled on a nine-point Likert scale ranging from 1 (*strongly disagree*) to 9 (*strongly agree*).

4.2.3 Stimulus Material: Detailed Exercise Vignette

Vignettes are an effective tool to help examine constructs that might otherwise be difficult to measure overtly (see reviews by Aguinis & Bradley, 2014; Hughes & Huby, 2002; Wallander, 2009). They have been used in numerous and diverse circumstances to examine unobservable phenomena (e.g., understanding disease-related stigma; Schute, 2002). Responding to a vignette was apt means of examining cognitive errors and some of the biases outlined by Hertel and Mathews (2011).

In the present study, the vignette depicted a fictitious character who was considering relevant information in making the decision to exercise over the next month. The vignette contained equal amounts of content regarding information that would facilitate and would hinder the decision to exercise, which was designed to elicit processing differences between high and low ECE groups. The types of content used in the vignette were derived from published literature about exercise barriers (e.g., too busy, too tired; Glasgow, 2008) and facilitators (e.g., social support, perceived well-being; Tulloch, Sweet, Fortier, Capstick, Kenny, & Sigal, 2013). An example of facilitating content was, "Cory has access to free exercise facilities through his partner's work benefits". An example of hindering content was, "…with the increased workload, Cory has been getting up an hour and a half earlier".

Factors affecting information recall were also addressed (Krosnik, 1990). First, the vignette was short (270 words) to minimize information overload. Second, facilitating and hindering content were designed to be of similar length. Third, the order of the three scenario paragraphs was randomized to prevent order effects. Fourth, the vignette was written at a Flesch-Kincaid reading level of grade 7.9 to ensure comprehension. Fifth, male and female versions of the vignette were created to enhance the scenario's salience. The scenario character was given a gender-neutral name, Cory, and pronouns used in the scenario were either male or

female based on participants' self-reported gender. There were no response differences between the male and female version of the vignette.

Prior to the main study, the vignette was pilot tested to ensure that the context in which participants were asked to place themselves was salient. Pilot participants (N = 10) rated the scenario content as readable and realistic (scores above seven out of nine). Minor phrasing and content changes were made to improve the final vignette on the basis of this feedback. The final vignette can be found in Appendix E.

4.2.4 Procedure

Participants were recruited through online bulletin boards (e.g., a university's online bulletin board, Kijiji). They completed an online questionnaire that was approved by a university's research ethics board (See Appendix E). Participants first read a vignette about an exercise situation, then listed up to five thoughts they had while reading the scenario. After reading and being instructed to place themselves in the situation described in the vignette, they responded to the measures previously described. Finally, they responded to the manipulation checks.

4.2.5 Analytic Plan

Thought listing. A researcher with experience in qualitative content analysis read and coded the thought-listing responses. Thoughts were coded verbatim (i.e., thematic codes were assigned to the thoughts exactly as stated by the participant). This procedure follows that of other studies using past thought-listing analysis (e.g., Pankratow, Berry, & McHugh, 2013). Thought coding was conducted in three steps. First, the researcher read through all of the listed thoughts to generate themes as they emerged from the data. Second, thought content was coded using the emergent themes from the first step. Third, to check on reliability of the coding scheme and percent agreement between different coders, a second researcher coded a random

selection of one-half of the thoughts. The two raters had an 88% agreement (Kappa = .82) on the thematic codes. The raters discussed any discrepancies until they reached agreement

Valence. A valence code was created for each participant by subtracting the number of negative statements from the number of positive statements observed in the thought-listing. Each thought was coded as positive (+1), neutral (0), or negative (-1). This procedure is in line with previous thought-listing (Pankratow et al., 2013) and acute exercise thought research (Gyurcsik & Brawley, 2001).

Comparing themes between ECE groups. Independent sample t-tests (with unequal variance correction as needed; Field, 2013) were conducted to examine processing differences in the thought content (i.e., emergent themes and valence) between those with high and low ECE scores. In this way, we examined if the emergent themes showed a consistent pattern due to something other than chance. Field (2013) recommends this type of analytic procedure when comparing two unbalanced groups that violate the assumption of homogeneity of variance, as was the case with the current data. Other analytic procedures are not robust to such violations (e.g., MANOVA). T-tests were not conducted for themes where the power dropped to a low level (i.e., too few responses [n=10]) or where comparisons were uninterpretable (e.g., comparing the number of miscellaneous responses between groups).

Decision to exercise. Chi-square test was used to examine differences between the high and low ECE groups on their decision to exercise given the situation proposed in the vignette. Recall that participants were asked what they would do given the conditions in the vignette. Thus, the frequency of responses coded as “yes, I would exercise” and “no, I wouldn’t exercise” were compared between groups.

Social cognitive differences. Independent sample t-tests (with unequal variance correction as needed; Field, 2013) were conducted to examine differences in participants’ social

cognitions (i.e., SRE-P, SRE-CE, difficulty, decisional struggle) about being in the vignette between those with high and low ECEs.

Message quality checks. First, means and standard deviations of the message quality checks (i.e., ability to relate to and understand the situation in the vignette, its realism for both hindering and facilitating content, as well as its readability and believability) were examined. Next, t-tests were used to examine whether or not the high and low ECE groups were differentially perceiving message quality. The *a priori* alpha was set at a higher threshold ($p < .2$) to avoid type 1 error in examining the alternative hypothesis (i.e., expect no differences).

4.3 Results

4.3.1 Thought-listing

Participants ($N = 138$) listed a total of 368 separate thoughts. On average, participants listed 2.66 thoughts out of a maximum of 5. In terms of the phenomenology of the themes, there were eight emergent themes. For two emergent themes ("Stated benefits/enjoyment of exercise" and "Related to the character"), had too few responses to make statistical comparison meaningful. The final two emergent themes ("The character in the scenario is bad at prioritizing" and "Miscellaneous") did not yield interpretable or meaningful comparisons. In considering four themes for further examination, we chose to employ comparison tests to determine if these themes showed a consistent pattern between the high and low ECE groups (Table 6).

Table 6. *Thought-listing themes by low and high ECE group*

Theme	**Low ECE group: Average number of thoughts (*raw number*)**	**High ECE group: Average number of thoughts (*raw number*)**	***Cohen's d***
Focus on hindering content from the scenario	1.01(110)	1.55(45)	.50**
Focus on facilitating content from the scenario	.83(90)	.28(8)	.83***
Suggested the character should exercise	.84(92)	.45(13)	.45*ǂ
Suggested the character should not exercise	.22(24)	.31(9)	.08ǂ
Overall Group Valence	.29	-1.07	-.74***

Note: *p<.05; **p<.01; ***p<.001. ǂ indicates variance corrected t-test. Cohen's d effect size conventions: small = .2, medium = .5, large = .8. Percentage Low ECE group (n = 109) and High ECE group (n = 29). Regarding the average number of thoughts, 1.55 for the first theme indicates that participants in the high ECE group reported an average of 1.55 thoughts that focused on hindering content from the scenario.

4.3.2 ECE Group Comparisons

Results comparing high (score at or above the scale midpoint of 5; n = 29; M = 5.77, SD = .96) and low (score below the scale midpoint of 5; n = 109; M = 2.82, SD = .64) ECE groups on the emergent themes are also presented in Table 6. There were no significant demographic differences (p<.05) between ECE groups. In examining the comparisons, the proportion of the responses appears to be consistent with the nature of ECEs as was hypothesized. Those in the high ECE group thought about a significantly higher proportion of hindering scenario content (t = -2.41, p < .01, d = .5; e.g., "She must really be tired") and a lower proportion of facilitating content than those in the low ECE group (t = 3.97, p < .001, d = .83; e.g., "The support from family and friends could help her maintain her exercise goals"). Those in the high ECE group were less likely to suggest that the scenario character should exercise (t = 2.17, p < .05, d = .45; "She would likely exercise"). A greater proportion of the high ECE group (.31) more often thought that the character in the scenario should not exercise (t = .69, p > .05, d = .08; "Likely

give up exercise as a priority") as compared to the low ECE group (.21). While this comparison was not statistically significant, the proportions are in the hypothesized direction. The other two themes were underpowered but followed the hypothesized direction. A greater proportion of the high ECE group more often stated that they related to the character in the scenario, and less often stated general exercise benefits.

4.3.3 Valence Comparison

There was a significant difference (t = 3.09. p < .001, d = .74) between the thought valence total of the low and high ECE groups. Those in the high ECE group reported a lower and negative valence (negative average valence = -1.07) as compared to the low ECE group (positive average valence = .29).

4.3.4 Decision to Exercise

Regarding the participants' responses to placing themselves in the scenario and making an exercise decision, there was a significant difference (χ^2 = 10.106, df =1, p < .001, d = .59) between high and low ECE participants. A higher proportion of individuals in the *high* ECE group responded that they would *not exercise* (high = .52 [13/25] VS low = .21 [21/102]). By contrast, a high proportion of individuals in the *low* ECE group said that they *would exercise* (high = .48 [12/25] VS low = .79 [81/102]).

4.3.5 Differences in Social Cognitions

After reading the vignette, participants were asked to place themselves in the situation and then respond to number of social cognitive measures related to exercise adherence (cf. measures section: SRE-P; SRE-CE; difficulty; struggle). See Table 7 for ECE group comparisons. Compared to low ECE individuals, those with high ECEs reported significantly lower SRE-P (p < .001), and SRE-CE (p < .001). They also perceived that their personal exercise in the vignette situation would be more difficult (p < .001), and that they would have a

greater struggle in deciding to exercise ($p < .001$), than those with low ECEs. These social cognitive findings support the hypothesized group differences. See Appendix G for a correlation table of study variables.

Table 7. *Differences between high and low ECE groups on exercise cognitions*

Variable	**Low ECE Mean(SD)**	**High ECE Mean(SD)**	***t-value***	***Cohen's d***
Self-regulatory efficacy to manage exercise	69.32(19.12)	38.20(17.92)	7.70***	1.65
Self-regulatory efficacy to manage ECEs	66.15(19.96)	37.36(15.58)	7.04***	1.50
Perceived difficulty of exercise scenario	5.04(2.05)	6.64(1.83)	-4.00***	.80
Struggle in making the decision to exercise	4.67(2.23)	7.07(1.36)	-7.06***	1.15

Note: ***p<.001. Analyses were conducted using t-tests with unequal variance correction as needed. ECEs = Exercise-related Cognitive Error. Cohen's *d* effect size conventions: small = .2, medium = .5, large = .8. Participants responded to all variables with regards to being in a situation similar to the one depicted in the vignette.

