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The Development of the Experiential Impact of Mental Fatigue Scale

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Abstract

Measures of mental fatigue often do not consider daily life experiences, and existing measures fail to distinguish among various, potentially dissociable, ways that mental fatigue manifests. The present studies assessed the validity of the newly created Experiential Impact of Mental Fatigue Scale (EIMFS). Participants (Study 1, n = 365; Study 2, n = 243) responded to 85 items that address the various forms of mental fatigue across different situational contexts. The final scale, analysed through both exploratory and confirmatory factor analysis, included 22 items that loaded differentially on four factors which I term: emotional consequences, daily life impact, cognitive difficulties, and motivation and engagement. Each of the four subfactors as well as the scale overall had acceptable reliability and demonstrated construct and criterion validity with ancillary measures. Future research should administer the EIMFS in various neuropsychological populations to explore the relationship between mental fatigue and other symptoms experienced by these groups.

Keywords: Mental fatigue, quality of life, assessment, scale development, factor analysis, psychometric properties

Summary for Lay Audience

Fatigue, including mental fatigue affects all aspects of cognition and emotion, with potentially devastating effects on quality of life. The onset may begin after engaging in intense or demanding cognitive experiences. It can result in difficulties making decisions, negative effects on mood, poor task performance, and reduced productivity. And yet, mental fatigue remains relatively unexplored as a construct, since it is difficult to define and measure. Assessment of mental fatigue should include how it affects people in their daily life. This would include examining contextual factors that exacerbate feelings of mental fatigue.

Although numerous mental fatigue scales exist, these measures often fail to assess how mental fatigue manifests in daily life experiences. Thus, I present a new scale to address mental fatigue – The Experiential Impact of Mental Fatigue Scale (EIMFS). This self-report measure assesses individuals' experiences of mental fatigue and impact it has on their life. The experiential impact of mental fatigue is characterized as a psychological condition that has both subjective and objective aspects. Subjectively it can be defined as the perception of being involuntarily unable to complete mental tasks. Objectively it influences an individual's ability to focus, withstand distraction, and/or initiate and sustain motivation. The EIMFS includes 88 questions (three attention checks and 85 "true" items) that address the various forms of mental fatigue across different situational contexts.

Data were collected from two samples (Study 1 included 365 participants and Study 2 included 243 participants). Participants completed the EIMFS by rating the extent to which each of the items applied to them right now. The final scale included 22 of the original 85 items.

The results from this study suggest that the EIMFS has good reliability and validity. The EIMFS includes four subscales which I term: emotional consequences, daily life impact, cognitive difficulties, and motivation and engagement.

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Table of Contents

List of Figures

List of Tables

List of Appendices

Chapter 1: Literature Review

Introduction

Mental fatigue, a reversible inability to engage in mental work requiring focus and cognitive effort, is an important cause of reduced quality of life and productivity in people with a variety of neurological and other conditions, including mild traumatic brain injury, epilepsy, and hearing loss (Dobryakova et al., 2015). Mental fatigue has been described as unpleasant, leading to sub-optimal functioning, which increases the likelihood of human error (Chaudhuri & Behan, 2004; Lorist et al., 2005). As a result of mental fatigue, children and adults may find themselves at an increased risk for negative psycho-educational or work outcomes (Bess et al., 2014).

The effective study and treatment of the impact of mental fatigue requires that we have reliable and valid measures and assess it accurately across time. Progress in this area remains slow given that there is no clear definition of "mental fatigue" or a conceptual framework as a basis for measurement (Tyson & Brown, 2014). Without a clear definition, we cannot know which instruments are most effective at assessing the impact of mental fatigue.

Mental fatigue can and should be distinguished from physical fatigue given their distinct origins in either mental or physical work, differences in symptom manifestation and expression, and distinctions in describing these constructs within the literature (Billones et al., 2021; Hockey, 2013). This work will focus on creating a new measure of mental fatigue that will primarily assess this construct.

The goal of this research is to develop a new measure to assess the experiential impact of mental fatigue in normal healthy controls. Sensitive assessment tools will enable earlier detection of mental fatigue, more confident decisions about its resolution, and otherwise aid in the development and assessment of treatment plans and interventions (Sharpe, 2002; Whitehead et al., 2016). Furthermore, the cognitive-neuroscience literature on cognitive control and motivation in the service of cognitive effort has been developing rapidly, and this new scale will incorporate items that reflect current understanding of constructs such as cognitive control, cognitive effort, cognition, emotion, and motivation.

A Brief Overview of General Fatigue

By its very nature the experience of fatigue is unpleasant, and it adversely affects health related outcomes and many aspects of quality of life (Flensner et al., 2013). Fatigue can decrease

work performance and productivity and increase the possibility of a workplace accident (Bess et al., 2014; Ricci et al., 2007). Older adults may find that fatigue reduces their desire to engage in activities outside the home, resulting in increased social isolation (Davis et al., 2021). Fatigue in children can reduce their ability to attend school or participate in extracurricular activities, impair their learning and school performance, and increase their stress levels (Bess et al., 2014).

Fatigue is also an important symptom of nearly all neurological and systemic diseases (Chaudhuri & Behan, 2004; Dobryakova et al., 2015; Şenol et al., 2007; Yan et al., 2016), and is a significant predictor of quality of life for affected individuals. As an example of its prevalence, approximately half of all patients with Parkinson's disease will be affected by fatigue (Kluger et al., 2017), yet the etiology of fatigue in this population remains unknown and there are no effective therapies (Franssen et al., 2014). For adults with hearing loss, listening related fatigue is common in social situations with even mild or moderate background noise (Bess & Hornsby, 2014; Davis et al., 2021; Holman et al., 2021). In people who experience a stroke, fatigue can linger for years after, with limited research on its underlying mechanisms (De Doncker et al., 2018), and individuals who have sustained neurological damage (such as through traumatic brain injuries), often report subsequent cognitive fatigue (DeLuca, 2005). Despite 42.5% of people with epilepsy (PWE) experiencing fatigue (either post-seizure or during pharmacological treatment; Şenol et al., 2007), there are not many studies examining fatigue in this population (Lagogianni et al., 2021). Many other chronic health conditions including multiple sclerosis, cancer, obesity diabetes, heart disease, systemic lupus erythematosus, and autoimmune disorders are associated with feelings of fatigue, as are psychiatric disorders such as depression and anxiety (American Psychological Association, 2013; Bess et al., 2014).