4.3.6 Message Quality Checks

Message quality was demonstrated based on the six message quality checks (scale range 1[*not realistic*] to 9[*completely realistic*]): relatable (M = 6.1, SD = 2.2), realistic hindering content (M = 7.6, SD = 1.7), realistic facilitating content (M = 7.6, SD = 1.7), understandable (M = 7.6, SD = 1.8), readable (M = 7.1, SD = 2.1), and believable (M = 7.5, SD = 1.8). There were no differences between the high and low ECE groups on their perceptions of the six message quality items ($ps > .2$).

4.4 Discussion

The main purpose of this study was to investigate information processing differences between participants with higher and lower exercise-related cognitive errors. As hypothesized, high ECE individuals *processed the exercise-relevant information described by a vignette in a biased manner differing from individuals scoring lower on the ECE measure.* This bias was

reflected in the themes of participants' responses to the vignette as well as in their social cognitive reactions to the vignette.

According to the cognitive errors model, cognitive errors should only be reported in a smaller subsection of the population – as for example, when depressed individuals are reporting cognitive errors (Lefebvre, 1981). This should also follow for the exercise context. The current results supported this. Approximately one-fifth of the sample reported high ECE scores (n_{high} = 29 VS n_{low} = 109). Indeed, it is "reassuring" to note that not everyone engages in biased thinking.

4.4.1 Thought Listing Phenomenology

Interpretable themes emerged from participants' thoughts while reading the scenario, which supported the hypothesized group differences. Two themes characterized participants' thoughts about vignette content which either (1) hindered or (2) facilitated the decision to exercise. ECE group differences on these two themes suggested that those in the high ECE group had a biased focus on vignette content that would hinder exercise whereas those in the low ECE group had a more balanced focus of hindering and facilitating content. The high ECE group's proportion of hindering to facilitating content was a disproportionate ratio of 5.6 to 1 whereas the low ECE group's ratio was 1.22 to 1.

Thoughts about exercise benefits also illustrated a bias. According to the nature of cognitive errors, those higher in ECEs should fail to consider the positives of exercise. Results supported this bias. While the low ECE group thought about the importance of exercise, such thoughts were predominantly absent within the high ECE group. Finally, people in the low ECE group were more likely to decide to exercise as a result of being in the scenario. In contrast, individuals in the high ECE group rarely mentioned anything about the positive aspects of exercise. While our conclusions are primarily based on those four comparisons with sufficient

power, the other two themes lacking power followed the same interpretable pattern. The pattern suggested that the high ECE group displayed a notable absence of positive exercise thoughts, reflecting one-sided information processing. The high ECE group had a distinctly negative valence to their thoughts and the low ECE group, a slightly positive valence. The low ECE group are individuals who do not think in cognitively errored ways. As noted earlier, their more even-handed processing of information results in an almost neutral valence as might be expected based on the cognitive errors model (Milman & Drapeau, 2012). These findings are commensurate with attentional processing biases described by Hertel and Mathews (2011). This type of one-sided information processing would be consistent among individuals expressing the Mental Filter cognitive error. Individuals making this error pay undue and complete attention to only one aspect of a situation (Drapeau & Perry, 2010).

4.4.2 Differences in Social Cognitions

Bandura (1989) notes challenging circumstances require individuals to exert self-regulatory efficacy over their thoughts, feelings, and behaviour. Weak efficacy beliefs are theorized to lead individuals to fail in regulating their thoughts and behaviour. To test the efficacy premise, placing individuals in potentially challenging circumstances is thought to create conditions whereby those having lower self-regulatory efficacy may think and act in ways that detract from self-regulatory pursuits. When challenged, participants with less efficacy would express thoughts and feelings counterproductive to exercise decision-making. In the present study, vignette circumstances represented a challenging situation. Participants processed information about circumstances that would make deciding to exercise regularly more difficult. As hypothesized, those in the high ECE group perceived that set of conditions as significantly more difficult and reported lower self-regulatory efficacy as compared to those in the low ECE

group. Those who reported high ECEs also reported more struggle in making the decision to exercise.

Self-regulatory efficacy and decisional struggle are social cognitions identified as being related to PA adherence (Bandura, 1986; Glazebrook & Brawley, 2011; Gyurcsik, Brawley, & Langhout, 2002). Collectively, lower scores on these beliefs and participants' report of less enjoyment may influence high ECE individuals to decide not to carry out planned exercise. However, our finding is one of parallel response rather than cause-effect. The latter will require a future experimental study.

Considered together, our social cognitive findings suggested interpretational biases were associated with cognitive errors similar to those described in Hertel and Mathews' (2011) review. The high ECE group had biased interpretations of the vignette, which differed from their low ECE counterparts. This supports Beck's (1976) description of cognitive errors and the E-CEQ operationalization of cognitive errors about exercise situations.

4.4.3 Strengths of the Study

Using an ECE measure based upon a conceptual model (Milman & Drapeau, 2012) was one investigation strength as it informed the hypotheses about processing differences. The demonstrated processing biases also supported the E-CEQ's operationalization of cognitive errors towards exercise.

Another strength was the careful design of the detailed exercise scenario, which adhered to recommendations about designing vignettes (e.g., Aguinis & Bradley, 2014). This included tailoring to gender, creating realistic content (i.e., corroborated by content and quality checks), and balancing amounts of facilitating and hindering content and their paragraph placement.

The vignette methodology and thought-listing procedure are complementary procedural strengths. They are particularly useful strategies for gathering inferential data to detect

unobservable phenomena such as making cognitive errors (Pankratow et al., 2013; Voncken, Bögels, & de Vries, 2003). The cognitive error phenomena are *not directly observable* except by the thoughts and reactions that they produce (Milman & Drapeau, 2012). The use of a vignette allowed us to examine participants' interpretation of a realistic exercise decision-making situation. The use of thought-listing as an outcome allowed us to examine interpretational and thought processing differences between those reporting high and low ECE levels.

4.4.4 Limitations

As with any investigation, there are potential caveats. The measurement of adherence cognitions at post-test only could be considered a limitation but was specifically necessary to avoid biasing participants' responses before they read the vignette. The post-vignette measures asked participants to respond relative to managing exercise upon placing themselves *in the vignette*. Thus, the social cognitive differences between ECE groups were those in relation to participants imagining themselves exercising in the vignette conditions. Future investigations could use a pre-post design to examine whether erroneous information processing about real world challenges to exercise decisions affects the social-cognitive responses of high ECE individuals.

5 General Discussion

Like many other cognitive behavioural constructs and intervention techniques used in health psychology, the concept of cognitive errors originated from a clinical understanding of maladaptive psychopathology (Beck, 1976). In support of applying the cognitive error framework to our understanding of inconsistent exercise adherence, Janis (1984) has suggested that irrational thinking may aid our understanding of maladaptive health behaviours. Milman and Drapeau's (2012) recent cognitive error conceptualization has enabled their examination beyond the psychopathological domain to within the exercise context. Consideration of the utility of this construct for understanding psychological aspects of exercise self-regulation was a focus of this dissertation research. The series of studies that comprise the dissertation was predicated on the notion that biased information processing influences individuals' perceptions of the situations they experience. The unhelpful thoughts resulting with cognitive errors may make regular exercise engagement more difficult.

This research represents the first investigation of cognitive errors specific to an exercise context. The three studies represent first-generation research with the goal of broadening of our understanding ECEs. This was accomplished through development of an exercise-related cognitive error measure (the E-CEQ) and the subsequent examination of ECEs predictive and convergent validity. Links between ECEs, perceptions of behavioural patterns, exercise social cognitions, exercise behaviour and finally, indicants of information-processing biases were examined. A summary of findings from all three studies can be found in Table 8.

5.1 Study 1

Study 1 undertook an iterative development process in the construction of the Exercise-Related Cognitive Errors Questionnaire. The final 16-item E-CEQ factorial model consisted of 3 factors and had acceptable psychometric properties. The three factors represent Catastrophizing,

All-or-Nothing Thinking, and Mental Filter cognitive errors. Catastrophizing occurs when an individual anticipates that a future outcome of some situation will be negative without giving consideration to more likely less negative outcomes (e.g., “I’m too busy to attempt regular exercise”). All-or-Nothing thinking occurs when an individual views a situation as fitting into one of only two opposing categories (e.g., “Since I don’t give 100% of my energy, I can’t workout today”). Mental Filter occurs when an individual pays undue and complete attention to only one aspect of an individual or situation without any acknowledgment of the other sides of the issue which would yield a whole picture (e.g., “I don’t exercise because it’s just no fun”).

Regarding the interpretation of the factors described above, some clarification is useful. There are items that cross load on the factors and this raises a point about valid item-to-factor relevance. Two points should be noted. First, retaining cross-loadings in a factor structure might be questioned when individuals first read about a new measure. Such questions may be raised because there are general magnitude conventions about item loading on any given factor (e.g., .3 or .4). However, these rules of thumb are somewhat arbitrary and the primary consideration driving cross-loading retention is interpretability. Cross-loadings may better represent the reality of the item indicators (Asparouhov, Muthén, & Morin, 2015). Recall that according to the Milman and Drapeau (2010) model, a biased thought can be caused by more than one cognitive error. The three retained cross-loadings were interpretable within this model, as discussed in Study 1 (i.e., for additional discussion of cross-loadings see Appendix A).

Evidence of predictive and convergent validity were also examined. Predictive validity evidence was presented through the negative relationship between the E-CEQ and exercise and exercise intention. These findings support the idea that stronger ECEs are negatively related to a lower frequency of self-regulated, planned exercise engagement. It is interesting to interpret these findings in light of Bandura’s (1986) notion of the dynamic, reciprocal relationship

between cognitions and behaviour. The relationships between past exercise and future exercise intention, while concurrent, suggest a need for future examinations of a potential dynamic, causal relationship.

The question of whether or not individuals can make cognitive errors if there is no intention to exercise is interesting. Clarification through the lens of the cognitive errors model may be useful. Consider the attentional biases associated with cognitive errors (Hertel & Mathews, 2011). Undue and unilateral focus to the negatives of exercise could cause a non-exerciser to either avoid forming an exercise intention or to form a conscious intention NOT to exercise. Thus, the inclusion of non-intenders in the dissertation broadens our understanding of the nature of ECEs as well as sparking future inquiry into the impact of ECEs on both intenders and non-intenders.

A related question is "who makes exercise-related cognitive errors? To clarify, it should be emphasized that while those reporting high ECEs were *more likely* to exercise less, high ECEs are not synonymous with non-exercise. Further, not all exerciser individuals reported low ECEs. In response, it is important to note that some non-exerciser and exerciser participants reported high ECEs. Reasons why low ECE non-exercisers and high ECE exercisers behave the way they do remains to be revealed by future study.

Regarding convergent validity evidence, the significant positive relationship between the E-CEQ and Lefebvre's (1981) original CEQ demonstrated that the two were measuring similar but related constructs. Findings from Study 1 provided validity evidence, which supported the E-CEQ operationalization of cognitive errors specific to exercise.

5.2 Study 2

As Messick (1987) notes, measure validation is an ongoing process through continued investigation. Study 2 built on Study 1 by examining relationships to social cognitions advantageous for the self-regulation of exercise (Bandura, 1986; 2005). Compared to individuals with low ECE scores, those scoring higher reported lower SRE to manage exercise, lower anticipated persistence with exercise management, higher perceived difficulty to exercise, and more decisional struggle. Those reporting higher ECE scores reported more challenge in carrying out regular exercise. These findings support the primary research premise that ECEs might be one new construct that helps us better understand why individuals struggle with regular exercise participation.

Study 2 also examined ECE and social cognition differences between individuals perceiving themselves as having consistent or inconsistent patterns to their exercise. Individuals' self-definitions of their exercise consistency might be related to the strength of the cognitive errors that they express. It should be made clear that this measure represents a self-perception of the consistency of individuals exercise pattern rather than an objective measure of past exercise. Those who perceived themselves as having more consistent exercise patterns reported lower levels of ECEs compared to those who perceived their patterns as inconsistent. Those not exercising at all expressed the highest levels of ECEs.

Social cognition differences were also observed between individuals who perceive their exercise as consistent or inconsistent. Consistent exercisers reported more exercise-facilitating social-cognitive outcomes (e.g., higher SRE, more persistence, lower struggle) compared to those who perceived themselves as being inconsistent. Overall, individuals who perceived themselves as having inconsistent or no pattern to their exercise reported self-regulatory social cognitions unlikely to facilitate exercise. The findings from this study also provide concurrent

validity evidence. That is, the E-CEQ was able to differentiate between those differing in their perceived level of exercise consistency.

5.3 Study 3

The third and final study of the dissertation provided evidence supporting construct validity. Specifically, individuals expressing higher E-CEQ scores also expressed indicants of biased processing about an exercise decision-making situation. These findings align with Milman and Drapeau's (2012) conceptual cognitive errors model, whereby those making cognitive errors should display information processing biases. This was demonstrated in information processing differences between those reporting higher and lower ECEs. As indicated by the thought listing following review of the exercise vignette, those reporting high ECEs attended to and focused primarily on the negative, hindering aspects of exercise, whereas lower ECE individuals had a balanced focus on both negative and positive content. Higher ECE individuals also interpreted the exercise situation described in the scenario as being more difficult with respect to making exercise decisions. Together, the results of Study 3 supported Hertel and Mathews' (2011) review suggesting interpretational and attentional processing biases are associated with cognitive errors.

Table 8. *Summary of study findings*

Study	Hypotheses	Supported	Magnitude of effect (if applicable)
1	The analysis will yield a valid E-CEQ factor structure.	Yes	N/A
	The original CEQ and E-CEQ will moderately correlate, indicating convergent validity.	Yes	Medium
	There will be a negative correlation between the E-CEQ and the number of planned exercise bouts engaged in and exercise intention.	Yes	Medium
	The E-CEQ will account for a significant proportion of variance in planned exercise after controlling for the CEQ	Yes	Medium
	The E-CEQ will account for a significant proportion of variance in exercise intention after controlling for past exercise behaviour.	Yes	Small
2	Compared to those who report a consistent exercise pattern, those who report having an inconsistent pattern of exercise will report:		
	1. Have higher ECEs	Yes	Large
	2. Lower SRE	Yes	Large
	3. Lower anticipated persistence	Yes	Large
	4. Greater perceived struggle in managing exercise	Yes	Medium
	5. Greater perceived exercise difficulty	Yes	Medium
	6. Planned Physical Activity	Yes	Large
	Compared to those reporting low ECEs , those reporting high ECEs will report:		
	1. Lower SRE	Yes	Large
	2. Lower anticipated persistence	Yes	Large
	3. Greater perceived struggle in managing exercise	Yes	Large
	4. Greater perceived exercise difficulty	Yes	Large

Study	Hypotheses	Supported	Magnitude of effect (if applicable)
3	Interpretable themes will emerge from participants' thoughts while reading the exercise vignette.	Yes	
	There will be differences between high and low ECE groups on the content that they focus on while reading the vignette.	Yes	
	Compared to those reporting low ECEs , those reporting high ECEs will:		
	1. Focus on a greater amount of hindering content from the vignette	Yes	Medium
	2. Have a negative tone to their thoughts while reading the vignette	Yes	Large
	3. Would be less likely to decide to exercise if placed in the vignette	Yes	Medium
	When imagining themselves in a challenging situation similar to that depicted in the vignette, those reporting high ECEs will report:		
	1. Lower SRE	Yes	Large
	2. Lower anticipated persistence	Yes	Large
	3. Greater perceived struggle in managing exercise	Yes	Large
	4. Greater perceived exercise difficulty	Yes	Large

Note: Effect sizes represent the magnitude of the association between two variables or the magnitude of difference between two or more groups. The magnitude of effects can range from no effect, to small, medium, or large.

5.4 Contribution to Exercise Psychology

There is a need to understand why individuals fail to maintain regular exercise given the many negative health consequences resulting from physical inactivity (WHO, 2014). The cognitive error framework provided a coherent means of understanding the nature and outcome of ECEs.

Results from this program of research have provided initial evidence suggesting that ECEs may aid our understanding of inconsistent exercise adherence and nonadherence. Whereas the negative associations between ECEs and exercise are cross-sectional, the strength and

direction of the relationships support the cognitive errors model (Milman & Drapeau, 2012). According to the cognitive errors model, cognitive errors negatively impact thoughts, emotion, and behaviour. These first-generation relationships lay the foundation for future researchers who might causally examine whether ECEs elicit unhelpful exercise cognitions which, in turn, lead to erratic or nonadherence to regular exercise.

Studies 2 and 3 examined relationships between ECEs and social cognitive variables known to be related to exercise adherence (e.g., self-regulatory efficacy; Bandura, 1997). Bandura (1997) has noted that biased self-appraisals can cause individuals to misconstrue and improperly filter efficacy-relevant information. As such, individuals who see exercise situations through the biases associated with cognitive errors would have lower self-regulatory efficacy and would struggle more with exercise decisions. Those reporting high ECEs individuals reported social cognitions (e.g., low self-regulatory efficacy) that may not facilitate exercise intentions or behaviour.

According to the cognitive errors model, cognitive errors should only be reported in a smaller subsection of the population – as for example, when depressed individuals are reporting cognitive errors (Lefebvre, 1981). In the same way, it was expected that a smaller proportion of individuals in the exercise context would report thinking in cognitively errored ways specific to that context. Across the dissertation studies, there was a low proportion of individuals reporting high ECE scores compared to those reporting low ECE scores. For example, this was demonstrated in the unequal proportion of individuals reporting high and low ECE scores in Study 2 (n_{high} = 89 VS n_{low} = 260) and Study 3 (n_{high} = 29 VS n_{low} = 109). Approximately one-quarter of participants in both samples reported high ECE scores. These participants were more likely to report: lower exercise levels, more inconsistent exercise patterns, and more struggle making exercise decisions. They also displayed one-sided attention to negative exercise

decision-making information. These findings converge, suggesting individuals reporting high ECEs appear to have thoughts that are not helpful for participants to achieve a goal of regular exercise. Indeed, it is "reassuring" to note that not everyone engages in biased thinking that may be unhelpful to starting exercise or establishing stability in an exercise pattern.

Using the ECE construct in complementary fashion with the agency aspect of Social Cognitive Theory (Bandura, 1986) is a novel approach for understanding how individuals process exercise-relevant information. Cognitive errors are conceptualized to affect the information that individuals attend to and interpret. As noted by Bandura (1997), social cognitive differences between high and low ECE groups might be one preliminary indication that cognitive errors can affect how individuals construe self-relevant information. These initial findings lay the groundwork for additional investigation into cognitive errors' effect on self-efficacy formation, which may aid our understanding of why some individuals fail to develop a strong sense of personal exercise efficacy.

The E-CEQ measure is the first cognitive errors measure specific to exercise for use with apparently healthy adults. Measure creation is an important contribution to the literature as it enables the continued study of ECEs by operationalizing the construct. Validating and publishing the measure helped to optimize its potential impact. The evidence from the three studies increased confidence that (1) the E-CEQ represents cognitive errors, (2) there are cognitive errors specific to an exercise context, and (3) they are associated with biased processing of exercise-related information.

In Study 1, the final E-CEQ model included three factors representing Catastrophizing, All-or-Nothing thinking, and Mental Filter cognitive errors. At present, this number of E-CEQ factors has been identified and represents the ECE construct. However, unlike the clinical approach characteristic of the psychopathology literature, the utility of interpretations of discrete

E-CEQ factors and how they might influence decisions and behaviors remains open to question. In Studies 2 and 3, the research questions were only related to the magnitude of cognitive errors being made, not the type of ECE. Thus, the total score for the E-CEQ was used in analyses. For example, those making greater cognitive errors respond differently with respect to cognitions and information processed.

5.5 Strengths

One of the strengths of this program of research was the use of an evidence-based cognitive error model proposed by Milman and Drapeau (2012). While other cognitive error conceptualizations were specific to depression (e.g., Beck, 1976; Mueser et al., 2009), Milman and Drapeau's definition was broader and allowed for cognitive errors to be operationalized for a non-clinical population of adults relative to exercise behaviour. This model was the backbone of the E-CEQ and provided operational definitions for the ECE factors. Integrating cognitive errors within an existing evidence-based approach should optimize their utility in understanding their relation to individuals' motivation to exercise, decisions about exercise, and potentially, that behaviour.