I reviewed the qualitative literature to determine how individuals with various conditions (i.e., those suffering from cancer, kidney disease, heart failure, stroke, multiple sclerosis, rheumatoid arthritis, chronic obstructive pulmonary disease, and traumatic brain injury) often describe their fatigue, including the situations and contexts in which fatigue occurs, and specific characteristics of the experience. From this, I learned that when discussing their fatigue, individuals will often report on the emotional consequences such as low mood, feelings such as anxiety, anger, or frustration, or an overall "feeling of emptiness" (Glaus et al., 1996; Picariello et al., 2018; Raymond et al., 2021; Valentine & Meyers, 2001; White et al., 2012). Moreover, the fatigue may foster insecurity or feelings of worthlessness, and diminish self-esteem (White et al.,

2012). Unpredictability in the onset of the fatigue can impair their ability to make plans with others leading to reduce social behaviour (Larun & Malterud, 2007). Other daily life impacts include a lack of interest in or avoidance of activities, and challenges with sedentary activities (e.g., reading, using the computer, writing, administrative tasks, or watching TV) (Ezekiel et al., 2021; Walthall et al., 2019). Cognitive decline from fatigue may result in a need to allocate mental resources for demanding tasks, which may reduce how much work the individual can complete in a day (Glaus et al., 1996; Jaime-Lara et al., 2020). Finally, the experience of fatigue can lead to a loss of motivation (e.g., "can't be bothered"), and the desire to do things but being unable to bring oneself to start (Ezekiel et al., 2021; Flinn & Stube, 2010; Glaus et al., 1996; Jamie-Lara et al., 2020; Magnusson et al., 1999; Picariello et al., 2018). These descriptions of how patients experience fatigue in their lives were used as the basis for the EIMFS item development.

Fatigue as a Multidimensional Construct

It is clear from the numerous descriptions of fatigue used across the literature that it is not limited to just physical symptoms, but there are cognitive and mental symptoms as well (Lagogianni et al., 2021; Pattyn et al., 2018). However, there is debate about whether different types of fatigue symptoms (such as physical, mental, and cognitive) reflect a common, unitary, underlying state (or overall dimension of severity), or if they are distinct dimensions (Matthews, 2012).

In 1947 Bartley and Chute reported no reason to view mental and physical fatigue as distinct entities (Matthews, 2012). More recently in 2012, after examining the differences and similarities between forms of fatigue, researchers concluded that there was no significant reason to separate these constructs when it comes to measuring the resulting fatigue state (Matthews, 2012). For instance, much of the variance in different fatigue scales can be accounted for by a single broad dimension (e.g., the Swedish Occupational Fatigue Inventory; Åhsberg, 2000; Åhsberg et al., 1997; Matthews, 2012). Other researchers have determined various fatigue questionnaires to be unidimensional measures, even measures that sample multiple kinds of symptoms (e.g., physical, emotional, cognitive, etc.), such as the Fatigue Scale (with subscales of Mental and Physical Fatigue; Chalder et al., 1993) and the Checklist of Individual Strength (with subscales of Subjective Experience of Fatigue, Concentration, Motivation, and Physical Activity; De Vries, 2003; Vercoulen et al., 1994; Matthews, 2012).

Over the same period, others have argued for a distinction between mental and physical fatigue, given differences in origin and symptom expression (Matthews, 2012). In 1995, Smets and colleagues pushed for a multidimensional approach to scale development to encapsulate the entire experience of fatigue. Using confirmatory factor analysis, they discerned five dimensions of fatigue including general fatigue, physical fatigue, mental fatigue, reduced motivation, and reduced activity (Matthews, 2012; Smets et al., 1995). In a scoping review conducted by Billones and colleagues (2021), 55% of the articles defined fatigue as multidimensional and eight fatigue dimensions were identified (based on the authors reviewing fatigue descriptions in the final subset of included articles): physical, cognitive, mental, central, peripheral, emotional, motivational, and psychosocial. In fact, many scales incorporate items that index multiple dimensions (e.g., Fatigue Impact Scale [FIS; Fisk et al., 1994], Fatigue Questionnaire [FQ; Chalder et al., 1993], Fatigue Assessment Instrument [FAS; Shahid et al., 2011a], Fatigue Symptom Inventory [FSI; Hann et al., 1998], Multidimensional Assessment of Fatigue [MAF; Belza et al., 1993; Belza et al., 2018], Multidimensional Fatigue Inventory [MFI; Smets et al., 1995]).

Technical and methodological issues may explain discrepancies in whether a scale appears to reflect many dimensions of fatigue or only one (e.g., orthogonal varimax rotations versus correlated-factor solutions in factor analysis) (Matthews, 2012). The variety of phenomena that are sampled is also important to consider. Depending on the items included, certain symptoms of fatigue may be over-represented, influencing the output of the factor analysis (e.g., resulting in a strong general factor; Mathews, 2012). In comparison, sampling a broader range of symptoms is more likely to produce an output that supports multiple factors (Matthews, 2012).