According to Painter, Borba, Hynes, Mays, and Glanz (2008) studies of health behaviour change are most effective when based on theory. Another strength of this research was the complementary use of ECEs with the agency aspect of Social Cognitive Theory (Bandura, 1986), in which agency constructs aid in understanding and intervening upon health behaviours like exercise (Luszczynska & Schwarzer, 2005).

The process of measure development and validation is yet another strength. Strengths of the measure development process include being modelled after an existing cognitive errors measure (CEQ; Lefebvre, 1981), using established operational definitions (Milman & Drapeau, 2012), and creating items to represent realistic exercise situations. In this way, items took the

form of brief vignettes depicting an exercise situation with a cognitively errored response. Vignette methodology was a strength because it allowed for the operationalization of ECEs, which are not directly observable. This also enhanced the salience of ECEs through the use of a description of a realistic exercise situation.

Regarding validation of the E-CEQ, examination of the accumulated evidence from the three studies reflect *a beginning*. However, scale validation is an ongoing process (Messick, 1987). This process has been started by recognizing the different aspects of this accumulated evidence. *Construct validity* is a broad term that concerns the accuracy to which a measure reflects the operationalization of the target construct. Specifically, it speaks to how well the E-CEQ represents the concept of exercise-related cognitive errors. Construct validity draws on multiple forms of evidence to help strengthen the inference about representing the construct. This dissertation examined the following forms:

a) *Factorial validity*: examining the E-CEQ's factor structure provided one indicant.
b) *Content validity*: the measure development process provided an indicant.
c) *Convergent validity*: the positive moderate correlation between the E-CEQ and the original CEQ provided an indicant. (See Study 1 and Appendix A).
d) *Predictive validity*: detection of relationships between the E-CEQ, exercise, and social cognitions provided a first indicant. Further, the finding that the E-CEQ accounts for all significant variance in predicting exercise after controlling for that predicted by the original CEQ is a second indicant.
e) *Concurrent validity*: the ECE differences evident in comparing exercise pattern groups provided a first indicant. (Study 2). A second indicant was demonstrated through the information processing differences evident in comparing high and low ECE groups (Study 3).

5.6 Limitations

As with any study, the current program of research is not without limitation or caveat.

Measure development. There were a few caveats regarding the E-CEQ measure development process, despite its numerous strengths. The use of a greater number of experienced raters might have strengthened inferences of content validity. Regarding the factor structure and the clear separation of factors, the retention of cross-loadings may be statistically problematic in certain analytical procedures (e.g., multiple regression). However, at this stage of the E-CEQ research, the use of the overall scale mean is one practical strategy to overcome this limitation. As well, in Studies 2 and 3, research questions were not concerned with discrete factors, but rather the overall magnitude of ECEs made by participants. Last, the final E-CEQ factor structure had good fit to the data. Replication with different samples and future factor analysis may verify the factors retained and the stability of cross-loadings.

Observational Design. All studies in this dissertation were observational, limiting the interpretation to relationships. Thus, comments about the nature and direction of cognitive error relationships, while guided by theoretical frameworks, must be regarded as speculative. Future efforts could build on current research by using prospective and experimental designs to examine causal relationships.

Generalizability. Participants from both samples across the three studies were recruited through convenience sampling. Participation may not be representative of different segments of the general population (e.g., working women, older adults). Additionally, the samples were generally healthy adults engaged in different levels of exercise (i.e., none to regular) who were predominantly (>70%) female, Caucasian, and Canadian. At this stage of the research, findings should not be generalized beyond the sample demographics. For example, additional research is

needed to understand if chronically diseased populations make ECEs, and whether the E-CEQ is appropriate for use in such populations.

Vignettes. Using vignettes to operationalize both the E-CEQ items and the Study 3 stimulus was advantageous, specifically allowing for the examination of unobservable phenomena. However, some potential limitations of vignettes have been identified (c.f., Hughes and Huby, 2001). For examining decision-making in real life, one criticism could be that vignettes do not adequately capture the reality of biased thinking in real-life contexts. However, to experimentally control such real life contexts would be a challenging task and subject to many similar criticisms about salience and meaningfulness to subjects. It is important to recognize the advantages provided by vignettes traded off against the challenges of experimentally testing cognitive errors in real-life contexts. Careful pilot testing and vignette content, salience and believability checks also strengthen the utility of this methodology in addressing the present first-generation research.

5.7 Future Research

First, aspects of this dissertation represent the initial step in examining validity evidence. The measure development was conceptually driven, and there is a need to ensure that the concept is sufficiently represented. Following best practices for measure development and use (DeVellis, 2011), subsequent factor analysis would provide additional evidence of the E-CEQ's factorial validity. Additional avenues of psychometric development and evaluation might include (1) attempting to enhance E-CEQ internal consistency, (2) examining its test-retest reliability, (3) validating additional content as necessary for disease-specific populations. (e.g., in prediabetes populations). Concept representation and situational salience are critical factors for future examinations of ECEs in chronically-diseased populations. For example, there may be thoughts

important and salient to studying ECEs for individuals living with prediabetes, but not relevant to a general population (e.g., “Walking won’t prevent me from getting type 2 diabetes”).

Second, investigating the E-CEQ’s utility among chronically-diseased individuals would extend its applicability from asymptomatic to symptomatic people. Among the asymptomatic, inconsistent exercisers were more likely to be people with high ECE scores, Chronically-diseased individuals whose symptoms and their interpretation may hinder exercise could be inconsistent in exercising (e.g., Flora, Anderson & Brawley, 2015) and may have related high ECE scores. Understanding the influence of their ECEs may provide insight on where to focus efforts toward change (e.g., reframing one-sided, negatively focused disease-related thoughts).

Third, expanding the generalizability of these findings is another avenue of future research. Are ECEs related to short-term or long-term exercise adherence? Do ECEs cause individuals to struggle with decision-making about carrying out their planned exercise? Do ECEs bias the information that individuals consider in making real life exercise decisions? Future second generation research will be achieved using more prospective and experimental designs in attempting to answer these questions.

Fourth and finally, if those reporting high ECEs consistently process biased information that negates exercise decisions or makes individuals indecisive, then initiating regular exercise may be more challenging. The reliable identification of exercise-related cognitive errors and the detection of their demotivating impact is a necessary first step in this novel exercise research area. Evidence of this phenomenon among individuals struggling with their exercise decisions and behavior may also demand a second, related step – modification. Cognitive reframing is a common cognitive behavioral technique that has been used to intervene in order to successfully reduce cognitive errors for anxious and depressive individuals (cf. Leahy, Tirch & Napolitano,

2011; Mueser, Rosenberg & Rosenberg, 2009). Cognitive reframing teaches individuals to identify and challenge irrational thought patterns caused by cognitive errors.

Examining cognitive reframing in the modification of ECEs is one future avenue to reduce unhelpful thoughts resulting from ECEs. Such an examination would provide evidence that cognitive errors specific to the exercise context are modifiable targets. However, before cognitive reframing to counter problematic information processing can be utilized in exercise intervention, a strong research foundation that promotes understanding of ECEs must be established. The present research program is one step toward furthering that understanding.

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7 Appendices

Appendix A. Supplementary Information for Study 1.

Appendix A contains supplementary information for Study 1 that was not contained in the published manuscript due to page limitations and reviewer feedback regarding certain content being unnecessary for publication. The appendix is provided to answer some major questions but not to provide the level of detail that might be provided in a monograph on a measure's development.

Introduction

Use of Milman and Drapeau's (2012) conceptual cognitive errors model and Drapeau and Perry's (2010) cognitive errors rating scale to guide measure development requires further elaboration as it bears implication on operationalization, measurement, and selection of cognitive errors. Milman and Drapeau provide a general cognitive error definition, describing them as biased thought processes. Biased thought processing characteristic of cognitive errors was operationalized in the E-CEQ measure through the use of vignette items.

Milman and Drapeau identify up to 17 different cognitive errors that can cause or perpetuate depression. There are four points regarding these different cognitive errors that factored into selection of specific errors operationalized in the E-CEQ. First, as mentioned in the item development section in Study 1, selection of cognitive errors was based on a review of the health and exercise psychology literature regarding biased beliefs and their hypothesized saliency in the exercise literature. Consequently, it is impractical and lacking parsimony to operationalize 17 cognitive error sub-factors in a Likert measure particularly when a number of the factors do not apply to the exercise context (i.e., errors associated with psychopathology).

Second, there is a high degree of similarity between certain cognitive errors, as noted by Milman and Drapeau (2012) and Lefebvre (1981). For example, Drapeau and Perry (2010) suggest that Mental Filter and Tunnel Vision cognitive errors are "close neighbours" (p.41) that can be differentiated by the extent to which information is selectively abstracted or biased. For this reason, Drapeau and Perry (2010) note that distinguishing these two can be challenging in the context of clinical diagnosis. However, if the research question is not concerned with identifying separate factors, but simply with identifying if the person is making errors and thus thinking in biased fashion, the close neighbour concern may be less.

Third, not all cognitive errors may be appropriate or sufficiently salient for the exercise context. For example, the Mind Reading and Personalization cognitive errors operate in such a way as to specifically perpetuate the negative affect associated with depression (Drapeau & Perry, 2010). As such, these cognitive errors were not operationalized in the exercise-specific measure.

Fourth, the Milman and Drapeau model does not suggest that the 17 cognitive errors are components of one overall cognitive error factor. Rather, there are 17 identified types of errors whose source was from individuals in the clinical context. Thus, the conceptual model was used as guide for definitions. There was no intent in measurement development to duplicate all 17 errors described by the model.