Physical versus mental fatigue. One of the main arguments that mental fatigue can (and should) be distinguished from physical fatigue is the distinct origins in either mental or physical work (Hockey, 2013). On the one hand "physical fatigue is dependent on factors such as the type, magnitude and intensity of physical labor and effort as well as neuromuscular characteristics, metabolite storage, buffering capacity, etc." (Bogdanis, 2012; Pattyn et al., 2018, p. 2). This form of fatigue is described as a "debilitating physical exhaustion or a distressing lack of energy…" (Norton et al., 2015 as cited in Billones set al., 2021, p. 3). Conversely, mental fatigue "can be conceptualized as an outcome of incremented cognitive load due to constrained

time to process perpetual cognitive demands amongst others…" (Pattyn et al., 2018, p. 2). It can be described as "mental exhaustion that appears especially during sensory stimulation or following mentally strenuous tasks" (Papakokkinou et al., 2015 as cited in Billones et al., 2021, p. 5) and as "the subjective perception of feeling fatigued after performing intense or demanding cognitive activities that involve concentration" (Falup-Pecurariu, 2013 as cited in Billones et al., 2021, p. 5). Commonly used phrases also included: "reduced sustained mental effort", "quickly becoming fatigued after reading or watching television with others", "prolonged rest to recover after mentally strenuous activity", and "forgetting things easily" (Berginstrom et al., 2017 as cited in Billones et al., 2021, p. 5). In this work I will use the terms cognitive and mental fatigue synonymously, following the precedent set by Billones et al. (2021), Deluca (2008), and Matthews (2012).

Engaging in excessive mental demands can result in mental fatigue, and mental fatigue has also been associated with decreases in cognitive task performance (Díaz-García et al., 2022). In addition, questionnaires have tended to differentiate between the type of fatigue that affects mental or cognitive activities (such as impaired concentration) from fatigue that interferes with physical or muscular activities (such as decreases in sustained activity) (Matthews, 2012).

Given the difficulties in distinguishing from mental fatigue and physical fatigue in the literature, it is unlikely that the EIMFS will be able to clearly separate the impacts of mental fatigue from physical fatigue. Thus, there is no reason why the EIMFS will not correlate with other measures assessing physical fatigue.

Dimensions of mental fatigue. Not only is there debate about whether physical and mental fatigue should be assessed separately, but also about whether mental fatigue is a single state, or is itself multidimensional (Matthews, 2012). Pattyn and colleagues (2018) proposed that the term "mental fatigue" could encompass symptoms of motivational, emotional, as well as cognitive fatigue. For example, *motivation fatigue* is defined as "a symptom that is disruptive in terms of motivation and initiative activities" (Kratz et al., 2016 as cited in Billones et al., 2021, p. 6), and "having capabilities to considerably interfere with patients' ability to work and lead a normal life, including social activities with family and friends" (Palm et al., 2017 as cited in Billones et al., 2021, p. 6). Another possible dimension of mental fatigue is *emotional fatigue* "an unpleasant symptom that is strongly associated with depression and is extremely disruptive to health-related quality of life," (Norton et al., 2015; Lie et al., 2017 as cited in Billones et al.,

2021, p. 6). Emotional fatigue can occur in situations where there are strong and sustained emotional reactions and responses (Matthews, 2012).

The Timescale of Fatigue. Fatigue can also be evaluated on different timescales by distinguishing between the general tendency to become mentally fatigued (i.e., "sustained over time" fatigue or "sustained" from now on) and the instantaneous experience of fatigue in a given moment (i.e., "state" fatigue") (Malloy et al., 2021; Müller et al., 2021). Interventions and therapies may be tailored depending on the timescale of fatigue (Matthews, 2012).

Sustained fatigue occurs over a long period of time (e.g., weeks and months), is somewhat stable, and is often associated with chronic illness (e.g., multiple sclerosis, chronic obstructive pulmonary disease, and rheumatoid arthritis) (Behrens et al., 2023). Although sustained fatigue can be due to either primary disease-related mechanisms or secondary mechanisms of the disease, healthy individuals may also experience a milder form (Behrens et al., 2023). Generally, sustained fatigue is not influenced by the demands of any particular tasks (Malloy et al., 2021).

Conversely, state fatigue is activity-induced and "is characterized by an acute and temporary change in motor or cognitive performance as well as the subjective experience of weariness or exhaustion that occur in the context of a specific motor or cognitive task," (Behrens et al., 2023, p. 9). A task that results in a short-term increase in fatigue followed by a short period of recovery can be classified as *recoverable fatigue* (Müller et al., 2021). On the other hand, *unrecoverable fatigue* has long-term increases in fatigue that occur after extended periods of work (Müller et al., 2021). In these instances, rest does not necessarily lead to recovery (Müller et al., 2021).

Identifying Critical Aspects of Mental Fatigue and Operationalizing the Construct

In general, the psychological literature refers to mental fatigue as a diminished sense of energy (Chaudhuri & Behan, 2004). Mental fatigue can include subjective (e.g., feelings of tiredness, an absence of energy, or a lower sense of motivation), behavioural (e.g., decrease in performance on a cognitive task), physiological (e.g., changes in brain activity), affective (e.g., increases in anxiety, depression, or stress) as well as cognitive aspects (e.g., poorer executive functioning and cognitive flexibility) (Díaz-García et al., 2022). Mental fatigue can influence productivity, diminish performance, worsen concentration, decrease the ability to perform

sustained mental tasks, and increase risk of error when completing cognitive tasks (McCormick et al., 2013).

In this research I take a broad view of mental fatigue and hypothesize that it has multiple interrelated dimensions related to emotion, cognition, and motivation. The first step in the development of the EIMFS was to operationalize mental fatigue and identify the domain boundaries. Guided by the steps outlined by McCoach and colleagues (as cited in Boateng et al., 2018), an in-depth literature search was conducted to determine the influence of mental fatigue on an individual's quality of life, and additionally confirmed that there were no existing instruments that would tap into what we hoped the EIMFS would capture. The literature review forms a foundation for this first step, as it served to provide a working definition of mental fatigue, that we aimed to capture in the EIMFS (Boateng et al., 2018).

I define mental fatigue as: *a psychological condition that has both subjective and objective aspects. Subjectively it can be defined as the perception of being involuntarily unable to complete mental tasks. Objectively it influences an individual's ability to focus, withstand distraction, and/or initiate and sustain motivation. It can result in difficulties making decisions, negative effects on mood, poor task performance, and reduced productivity*. This includes aspects of what is often described as "tiredness" or "lethargy" in the literature.

Difficulties making decisions, effects on mood, task performance, and reduced productively are all aspects I will be assessing in the questionnaire. Four critical aspects were hypothesized to make up the impact of mental fatigue: impaired cognitive control, impaired cognition, emotion, and decreased motivation. Several factors were taken into consideration to make the EIMFS distinct from other measures of mental fatigue (existing measures are discussed under the subheading "basis for a new mental fatigue scale"). The first factor was the time frame of the experiences that would be included in the items. Many existing scales assess for sustained mental fatigue whereas the EIMFS was designed to measure the impact of state mental fatigue. Secondly, the items created for the EIMFS were designed to assess only the impact of mental fatigue and did not include items assessing physical fatigue (e.g., ability to walk, exercise, etc.). Third, mental fatigue was framed as an experience affecting everyday tasks and activities. Fourth, care was taken to specify the types of tasks, situations, and contexts in which mental fatigue occurs.

Impaired Cognitive Control, Effort, & Cognition

The experiential impact of mental fatigue involves greater distractibility, i.e., a lack of cognitive control. *Cognitive control* is defined as "a collection of mechanisms, including perceptual selection, response biasing, and online maintenance of contextual or goal information, by which the human cognitive system adaptively configures itself to optimally perform specific tasks," (Chiew & Braver, 2011 p. 1). Cognitive control allows individuals to adapt their behavior to meet demands by helping to process information flexibly through enhancing the perceived salience of information relevant to the task, and dismissing thoughts that contest with those that are goal-oriented (Dreher & Berman, 2002).

When an individual engages in cognitive control, they are expending cognitive effort, and multiple theorists have proposed that effort be implicitly or explicitly taken into account by the individual in deciding to use cognitive control resources (Van den Bussche et al., 2020). The ability to exert mental effort, however, may be influenced by the experience of mental fatigue. Many tasks and activities completed in daily life require the exertion of mental effort, sometimes over a prolonged period. This may itself result in fatigue, and declining motivation to continue to exert effort (Westbrook & Braver, 2015).

Cognition can be defined as "the process of coming to know and understand; of encoding, perceiving, storing, processing, and retrieving information," (Huitt & Cain, 2005, p. 1). The cognitive domain can include analytic and interpretive functions, reasoning, memory, symbol-manipulation, language, fluid intelligence, and crystallized intelligence (Hilgard, 1980). Prior evidence suggests that fatigue may be significantly related to critical aspects of cognition (Lagogianni et al., 2018).

Emotion

Emotion is defined as "the emotional interpretation of perceptions, information, or knowledge…" (Huitt & Cain, 2005, p. 1). Fatigue is frequently a secondary symptom of mood disturbances and anxiety (Kuppuswamy, 2021; Lagogianni et al., 2021; Neu et al., 2010). Over 90% of individuals diagnosed with major depressive disorder (MDD) report fatigue as a symptom (predominantly expressed through physical, emotional, or cognitive symptoms). Aspects of mental fatigue (e.g., diminished concentration, attention and focus, and difficulties finding the right word, etc.) overlap with the MDD symptom of cognitive dysfunction, and may also cluster with symptoms such as apathy, anhedonia, or a lack of motivation (Ghanean et al.,

2018). Even after a patient is in remission from a major depressive episode, fatigue will often remain as a residual symptom (Ghanean et al., 2018). Experiencing either fatigue or depression doubles the likelihood that an individual will go on to develop both conditions (Penner & Paul, 2017).

Experiencing fatigue may also lead some individuals to develop a psychiatric disorder (i.e., through the negative influence fatigue has on the ability to complete tasks and goals), for others, fatigue may be a symptom of a psychiatric disorder (Matthews, 2012).

Decreased Motivation

The impact of mental fatigue may be accompanied by a lack of motivation, and it has been argued that motivation and emotional aspects may be included within the experience of mental fatigue (Pattyn et al., 2018). *Motivation* is "an internal state that drives behaviour toward a reward goal or end point and away from undesirable or punishing outcomes," (Inzlicht et al., 2015, p. 128). Motivation is a crucial determinant of individual variation in performance (Braver et al., 2014; Chiew & Braver, 2011; Duckworth & Carlson, 2013; Miller, 2000; Shenhav et al., 2017; Yee & Braver, 2018). Brehm's motivation intensity theory helps to explain the factors that underlie the investment of resources needed to perform behaviour (Richter et al., 2016). Although this theory was not originally developed with effort in mind, subsequent work has used this theory to address the mobilization of effort to carry out goals (Richter et al., 2016). Participants will vary their investment in mental effort depending on rewards and whether they anticipate their investment of effort will override the cost (Frömer et al., 2021; Otto & Vassena, 2021). The cost-reward-trade-off has been proposed to be a key component of general fatigue, with the need to sustain too much effort leading to feelings of strain and fatigue (Zijlstra, 1993 as cited in Otto et al., 2014).