Method

Participant demographics

Supplementary Table. *Study 1 Demographic Information.*

Demographics	***n***	**% of Sample**
Age		
18-25 years old	193	53.3%
26-34 years old	96	26.5%
35-44 years old	19	5.1%
45+ years old	50	13.7%
Unknown	6	1.4%
Gender		
Male	67	18.5%
Female	297	81.3%
Transgendered	1	0.3%
Country Currently Living In		
Canada	347	96.1%
USA	9	2.2%
Other/unknown	8	1.7%
Education		
Some High school	9	2.5%
High School Diploma	33	8.9%
Some College or University	136	36.8%
College or University Graduate	131	36.3%
Graduate Degree	55	15.5%
Employment Status		
Full-Time	147	40.5%
Part-Time	107	29.5%
Not At All	96	26.4%
Retired	10	2.8%
Unknown	4	0.8%
Relationship Status		
Single	152	41.9%
In a relationship, but not married	128	35.2%
Married	65	17.8%
Widowed/Divorced	16	4.5%
Unknown	3	0.6%
Household Income		
Under $20,000	91	25.1%
$20,000 to $39,999	69	19.0%
$40,000 to $59,999	62	17.1%
$60,000 to $79,999	40	11.0%

$80,000 to $99,000	33	9.1%
More than $100,000	63	17.4%
Unknown	6	1.5%
Ethnicity		
Caucasian	294	81.0%
Aboriginal/Metis/First Nations	15	4.2%
Asian	26	7.1%
African	3	0.9%
Latino	5	1.5%
Other/Unknown	20	5.3%

Note: *N* = 364.

Results

Factor structure: Cross-loading retention and decision-making.

There are general conventions suggesting the retention of cross-loadings above .3 or .4, or retaining only those cross-loadings that are less than half the magnitude of the main loading. However, these rules of thumb are somewhat arbitrary and the primary consideration driving cross-loading retention is interpretability. The three retained cross-loadings were interpretable within Milman and Drapeau's (2010) model, as discussed in Study 1. As Milman and Drapeau suggest, a biased thought can be caused by more than one cognitive error.

The notion that cross-loadings complicate the factor structure is one reason against retaining cross-loadings in a measure's factor structure. Cross-loadings may be difficult to interpret and can result in measurement issues. While the issue of interpretability has been addressed above, cross-loaded items can bring about challenges when conducting certain statistical analyses using all three sub-factors in the same analysis. For example, using all three factors in a regression analysis may produce overlap in accounted for variance between the factors containing the same cross-loaded item. While this may impact the individual

contribution of factors with cross-loaded items, it should not impact the overall amount of accounted for variance.

Finally, it should be noted that cross-loadings are not problematic in and of themselves. In their review and Monte Carlo study, Asparouhov, Muthén, and Morin (2015) suggest that "psychometric indicators are seldom perfectly pure construct indicators" (p.1563). As such, cross-loadings may better represent the reality of the item indicators. While study replication is needed, the cross-loadings retained in the current study represent meaningful and relevant information at the construct indicator level. Their retention at this stage of E-CEQ development follows suggestions by Asparouhov et al. (2015).

Criterion-related validity

The correlation between the CEQ (Lefebvre, 1981) and E-CEQ was moderate. This was interpreted that they were measuring similar but not identical content and was an indicant of convergent validity. If the correlation was too large, this would suggest that measures were redundant, if the correlation was too small, this would question whether the two measures were operationalizing similar constructs.

The E-CEQ contains three cognitive errors (All-or-Nothing, Catastrophizing, and Mental Filter), whereas the CEQ contains four (Catastrophizing, Overgeneralizing, Personalization, and Selective Abstraction). It is tenable to suggest that containing a different set of cognitive error factors may have attenuated the correlation between the two scales. A supplementary correlation between the E-CEQ Catastrophizing and the CEQ Catastrophizing sub-factors was run to examine the correlation between the same sub-factors on both scales. There was a moderate correlation ($r = .342$, $p < .001$). Recall, the correlation between the overall scale scores was

larger (r = .402). A large correlation between the Catastrophizing factors on the two scales would have supported the attenuation argument, but the correlation was not large.

Appendix B - Study 1 Survey Measures

List of Measures

1. **Demographic information**
2. **Physical activity behaviour and intention**
3. **General cognitive errors**
4. **Exercise-specific cognitive errors**

1. Demographics

Age: ☐ Sex: ☐ Female ☐ Male ☐ Transgender

What is your country/continent of residence?
Options:
___ Canada
___ USA
___ Australia
___ Europe
___ Other (please list) _____

What is your highest level of education?

☐ some high school ☐ some college or university ☐ some graduate school
☐ high school graduate ☐ college/university graduate ☐ graduate degree

Are you currently employed?

☐ full-time ☐ part-time ☐ not at all ☐ retired ☐ disabled

What is your annual household income?

_____

What is your first language?

_____

What is your ethnic background? (For example: Caucasian, French Canadian, Italian, East Indian, etc.)

_____

What is your relationship status? (please check the one that applies best to you)

	Married/Living with an intimate other		Never married
	Separated/Divorced		Widowed

Do you have any diagnosed chronic medical conditions? If so, please explain.

_____
_____
_____

What are the primary symptoms associated with your medical condition (e.g., pain, fatigue, insomnia)?

2. Physical Activity

Past Physical Activity (Godin & Shepard, 1985)

We are now interested in your average level of **planned physical activity**. Please be as specific and honest as possible.

During a *typical week within* ***the past four weeks***, how many times on average did you do the following kinds of exercise for **30 minutes or more** during your free time (write on each line the appropriate number)?

Each of the following physical activity intensities provides some examples of activities with the typical corresponding intensity. The list is not all-inclusive. If your typical activity is not listed, try to think of which intensity best applies to the activity.

a) **STRENUOUS EXERCISE (HEART BEATS RAPIDLY) ____times/wk**

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

b) **MODERATE EXERCISE (NOT EXHAUSTING) ____times/wk**

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

c) **MILD EXERCISE (MINIMAL EFFORT) ____times/wk**

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

Physical activity intention

How many 30-minute or more bouts of moderate or strenuous exercise do you intend on doing in the next

7 days? _____

3. General cognitive errors (Lefebvre, 1981)

Please rate how similar each statement reflects the thought you would have in a similar situation. The situations need not be exactly identical. Your rating should simply reflect the similarity or difference in the way you would think in a similar situation.

0	2	4
almost exactly like I would think	somewhat like I would think	not at all like I would think

1. Your boss just told you that because of a general slowdown in the industry, he has to lay off all of the people who do your job including you. You think to yourself, "I must be doing a lousy job or else he wouldn't have laid me off."

2. You are a manager in a small business firm. You have to fire one of your employees who has been doing a terrible job. You have been putting off this decision for days and you think to yourself, "I just know that when I fire her, she is going to raise hell and will sue the company."

3. Last week you painted the living room and your partner said it really looked great. When you were cleaning up, you found that you had gotten paint on the rug and thought, "Boy, this wasn't a very good painting job."

4. You noticed recently that a lot of your friends are taking up golf and tennis. You would like to learn, but remember the difficulty you had that time you tried to ski. You think to yourself, "I couldn't learn skiing, so I doubt if I can learn to play tennis."

5. You and your partner recently went to an office party at the place where your partner works. You didn't know anybody there and had a terrible time. When your partner asked you if you want to go to the neighbors to visit, you think, "I'll have a terrible time just like at that office party."

6. You just finished spending 3 hours cleaning the basement. Your partner however, doesn't say anything about it. You think to yourself, "S/He must think I did a lousy job."

7. Last night, your partner said s/he thought you should have a serious discussion about sex. You think to yourself, "S/He hates the way we make love."

8. You have been working for 6 months as a car salesperson. You had never been a salesperson before and were just fired because you had not been meeting your quotas. You thought, "Why try to get another job, I'll just get fired."

9. Your job requires a lot of travel. You had hoped to drive 400 miles today but you hit bad weather that slowed you down. When you stopped for the night, you thought, “I didn’t make that 400 miles: Today was a complete waste.”

10. You have just finished nine holes of golf. Totaling your score, you recall that although you got par on seven holes, you got two over par on the last two holes. You think to yourself, “Today I really played poorly.”

11. You went fishing for the first time today with some of your friends who love fishing. Nobody got anything, and the group seemed to be discouraged. You think to yourself on the way home, “I guess I made too much noise or did something that scared the fish off.”

12. Your friends are all going out to ride their snowmobiles. Last time you went, you ran out of gas, and you think to yourself, “What if I run out of gas again, I’ll freeze to death.”

13. You have three children who generally do quite well in school. One of your children came home today and told you that he had to stay after school because he got into a fight. You think to yourself, “He wouldn’t have gotten that detention if I disciplined him more.”

14. You are taking your coffee break when your boss stops by and reminds you of some work that has to get done today. You think to yourself, “If I don’t start getting back to work earlier, I’m going to lose this job.”

15. You have noticed that many of your friends have begun playing tennis and are now urging you to play, too. You had taken golf lessons with your spouse last year and had difficulty learning to play golf. You think to yourself, “I had so much trouble learning golf, I doubt if I could learn tennis.”

16. Your seven-year-old son normally does very well in school. Last week, he brought home a paper which he had done incorrectly and was supposed to do over. You think to yourself, “Oh no, now he’s having trouble in school. I better make an appointment with his teacher.”

17. Earlier today, your spouse asked to have a serious talk with you after work about some things that were troublesome at home. You have no idea what’s going on and you think, “We don’t communicate enough: Our marriage is going to fall apart.”

18. On your last job, you had not received a raise even though a co-worker with similar experience had. You are now up for a raise in your present job and think, “I didn’t get a raise the last time and I probably won’t now.”

19. Your teenage daughter has just asked if two of her friends can stay overnight. You recall that you got very upset when your son had some friends over for pizza several weeks ago, and they had made a lot of noise. You think, “If they come over, I’ll get upset again.”

20. You run a day care center. Today, the mother of a child you have been having difficulty with

calls and notifies you that she has quit work and will be withdrawing her child from your program. You think, “She probably thinks I wasn’t handling him as well as I should.”

21. You took your children to the neighborhood pool for the afternoon. Although your kids urged you to swim with them, you were enjoying lying in the sun. Later you look up and see them arguing over a float. You think to yourself, “If I had gone in the water, they probably wouldn’t be fighting now.”

22. You went shopping for some new clothes today and were unable to find anything you liked. You think, “What a waste of a day.”

23. You met with your boss today to discuss how you have been doing on your job. He said that he really thought you were doing a good job, but asked you to try to improve in one small area. You think to yourself, “He really thinks I’m doing a lousy job.”