Measuring Mental Fatigue

Subjective Measures of Mental Fatigue

Self-report measures are common in fatigue research (Whitehead, 2009; Whitehead et al., 2016). Self-report captures the feelings and perceptions of a participant during experiences of mental fatigue and can be tailored to specific contexts or for certain populations (Gawron, 2016; Matthews, 2012). Despite the practicality of this form of assessment (e.g., being widely available, easy to administer, and simple to use; Bess & Hornsby, 2014; Matthews, 2012), the reliance on the insight of the participant can result in biases based on mood, perception of what is

being asked, understanding of wording, desire to answer "correctly", and boredom (Chaudhuri & Behan, 2004; Gawron, 2016). In addition, self-report can be time consuming for the participant, and of course this tool can only assess fatigue of which the individual is explicitly aware (Gawron, 2016; Matthews, 2012). These limitations reduce the validity of the measure and are applicable to all self-report fatigue scales (Gawron, 2016). Refer to Appendix B1 for a review of existing mental fatigue scales and their limitations.

Objective Measures of Mental Fatigue

At present, there is no gold-standard, objective, tool to assess the impact of mental fatigue. Objective assessment would use performance-based measurement or brain imaging methods. Performance-based measures are behavioural or cognitive in nature, and typically define fatigue as impaired task performance, relative to a non-fatigue baseline (Gawron, 2016; Matthews, 2012). These types of measures allow for the possibility of external verification by outside observers and may provide a more reliable assessment (Heaton et al., 2020; Matthews, 2012; Walker et al., 2012).

To date, the neuroanatomical basis of cognitive and physical fatigue has yet to be fully established (Müller & Apps, 2019). However, modern cognitive neuroscience is beginning to examine how fatigue can be reflected in several brain arousal systems (Müller & Apps, 2019). Researchers have posited that greater levels of fatigue would necessitate a greater intensity control signal to override the increase in cost (Müller & Apps, 2019). In return, the value of reward associated with that task may be diminished (Müller & Apps, 2019). To determine which neural mechanisms are likely to underly cognitive fatigue different types of cognitive tasks are used, and correlations between changes in task performance and different brain regions are examined (Müller & Apps, 2019). Although different tasks will lead to the involvement of various brain regions, evidence has shown that the areas of the brain believed to be critical for the cognitive operations recruited by a given task do change over time, and that these changes are related to perceptions of effort and fatigue (Müller & Apps, 2019). Mental fatigue also appears to relate to changes in neural activity in areas associated with motivation, and the exertion of cognitive effort has also been linked to neural changes in areas such as the ACC, insula, and DLPFC (Müller & Apps, 2019). BOLD response in medial and lateral frontal sub-regions is linked to longer-term fatigue that affects effort-based decision-making, performance,

and choice in tasks, and the frontal-striatal system seems to be involved in deciding to allocate effort (Müller et al., 2021).

Basis for a New Mental Fatigue Scale

In 2009, a study by Whitehead reviewed 17 fatigue instruments. It was found that three short instruments had good psychometric properties (the FSS [Krupp, 1989], FIS [Fisk et al., 1994], and the Brief Fatigue Inventory [BFI; Mendoza et al., 1999]) as did three comprehensive measures (FSI [Shahid et al., 2011], MAF [Belza, 1993], and Multidimensional Fatigue Symptom Inventory [MFSI; Stein et al., 1998]) (Whitehead, 2009). However, the scales that were determined to have good psychometric properties have other limitations that warrant the development of the EIMFS. The FSS has issues of item redundancy, confusing scoring structures, and measures several constructs despite purporting to be a unidimensional measure (Tyson & Brown, 2014). All six of the scales measure sustained fatigue instead of state fatigue (except the FSS which does not specify a timeframe). The FSS, the FIS, and the BFI include scale items that are abstract and not specific in addressing the experiences and contexts in which mental fatigue occurs. Notably, the review concluded that no fatigue instrument was sufficient in meeting all the "ideal" criteria (defined as "…scale usability, clinical/research utility, and the robustness of psychometric properties"; Whitehead, 2009 p. 107). For a detailed overview of these measures as well as other selected measures that assess for elements of mental fatigue, please refer to the table in Appendix B1.

Since Whitehead's (2009) review, other scales such as The Neurological Fatigue Index (NFI-MS; Schwartz et al., 2010), and the Vanderbilt Fatigue Scale for Adults (VFS-A; Hornsby et al., 2021) have been developed. Although these two scales are related to my area of work, they assess a more specific context of mental fatigue (i.e., mental fatigue for individuals with multiple sclerosis and hearing loss) as opposed to the general impact of mental fatigue that my own scale will measure.

At the time of writing, I am only aware of two existing scales that tap into the ways in which general mental fatigue affects daily life: the Situational Fatigue Scale (SFS; Yang & Wu, 2005), and the State-Trait Inventory for Cognitive Fatigue (STI-CF; Shuman-Paretsky et al., 2017).

The Situational Fatigue Scale

The Situational Fatigue Scale (SFS) is a subjective rating scaled developed by Yang & Wu (2005) and is based on the belief that it is important to consider both an individuals' resources as well as their situational context when assessing fatigue. According to this view, fatigue is determined not only by one's subjective feeling about the state of their internal resources, but also by the demands of the work the individual is engaging in (Yang & Wu, 2005). There are two main limitations for the SFS. First, it contains both items involving physical and mental fatigue (Yang & Wu, 2005), and as has been discussed previously, the assessment of physical and mental fatigue within the same measure is not ideal as I wish to focus only on mental fatigue. Secondly, this is a sustained measure of fatigue based on the past month, but it also imposes precise timeframes on the items (e.g., "watching TV for two hours). This could make it difficult for a participant to judge where on the rating scale (0 = *no fatigue at all* to 5 = *extreme fatigue*) their level of fatigue would be most accurate. Although the SFS asks about activities (i.e., paperwork, chatting, or reading), it does not consider the experience of the participants when they are trying to engage in such tasks (e.g., whether they become easily distracted when they are trying to focus), and the way other factors such as effort, motivation, and cognitive control relate to mental fatigue. The development of the EIMFS will address both these limitations.

The State-Trait Inventory for Cognitive Fatigue (STI-CF)

More recently, the State-Trait Inventory for Cognitive Fatigue (STI-CF; Shuman-Paretsky et al., 2017) was developed. The STI-CF is a 32-item subjective measure of *cognitive fatigue* defined as "the executive failure to maintain and optimize the performance over acute but sustained cognitive effort," (Shuman-Paretsky et al., 2017, p. 2). In my own definition I recognize that mental fatigue can result in poor task performance. However, this definition does not recognize the subjective aspects of mental fatigue as I do (i.e., being involuntarily unable to complete mental tasks, the negative influence on mood, etc.).

Although the authors do not explicitly state whether the STI-CF is unidimensional or multidimensional, the principal components analysis produced four subscales (cognitive fatigue, mental effort, motivation, and boredom) for both state and trait inventories (Shuman-Paretsky et al., 2017). The subscales of this measure assess an individuals' experience while completing "challenging mental tasks" or "repetitive and monotonous tasks." In addition, the inclusion of

state and trait forms allow researchers to account for intra- and inter- individual variability, bolstering the usefulness of the measure for longitudinal studies and experimental manipulation (Shuman-Paretsky et al., 2017). The STI-CF also captures constructs that are closely associated with, and likely to influence the experience of, cognitive fatigue; such as mental effort, motivation, and boredom.

The STI-CF is based on a definition of cognitive fatigue that is centered around failure to optimize performance, and the items included on the scale are mainly designed to assess a participant's ability to focus, or the allocation of effort (i.e., it is difficult for me to focus on challenging mental tasks; I am putting forth as much effort as possible on monotonous tasks). That said the STI-CF does not specify what a "challenging" or "repetitive and monotonous" task may be. Finally, this scale does not assess the emotional manifestation of mental fatigue (e.g., feelings of sadness, guilt, frustration, etc.)

The development of the EIMFS will help address these limitations. The EIMFS will still include items asking about participant's ability to focus (similar to the STI-CF item "it is difficult for me to focus for a long period of time"; Shuman-Paretsky et al., 2017). However, it will also include specific items to address contexts that may engender problems focusing (i.e., "when I am trying to focus, having distractions such as the TV on or people talking in the background makes me very mentally fatigued", or "it is hard for me to keep track of conversations in social settings"). The STI-CF asks about mental functioning (i.e., "it is difficult for me to mentally manipulate information"; Shuman-Paretsky et al., 2017). In comparison, some of the EIMFS items will address *how* mental fatigue impacts mental functioning (e.g., "I feel like I can't organize my thoughts enough to properly complete tasks", "it is hard for me to keep up my effort", "I feel like my learning abilities have deteriorated", or "I don't believe I can do well on tasks because I am too mentally fatigued"). To assess the emotional aspects of mental fatigue, there will be such as "I feel sad because of mental fatigue" and "I am less confident because of mental fatigue". Finally, the EIMFS will specifically define for participants what is meant by "challenging mental tasks" and will also include items that ask about specific tasks (e.g., reading, writing emails, making a grocery list, etc.).

Rationale

Considering the prevalence of mental fatigue, and its effect on quality of life, the assessment, adequate management, and recognition of the impact of mental fatigue is critical in

increasing effective care (Shuman-Paretsky et al., 2017). Despite increased interest in general fatigue in both clinical and research settings, and the corresponding significant growth in publications on the topic, mental fatigue remains underrecognized when it comes to treatment for individuals in general and neuropsychological populations (Sharpe, 2002; Whitehead et al., 2016). This may partly be attributed to a lack of an established "gold standard" for measuring mental fatigue (Pattyn et al., 2018; Shahid et al., 2011b; Shen et al., 2006).

The goal of this research is to fill a significant gap in the literature by developing a measure of the experiential impact of mental fatigue that can be reliably used to accurately assess this construct within clinical and research settings. Many scales assess aspects of mental fatigue within a broader construct of general fatigue; however, research suggests that mental fatigue is likely to be a distinct construct from physical fatigue, and there is reason to support the measurement and evaluation of mental fatigue as an independent construct. As reviewed previously, mental fatigue itself may have sub dimensions such as cognitive, motivational, and emotional fatigue. Thus, the newly developed Experiential Impact of Mental Fatigue Scale (EIMFS) will be unique in that it will assess mental fatigue as a multidimensional construct. Given the prior evidence suggesting that fatigue may be significantly related to critical aspects of cognition (Lagogianni et al., 2018), the scale will include items that ask about how mental fatigue has influenced daily cognitive functioning (e.g., "I feel like my ability to learn has decreased", and "I find it hard to pay attention for a long time"). Moreover, the Need for Cognition Scale (Cacioppo & Petty, 1982) will be administered to determine whether the desire to engage in intellectual problems predicts responses to questions assessing the effect of mental fatigue on mental function. Although we will be unable to determine whether mental fatigue is primary or secondary symptom (i.e., cause or effect), the current study will incorporate questions assessing depression, anxiety, and stress. Finally, questions about how the experience of mental fatigue may be influenced by perceived rewards and motivation will also be included.

Different indices of mental fatigue will be used in this research to best identify and assess its presence as well as increase validity and reliability of the results (Díaz-García et al., 2022). In addition, the scale will assess state fatigue as opposed to sustained fatigue, in order to be suitable to assess changes over time; with recovery from illness, for example. It will contain items sensitive to a respondent's experience of fatigue in daily situations, that may influence their quality of life. The *n*-back working memory test (for letters) will be administered both before and

after a long period of answering subjective questionnaires, to pick up on objective fatigue The *n*-back task requires constant online maintenance, and updating of the contents of working memory to "accurately respond to target stimuli that recur at the specified interval," (Jacola et al., 2014 p. 3). *N*-back tasks are often used in neuroimaging research to examine the neural mechanisms underlying working memory, and is described as "a standard executive working memory measure in cognitive neuroscience" (Kane et al., 2007, p. 1; Miller et al., 2009; Redick & Lindsey, 2013). Prior research supports the validity of the *n*-back as a clinically useful measure to assess working memory (Jacola et al., 2014).