24. Last time you went skiing, you took a hard fall and got shook up. You’re supposed to go skiing this weekend but think, “I’ll probably fall and break my leg and there will be no one to help me.”

4. Exercise-related cognitive errors

Instructions:

The following short scenarios represent people’s reactions to different situations they might encounter when trying to exercise. Please indicate the degree to which the reactions in the following scenarios are similar to how you would think.

The following scenarios might not be exactly applicable to you and your situation (Example: while the type of sport depicted in the scenario is one you would never consider doing, you could still react to the scenario).

Please try to put yourself in the situation and rate how similar the thought expressed in the scenario is to how you might react. If the scenario is absolutely not applicable to you, please leave it blank.

1 (not at all like I would think) to 9 (almost exactly like I would think).

Catastrophizing

1. The last time you went to the gym, you thought some of the other people were looking in your direction. You thought to yourself, “they must be making fun of me because I’m doing this exercise incorrectly.”

2. You have just come off holidays and haven't exercised in two weeks. When it comes time to exercise, you think to yourself, "it's been so long since I've exercise that I'm going to be painfully sore for days."

3. You are considering starting to cycle with a local club. Every time you consider going to the club to join, you think to yourself, "I haven't biked in years, I'm going to get way too tired to even be able to finish the ride."

4. Your doctor recommends jogging/running at a higher intensity than you are used to. When considering the doctor's recommendations, you think to yourself, "going that fast is going to really aggravate my medical condition."

All-or-nothing thinking

5. You are just getting home from a vacation. You're a bit tired, but you want to go exercise today. You think to yourself, "since I'm not going to have the energy to complete my usual routine I'll will just start next week."

6. You're having a pretty busy week. You plan to exercise tonight, but when you get home from work you think to yourself, "I can't justify exercising because I have so many other things to do."

7. Because your exercise class is cancelled this week, you think to yourself, "I'm going to take the week off because I have no exercise class".

8. You hear that you have to exercise 150 minutes a week to get health benefits. You think to yourself, "I'm never going to be able to achieve that."

Overgeneralization

9. Your friends want to go play some basketball (or a new sport you've never tried). You remember that the first time you attempted to play pick-up hockey you took a wrong step and twisted your ankle. You think to yourself, "I shouldn't go play because I am going to injure myself again."

10. Your friends are all joining a gym and ask you to come along. You remember how uncomfortable you felt the last time you got a gym membership. You think to yourself, "I'm going to feel self-conscious again and people are going to see that I don't know what I'm doing."

11. You are considering starting to jog with a friend. You remember hearing a story on the news about a marathon runner who had a heart attack while training, you think to yourself, “I might have a heart attack while running too.”

12. You consider starting an exercise routine, but think to yourself, “I’m not good at sticking with anything. I’ll probably quit after a month so why start.”

Mental Filter

13. You plan to exercise today, but you think to yourself, “I am not going to because I will be completely tired afterward.”

14. You plan to exercise after work today, but get home and think to yourself “there is a lot I still have to do tonight, exercise will really get in the way.”

15. You plan to exercise for the first time in a while today, but think to yourself, “I’d better not, I know how sore I'm going to be after exercise.”

16. You know the health the benefits of exercise, but think to yourself, “exercising is a big drain on all the other fun things I could be doing.”

Emotional reasoning

17. You decide that it’s time to get back into the exercise routine and that starting next week you are going to exercise. However, when next week rolls around, you think to yourself, “I don’t really feel excited about it this week, I can start it next week.”

18. You’ve been exercising for a few weeks. However, you’re getting frustrated because you aren’t seeing changes and the exercises aren’t getting easier. You think to yourself, “this is way too hard and no fun and decide to stop going to the gym.”

The Halo Effect

19. The news has a brief segment on exercising and good health. You consider exercising, and you think to yourself, “I don’t need to exercise to be healthy, I know plenty of people who don’t exercise and are healthy”.

20. You see a billboard about exercising leading to good health. You think to yourself, “my parents never exercised and they lived long and healthy lives.”

21. You are considering more than your usual once a week recreational sports league, but you think to yourself, “I don’t smoke, so I don’t need any more exercise.”

22. A friend asks if you want to start working out with him/her. You consider it, and you think to yourself, “I’m pretty skinny, I don’t need to workout.”

Emotional reasoning

23. You have been feeling down and even depressed all day, you think to yourself, “I should just stay home instead of going to the gym today.”

24. You feel awkward and lost in the first gym/fitness class you attend. You think to yourself, “I feel so uncomfortable that I don’t want to go back.”

Appendix C. E-CEQ Factor Structure

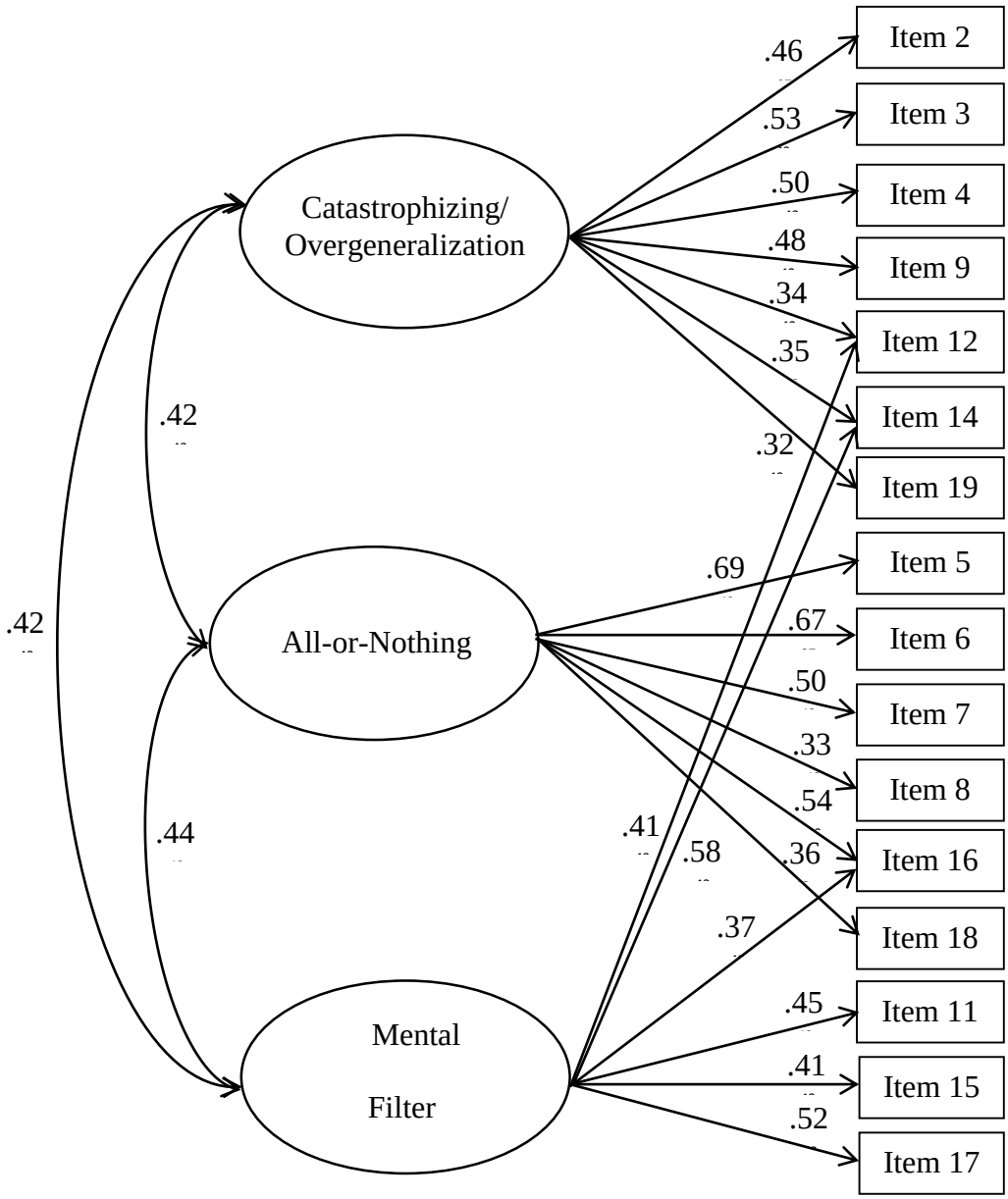

Figure 1. Final structure of the 3-factor 16-item E-CEQ.
Note: Standardized parameter estimates for the exercise-related cognitive errors questionnaire (E-CEQ). Rectangles represent the 16 E-CEQ items, ovals represent the latent cognitive error factors. Error and disturbance terms are omitted. All factor loadings are significant ($p < .001$).

Appendix D - Study 2 Survey Measures

List of Measures

1. **Demographic information**
2. **Physical activity pattern, behaviour, and intention**
3. **Exercise-specific cognitive errors (16 items)**
4. **Self-regulatory efficacy**
5. **Anticipated persistence**
6. **Perceived difficulty**
7. **Decisional struggle**

1. Demographics

Age: ☐ Sex: ☐ Female ☐ Male ☐ Transgender

What is your country/continent of residence?
Options:
___ Canada
___ USA
___ Australia
___ Europe
___ Other (please list) _____

What is your highest level of education?

☐ some high school	☐ some college or university	☐ some graduate school
☐ high school graduate	☐ college/university graduate	☐ graduate degree

Are you currently employed?
☐ full-time ☐ part-time ☐ not at all ☐ retired ☐ disabled

What is your annual household income?

_____

What is your first language?

_____

What is your ethnic background? (For example: Caucasian, French Canadian, Italian, East Indian, etc.)

_____

What is your relationship status? (please check the one that applies best to you)

	Married/Living with an intimate other		Never married
	Separated/Divorced		Widowed

Do you have any diagnosed chronic medical conditions? If so, please explain.

_____
_____
_____

What are the primary symptoms associated with your medical condition (e.g., pain, fatigue, insomnia)?

2. Physical Activity

Past Physical Activity (Godin & Shepard, 1985)

We are now interested in your average level of **planned physical activity**. Please be as specific and honest as possible.

During a *typical week within* ***the past four weeks***, how many times on average did you do the following kinds of exercise for **30 minutes or more** during your free time (write on each line the appropriate number)?