In addition, the Raven's Advanced Progressive Matrices (APM)is a well-known measure of general cognitive ability that is often used with higher-ability adults and was originally developed by John Raven (Arthur & Day, 1994). We will measure this in order to remove variability in *n*-back performance that is due to general cognitive ability. Most contemporary models of intelligence, based on factor analysis of cognitive batteries, posit a hierarchical structure with *g* as a global factor accounting for positive correlation across all tests, and then a cluster of more specific ability factors such as working memory *k* (Benson et al., 2018). Research has shown that the APM is highly related to Spearman's *g* and is one of the best general intelligence measures (Duncan et al., 2000).

This research has two objectives. First, the main aim is to develop, validate, and streamline the EIMFS in healthy populations. The objective of Study 1 (N = 400) is to assess the attributes of the EIMFS items to further refine the measure through best-practice factor analysis (Brown, 2015; Harrington, 2009). Factor analysis (FA; Spearman 1904, 1927) is a statistical procedure often used in psychometric evaluations of multiple-item measures (such as questionnaires; Floyd & Widaman, 1995) (Brown, 2015). FA is designed to identify the number of latent variables or factors, and to determine the relationships between observed measures or indicators (for the rest of this paper "indicators" will be referred to as "items") and these factors (by determining which factors account for the variation and covariation among the items) (Brown, 2015). The objective of Study 2 (N = 318) is to replicate the results of Study 1 within a new sample to confirm the reliability of the factor structure. Lastly, psychometric properties of the measure will be assessed using data collected in both Study 1 and 2, and exploratory analysis examining the correlation between participants subjective rating of current mental fatigue and an objective measure (the *n*-back auditory memory task) will be conducted.

Chapter 2: Study 1

The goal of Study 1 was to develop a set of single-statement items, a subset of which would become the EIMFS. These items encompassed a variety of situations and contexts in which mental fatigue can be felt, as well as subjective impressions of impaired cognitive control, impaired cognitive effort, emotion, and decreased motivation that I postulate are part of the experiential impact of mental fatigue. Participants were asked to rate the extent to which each statement accurately reflected them or their experience "right now" on a 7-point Likert scale (1 = *disagree strongly* to 7 = *agree strongly*).

Methods

Development of The Western Mental Fatigue Scale

The development of the Experiential Impact of Mental Fatigue Scale (EIMFS) followed the best practice guidelines for scale development in health research outlined by Boateng and colleagues (2018).

Item Development

Domain Identification. As discussed in the introduction, four domains were identified as possible dimensions of mental fatigue, and which formed the basis for item generation: impaired cognitive control, impaired cognition, emotion, and decreased motivation.

Item Generation. After defining the domain of interest, 88 items for the scale were created (85 true items and three items that were used for attention checks). The *deductive* method (i.e., "item generation based on extensive literature review and pre-existing scales"; Morgado et al., 2018, p. 1) was used to identify appropriate questions that would fit the defined construct of mental fatigue (refer to p. 5 for definition) and its four possible dimensions (Boateng et al., 2018). Items from existing measures assessing mental fatigue (or relevant subdomains) were included, and new items were also created to tap into the hypothesized subdomains and indicators of mental fatigue (Boateng et al., 2018). Refer to Appendix B11 for a description on how each item was created.

The generation of the initial item pool (see Appendix A4 for items) was overly inclusive since items would be removed over time (Clark & Watson, 2019). It is recommended that the initial item pool be at least twice the size of what is hoped to be included in the final version of the measure (Boateng et al., 2018). Moreover, a large number of items also acted as a buffer against lower internal consistency (DeVellis, 2017). Numerous and redundant items were added

so I could determine whether one version of an item was superior to another, and with the knowledge that questions tapping the same construct would likely yield consistent answers, whereas those capturing different constructs would yield inconsistent answers (DeVellis, 2017). Multiple possible items were developed for each subdomain to bolster reliability and ensure that all four domains were adequately represented in the final scale (Clark & Watson, 2019; Smith et al., 2003). Substantially fewer items were included under the subdomain of decreased motivation compared to the subdomains labeled "impaired cognitive control" or "impaired cognition" since "broader content areas should be represented by more items than narrow ones" (Clark & Watson, 2019, p. 7).

Items were written to be as short and clear as possible, avoiding ambiguous, outdated or slang terminology (Clark & Watson, 2019; DeVellis, 2017). To achieve easy readability and comprehension by a diverse sample, the Flesch-Kincaid Grade Level was calculated for each item, with a grade level of 7 being the highest grade level that was accepted. Items that were at a grade level greater than 7 were reworded until the grade level was acceptable. Based on this, twenty items were reworded.

Content validity. The final step in item development focused on "theoretical analysis" (Morgado et al., 2018) and assessing the content validity of the items (defined as the "adequacy with which a measure assesses the domain of interest"; Hinkin, 1995, p. 968) (Boateng et al., 2018). This is discussed in more detail in the section Reliability & Validity Procedure (p. 18).

Statistical Analysis Procedure

A confirmatory factor analysis (CFA) was conducted on the EIMFS (using Jamovi version 2.3.2.1.0) to examine how well the factor solution fit the hypothesized four-factor model. This type of statistical analysis allows for the potential reduction in the number of items (through modification indices) and the identification of meaningful subscales (Harrington, 2009).