Each of the following physical activity intensities provides some examples of activities with the typical corresponding intensity. The list is not all-inclusive. If your typical activity is not listed, try to think of which intensity best applies to the activity.

d) **STRENUOUS EXERCISE (HEART BEATS RAPIDLY)** **____times/wk**

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

e) **MODERATE EXERCISE (NOT EXHAUSTING)** **____times/wk**

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

f) **MILD EXERCISE (MINIMAL EFFORT)** **____times/wk**

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

Pattern of physical activity.

Think about your **planned weekly exercise** over the past four weeks. Please select the description that best describes your pattern of exercise over the past four weeks.

a) My planned exercise frequency and duration were exactly the same for all four of the weeks (e.g., you completed the same planned activities each week for about the same amount of time).

b) My planned exercise frequency and duration varied between the four weeks (e.g., of the 4 weeks, you completed the same planned activities for 3 weeks, and one week was different).

c) My planned exercise frequency and duration varied more between the four weeks (e.g., you completed the same planned activities for 2 weeks and the third and fourth weeks were different from the first two, but the same as one another).

d) There was no pattern to my planned exercise frequency and duration over the past 4 weeks (e.g., you may not have exercised at all one week, then exercised 6 times another, exercised once and still another you exercised twice).

e) You did not exercise at all in the past four weeks.

Physical activity intention

How many 30-minute or more bouts of moderate or strenuous exercise do you intend on doing in the next

7 days? _____

3. Exercise-related cognitive errors

Instructions:

The following short scenarios represent people's reactions to different situations they might encounter when trying to exercise. Please indicate the degree to which the reactions in the following scenarios are similar to how you would think.

The following scenarios might not be exactly applicable to you and your situation (Example: while the type of sport depicted in the scenario is one you would never consider doing, you could still react to the scenario).

Please try to put yourself in the situation and rate how similar the thought expressed in the scenario is to how you might react. If the scenario is absolutely not applicable to you, please leave it blank.

1 (not at all like I would think) to 9 (almost exactly like I would think).

Catastrophizing

1. You have just come off holidays and haven't exercised in two weeks. When it comes time to exercise, you think to yourself, "it's been so long since I've exercise that I'm going to be painfully sore for days."

2. You are considering starting to cycle with a local club. Every time you consider going to the club to join, you think to yourself, "I haven't biked in years, I'm going to get way too tired to even be able to finish the ride."

3. Your doctor recommends jogging/running at a higher intensity than you are used to. When considering the doctor's recommendations, you think to yourself, "going that fast is going to really aggravate my medical condition."

All-or-nothing thinking

4. You are just getting home from a vacation. You're a bit tired, but you want to go exercise today. You think to yourself, "since I'm not going to have the energy to complete my usual routine I'll will just start next week."

5. You're having a pretty busy week. You plan to exercise tonight, but when you get home from work you think to yourself, "I can't justify exercising because I have so many other things to do."

6. Because your exercise class is cancelled this week, you think to yourself, "I'm going to take the week off because I have no exercise class".

7. You hear that you have to exercise 150 minutes a week to get health benefits. You think to yourself, "I'm never going to be able to achieve that."

Overgeneralization

8. Your friends want to go play some basketball (or a new sport you've never tried). You remember that the first time you attempted to play pick-up hockey you took a wrong step and twisted your ankle. You think to yourself, "I shouldn't go play because I am going to injure myself again."

9. You consider starting an exercise routine, but think to yourself, "I'm not good at sticking with anything. I'll probably quit after a month so why start."

Mental Filter

10. You plan to exercise today, but you think to yourself, “I am not going to because I will be completely tired afterward.”

11. You plan to exercise for the first time in a while today, but think to yourself, “I’d better not, I know how sore I'm going to be after exercise.”

12. You know the health the benefits of exercise, but think to yourself, “exercising is a big drain on all the other fun things I could be doing.”

Emotional reasoning

13. You decide that it’s time to get back into the exercise routine and that starting next week you are going to exercise. However, when next week rolls around, you think to yourself, “I don’t really feel excited about it this week, I can start it next week.”

14. You’ve been exercising for a few weeks. However, you’re getting frustrated because you aren’t seeing changes and the exercises aren’t getting easier. You think to yourself, “this is way too hard and no fun and decide to stop going to the gym.”

15. You have been feeling down and even depressed all day, you think to yourself, “I should just stay home instead of going to the gym today.”

16. You feel awkward and lost in the first gym/fitness class you attend. You think to yourself, “I feel so uncomfortable that I don’t want to go back.”

4. Self-Regulatory Efficacy for Exercise

INSTRUCTIONS: The following questions are about your planned exercise participation. Please think of your typical weekly exercise participation and use the scale below to rate your confidence in carrying out each of the following actions related to your planned exercise ***over the next 2 weeks***:

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all Confident										Extremely Confident

1. Over the next 2 weeks, how confident are you that you can arrange your weekly schedule in order to do your exercise no matter what?

2. Over the next 2 weeks, how confident are you that you will develop solutions to cope with **unexpected** barriers that can interfere with your exercise?

3. Over the next 2 weeks, how confident are you that you can make up times during the same week when you miss your exercise sessions?

4. Over the next 2 weeks, how confident are you that you will maintain your regular exercise frequency even though it may be difficult at times?

5. Over the next 2 weeks, how confident are you that you will resume your regular exercise frequency when it is interrupted and you miss exercise for a few days?

6. Over the next 2 weeks, how confident are you that you will develop plans for each exercise session to reach your desired level (i.e., intensity) of exercise?

7. Over the next 2 weeks, how confident are you that you can make a plan of action to maintain your current exercise frequency each week, despite things that can prevent you from carrying out planned exercise?

8. Over the next 2 weeks, how confident are you that you can prevent other things from interfering with your efforts to maintain your current exercise frequency each week?

INSTRUCTIONS: The following questions are about your planned exercise participation. Please think of your typical weekly exercise participation and use the scale below to rate your confidence in ***dealing with unhelpful thoughts*** related to your planned exercise ***over the next 2 weeks***:

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all Confident										Extremely Confident

9. Over the next 2 weeks, how confident are you that you can prevent your unhelpful thoughts from interfering with deciding to exercise as planned?

10. Over the next 2 weeks, how confident are you that you can manage your negative thoughts about exercise so that they do not make you indecisive about engaging in exercise?

11. Over the next 2 weeks, how confident are you that you can maintain your motivation to exercise despite unhelpful thoughts about exercising?

12. Over the next 2 weeks, how confident are you that you can focus solely on the positive outcomes of exercise important to you instead of the negative outcomes you think about?

5. Anticipated Persistence

INSTRUCTIONS: Recall your most unhelpful thought based on the exercise-related cognitive errors questionnaire. Re-state most unhelpful thought here: _____

Please use the scale below to rate your persistence with respect to **carrying out planned exercise** when you experience such unhelpful thoughts.

1. Each and every week, how much **time** are you willing to put forth in order to **carry out planned exercise when you have unhelpful thoughts**?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Little or no time								**As much time as it takes**

2. Each and every week, how much **effort** are you willing to put forth in order to **carry out planned exercise when you have unhelpful thoughts**?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Little or no effort							**As much effort as it takes**	

3. Each and every week, how willing are you **to persist** with your strategies in order to **maintaining planned exercise when you have unhelpful thoughts**?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Will not persist at all							**Will persist with strategies**	

4. Each and every week, how much of your **attention** are you willing to direct toward **maintaining planned exercise when you have unhelpful thoughts**?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Little to no attention toward this								**Will direct complete attention toward this**

6. Perceived Difficulty

INSTRUCTIONS: Recall your most unhelpful thought based on the exercise-related cognitive errors questionnaire. Re-state your most unhelpful thought here:
_____

Please use the scale below to rate the degree to which you believe that it would be difficult to **carrying out planned exercise** when you have unhelpful thoughts.

How difficult do you believe it would be to **carry out planned exercise when you have unhelpful thoughts**?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Not at all difficult				**Somewhat difficult**				**Extremely difficult**

7. Decisional Struggle

Keeping in mind your most unhelpful thought based on the exercise-related cognitive errors questionnaire. Re-state your most unhelpful thought here: _____

When they arise, how much do these thoughts make you struggle with your decision to exercise?

INSTRUCTIONS: Please use the following scale to answer.

1	2	3	4	5	6	7	8	9
No Struggle				Moderate Struggle				Tremendous Struggle

Given your response, what are the things you think about that make you struggle with you decision to exercise as planned?
_____

Appendix E - Study 3 Measures and Stimulus

List of Measures

1. **Demographic information**
2. **Exercise-specific cognitive errors**
3. **Planned physical activity behaviour**
4. **Stimulus – Detailed exercise scenario**
5. **Thought listing**
6. **Reaction to being in the scenario**
7. **Message quality check**
8. **Perceived difficulty**
9. **Decisional struggle**
10. **Self-regulatory efficacy**

1. Demographics

Age: ☐ Sex: ☐ Female ☐ Male ☐ Transgender

What is your country/continent of residence?

Options:

___ Canada

___ USA

___ Australia

___ Europe

___ Other (please list) _____

What is your highest level of education?

☐ some high school ☐ some college or university ☐ some graduate school

☐ high school graduate ☐ college/university graduate ☐ graduate degree

Are you currently employed?

☐ full-time ☐ part-time ☐ not at all ☐ retired ☐ disabled

What is your annual household income?

_____

What is your first language?

_____

What is your ethnic background? (For example: Caucasian, French Canadian, Italian, East Indian, etc.)

_____

What is your relationship status? (please check the one that applies best to you)

	Married/Living with an intimate other		Never married
	Separated/Divorced		Widowed

Do you have any diagnosed chronic medical conditions? If so, please explain.

_____

_____

What are the primary symptoms associated with your medical condition (e.g., pain, fatigue, insomnia)?

_____

_____

2. Exercise-related cognitive errors

Instructions:

The following short scenarios represent people's reactions to different situations they might encounter when trying to exercise. Please indicate the degree to which the reactions in the following scenarios are similar to how you would think.

The following scenarios might not be exactly applicable to you and your situation (Example: while the type of sport depicted in the scenario is one you would never consider doing, you could still react to the scenario).

Please try to put yourself in the situation and rate how similar the thought expressed in the scenario is to how you might react. If the scenario is absolutely not applicable to you, please leave it blank.

1 (not at all like I would think) to 9 (almost exactly like I would think).

Catastrophizing

1. You have just come off holidays and haven't exercised in two weeks. When it comes time to exercise, you think to yourself, "it's been so long since I've exercise that I'm going to be painfully sore for days."

2. You are considering starting to cycle with a local club. Every time you consider going to the club to join, you think to yourself, "I haven't biked in years, I'm going to get way too tired to even be able to finish the ride."

3. Your doctor recommends jogging/running at a higher intensity than you are used to. When considering the doctor's recommendations, you think to yourself, "going that fast is going to really aggravate my medical condition."

All-or-nothing thinking

4. You are just getting home from a vacation. You're a bit tired, but you want to go exercise today. You think to yourself, "since I'm not going to have the energy to complete my usual routine I'll will just start next week."

5. You're having a pretty busy week. You plan to exercise tonight, but when you get home from work you think to yourself, "I can't justify exercising because I have so many other things to do."

6. Because your exercise class is cancelled this week, you think to yourself, "I'm going to take the week off because I have no exercise class".

7. You hear that you have to exercise 150 minutes a week to get health benefits. You think to yourself, "I'm never going to be able to achieve that."

Overgeneralization

8. Your friends want to go play some basketball (or a new sport you've never tried). You remember that the first time you attempted to play pick-up hockey you took a wrong step and twisted your ankle. You think to yourself, "I shouldn't go play because I am going to injure myself again."

9. You consider starting an exercise routine, but think to yourself, "I'm not good at sticking with anything. I'll probably quit after a month so why start."

Mental Filter

10. You plan to exercise today, but you think to yourself, "I am not going to because I will be completely tired afterward."

11. You plan to exercise for the first time in a while today, but think to yourself, "I'd better not, I know how sore I'm going to be after exercise."

12. You know the health the benefits of exercise, but think to yourself, "exercising is a big drain on all the other fun things I could be doing."

Emotional reasoning

13. You decide that it's time to get back into the exercise routine and that starting next week you are going to exercise. However, when next week rolls around, you think to yourself, "I don't really feel excited about it this week, I can start it next week."

14. You've been exercising for a few weeks. However, you're getting frustrated because you aren't seeing changes and the exercises aren't getting easier. You think to yourself, "this is way too hard and no fun and decide to stop going to the gym."

15. You have been feeling down and even depressed all day, you think to yourself, "I should just stay home instead of going to the gym today."

16. You feel awkward and lost in the first gym/fitness class you attend. You think to yourself, "I feel so uncomfortable that I don't want to go back."

3. Physical Activity

Past Physical Activity (Godin & Shepard, 1985)

We are now interested in your average level of **planned physical activity**. Please be as specific and honest as possible.

During a *typical week within* ***the past four weeks***, how many times on average did you do the following kinds of exercise for **30 minutes or more** during your free time (write on each line the appropriate number)?

Each of the following physical activity intensities provides some examples of activities with the typical corresponding intensity. The list is not all-inclusive. If your typical activity is not listed, try to think of which intensity best applies to the activity.

g) **STRENUOUS EXERCISE (HEART BEATS RAPIDLY)** **____times/wk**

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

h) **MODERATE EXERCISE (NOT EXHAUSTING)** **____times/wk**

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

i) **MILD EXERCISE (MINIMAL EFFORT)** **____times/wk**

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking)

Pattern of physical activity.

Think about your **planned weekly exercise** over the past four weeks. Please select the description that best describes your pattern of exercise over the past four weeks.

a) My planned exercise frequency and duration were exactly the same for all four of the weeks (e.g., you completed the same planned activities each week for about the same amount of time).

b) My planned exercise frequency and duration varied between the four weeks (e.g., of the 4 weeks, you completed the same planned activities for 3 weeks, and one week was different).

c) My planned exercise frequency and duration varied more between the four weeks (e.g., you completed the same planned activities for 2 weeks and the third and fourth weeks were different from the first two, but the same as one another).

d) There was no pattern to my planned exercise frequency and duration over the past 4 weeks (e.g., you may not have exercised at all one week, then exercised 6 times another, exercised once and still another you exercised twice).

e) You did not exercise at all in the past four weeks.

Physical activity intention

How many 30-minute or more bouts of moderate or strenuous exercise do you intend on doing in the next

7 days? _____

4. Exercise problem scenario

Below is a scenario about Cory. Please read the below scenario and be attentive to the details of the story.

Exercise Problem Scenario

Cory is 27 years old and is thinking about starting to exercise. Cory does not currently exercise. Cory is considering whether or not to begin exercising over the course of the next month.

His family has no history of chronic illness. He is married with two kids and has access to free exercise facilities through his partner's work benefits. He thinks he would enjoy the social aspect of exercising, but he doesn't have a partner to exercise with. He used to play sports in grade school.

Cory has the support of his close family members, who suggest that he should start to exercise. And he knows that regular exercise is beneficial to overall health. Cory doesn't smoke. However, there has been more work than usual, making him quite busy lately. Cory regularly does the administrative work (e.g., arranging the volunteer schedule) for the local charity he works with. However, he realizes that because of work, he has fallen a bit behind and will have to find time to get this done. Cory feels that exercising helped him feel less sore after shoveling snow off the long sidewalks bordering his corner lot house.

To help so that he doesn't fall behind at work with the increased workload, Cory has been getting up an hour and a half earlier, making him more fatigued than usual. He remembers that playing sports helps to release some of the stress from work. Cory has also been taking time to run errands for a close friend who is recovering from a recent surgery. He doesn't know the weather forecast over the next couple of weeks.

5. Thought Listing

Please list up to 5 thoughts you had while reading the scenario.

1._____
2. _____
3. _____
4. _____
5. _____

6. Reaction to being in scenario.

1. If you put in this scenario, how would you respond (e.g., what would you think/do)?

_____
_____

7. Message Quality Check

INSTRUCTIONS: The following questions are about the scenario that you read.
Please use the following scale to rate each item:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Strongly disagree								**Strongly Agree**

1. The person in the problem scenario could be someone like me.
2. The problem scenario was believable.
3. The problem scenario was easy to read.
4. The problem scenario was understandable.
5. The factors facilitating exercise depicted in the scenario were realistic.
6. The factors hindering exercise depicted in the

8. Perceived Difficulty

Please use the scale below to rate the degree to which you believe that it would be difficult to **carrying out planned exercise** under the conditions <u>during the 4-week period depicted in the scenario</u>.

How difficult do you believe this scenario would be?

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Not at all difficult				**Somewhat difficult**				**Extremely difficult**

9. Decisional Struggle

If you were in this scenario, how much would you struggle with the decision to exercise?

INSTRUCTIONS: Please use the following scale to answer.

1	2	3	4	5	6	7	8	9
No Struggle				Moderate Struggle				Tremendous Struggle

10. Self-Regulatory Efficacy for Exercise

INSTRUCTIONS: The following questions are about your planned exercise participation.

Please think back to being in a situation similar to the one depicted in the exercise scenario about Cory and rate your confidence in carrying out each of the following actions related to your planned exercise ***over the month depicted in the scenario***:

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all Confident										Extremely Confident

1. Over the month depicted in the scenario, how confident are you that you can arrange your weekly schedule in order to do your exercise no matter what?

2. Over the month depicted in the scenario, how confident are you that you will develop solutions to cope with **unexpected** barriers that can interfere with your exercise?

3. Over the month depicted in the scenario, how confident are you that you can make up times during the same week when you miss your exercise sessions?

4. Over the month depicted in the scenario, how confident are you that you will maintain your regular exercise frequency even though it may be difficult at times?

5. Over the month depicted in the scenario, how confident are you that you will resume your regular exercise frequency when it is interrupted and you miss exercise for a few days?

6. Over the month depicted in the scenario, how confident are you that you will develop plans for each exercise session to reach your desired level (i.e., intensity) of exercise?

7. Over the month depicted in the scenario, how confident are you that you can make a plan of action to maintain your current exercise frequency each week, despite things that can prevent you from carrying out planned exercise?

8. Over the month depicted in the scenario, how confident are you that you can prevent other things from interfering with your efforts to maintain your current exercise frequency each week?

INSTRUCTIONS: The following questions are about your planned exercise participation.

Please think back to being in a situation similar to the one depicted in the exercise scenario about Cory and rate your confidence in ***dealing with unhelpful thoughts*** related to your planned exercise ***over the month depicted in the scenario:***

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Not at all Confident										Extremely Confident

9. Over the month depicted in the scenario, how confident are you that you can prevent your unhelpful thoughts from interfering with deciding to exercise as planned?

10. Over the month depicted in the scenario, how confident are you that you can manage your negative thoughts about exercise so that they do not make you indecisive about engaging in exercise?

11. Over the month depicted in the scenario, how confident are you that you can maintain your motivation to exercise despite unhelpful thoughts about exercising?

12. Over the month depicted in the scenario, how confident are you that you can focus solely on the positive outcomes of exercise important to you instead of the negative outcomes you think about?

Appendix F. Study 2 Correlation Table.

Variables	ECEs	Planned MVPA Bouts	Intention	SRE	Perceived Difficulty	Decisional Struggle	Persistence
ECEs	-						
Planned MVPA bouts	-.339***	-					
Intention	-.373***	.490***	-				
SRE	-.655***	.342***	.428***	-			
Difficulty	.511***	-.163***	-.154***	-.416***	-		
Decisional Struggle	.549***	-.207***	-.217***	-.454***	.743***	-	
Persistence	-.579***	.334***	.333***	.674***	-.382***	-.431***	-

Note: ***p<.001. N = 364.

Appendix G. Study 3 Correlation Table.

Variables	ECEs	Planned MVPA Bouts	Intention	SRE-P	SRE-CE	Perceived Difficulty	Decisional Struggle
ECEs	-						
Planned MVPA bouts	-.429***	-					
Intention	-.422***	.555***	-				
SRE-P	-.685***	.422***	.400***	-			
SRE-CE	-.741***	.469***	.434***	.874***	-		
Difficulty	.439***	-.285***	-.212**	-.516***	-.451***	-	
Decisional Struggle	.561***	-.334***	-.267***	-.530***	-.538***	.693***	-

Note: ***p*<.01; ****p*<.001. *N* = 138.