Model Fit. To evaluate model fit, a maximum likelihood estimation method (ML; see Lawley 1940; Lawley and Maxwell, 1963) was used to estimate model parameters. Goodness-of-fit approaches (developed by: Bentler, 1990; Cochran, 1952; Henseler et al., 2014; Steiger & Lind, 1980; Tucker & Lewis, 1973) were used to identify a factor solution that (1) surpasses the reproduced observed correlations from a model with fewer factors, and (2) is equal (or superior) in its ability to reproduce these observed relationships in comparison to a model with more factors (Brown, 2015). The first goodness-of-fit criterion was based on whether the classic chi-

square/*df* ratio *absolute fit* index (χ^2) was ≤ 3, and insignificant at the 0.05 threshold (Barrett, 2007; Cochran, 1952). However, this index can be inflated by large *n* samples, leading to solutions being erroneously rejected based on χ^2 (Brown, 2015). Therefore, alternative fit indices were relied on more heavily in the evaluation of model fit (Brown, 2015). The standardized root mean square residual (SRMR ≤ 0.08; Henseler et al., 2014) assesses the average disparity between the correlations in the input matrix and those predicted by the model, and was used to assess *absolute fit*. The root mean square error of approximation (RMSEA $\leq 0.06, [90\% \, CI \leq 0.06]$; Steiger, 1990; Steiger & Lind, 1980) is considered an "error of approximation" index as it assesses the degree to which a model adequately holds in the population, and was also used to assess *absolute fit* (more specifically: *parsimony correction* [indices that include a penalty function for poor model parsimony]). The Tucker-Lewis index (TLI ≥ 0.95; Bentler & Bonett, 1980; Tucker & Lewis, 1973) and the comparative fit index CFI (CFI ≥ 0.95; Bentler, 1990) (Brown, 2015; Hu & Bentler, 1999) both include a penalty function for the addition of any freely estimated parameters that fail to substantially improve model fit. These were used for *incremental fit indices* (assesses the fit of a user-specified solution in comparison to a restricted baseline model [i.e., a model with the worst fit]; Brown, 2015; Hu & Bentler, 1999). The TLI is also known as a *non-normed-fit index* (NNFI; Bentler and Bonett, 1980), and the CFI is a *comparative fit index*. Both these statistics assume that all the latent variables in a model are uncorrelated and compares the sample covariance matrix to this null model.

Evaluating the model solely on overall goodness of fit indices is not appropriate. These indices provide information on a model's *lack of fit* instead of conclusive evidence for a good-fitting model (Brown, 2015). Other aspects of the model, such as localized strain and parameter estimates were also examined to gain information on the utility and adequacy of the solution (Brown, 2015).

Reliability & Validity Procedure

Reliability. A critical aspect of establishing the psychometric development of the EIMFS was determining its reliability (Brown, 2015). Reliability (i.e., how consistently the instrument measures the construct of interest; Brown, 2015; Navarro & Foxcroft, 2019) was assessed through internal consistency (i.e., defined as "the consistency of responses across items", Price et al., 2014, p. 88) measured as Cronbach's (1951) coefficient alpha (α). Given the multidimensional aspect of the EIMFS and to prevent alpha from being under-estimated,

Cronbach's was assessed for each dimension as well as for the overall scale (Navarro & Foxcroft, 2019).

A limitation of Cronbach's alpha is that it is sample specific: characteristic of the sample providing the data, rather than pertaining necessarily to the scale itself (Navarro & Foxcroft, 2019). Considering this, McDonald's omega (ω), was also calculated, as it is a more robust statistic, and has less risk of overestimation or underestimation of reliability (Dunn et al., 2013).

Validity. Validity (i.e., "the extent to which the scores from a measure represent the variable they are intended to" (Price et al., 2014, p. 90) was assessed by examining construct (with content and criterion validity subsumed), convergent, and discriminant validity. Each type of validity was assessed with a series of bivariate correlations on the EIMFS with other measures of fatigue and related constructs. Items that overlapped across the EIMFS and other related indices (were either the same or very similar) were cut from the ancillary measure. I examined Pearson correlation coefficients both in terms of significance ($\propto = .05$) and magnitude. Interpreting a correlation coefficient was based on the following standards for meaningful effect sizes: 0.00-0.10 (negligible), 0.10-0.39 (weak), 0.40-0.69 (moderate), 0.70-0.89 (strong), 0.90-1.00 (very strong) (Schober et al., 2018).

Construct validity is the extent to which scale scores measure the scale's purported hypothetical latent construct (Kline, 2005; Müeller & Apps, 2019). Although specific validities (i.e., content) were used to determine construct validity, many of the validities that I examine are ultimately all contributing to the construct validity of the EIMFS.

The results of the factor analyses will be able to provide evidence on whether the data fits the hypothesized four-factor structure. Construct validity was also assessed by examining the extent to which different forms of mental fatigue were related to one another (Müeller & Apps, 2019). As the items included in the EIMFS were all designed to assess experiences that are affected by mental fatigue, the four subfactors of mental fatigue were expected to be moderately correlated with one another, indicating that they represent a similar and consistent construct. Yet, each dimension was also expected to be sufficiently distinct to merit independent consideration. Pearson correlations were examined to evaluate the degree of correlation of the dimensions comprising the EIMFS.

Content validity was assessed based on Guion's (1977) recommendations. Guion (1977) stipulated five conditions that would instill confidence in the content validity of a scale: "(a) the

behavioural content has generally accepted meaning or definition; (b) the domain is unambiguously defined; (c) the content domain is relevant to the purposes of measurement; (d) qualified judges agree that the domain has been adequately sampled based on consensus; and (e) the response content must be reliably observed and evaluated" (Boateng et al., 2018; Guion, 1966).

The definition of mental fatigue that we used was the same as the one presented in the introduction (p. 5). The definition is as follows: "*a psychological condition that has both subjective and objective aspects. Subjectively it can be defined as the perception of being involuntarily unable to complete mental tasks. Objectively it influences an individual's ability to focus, withstand distraction, and/or initiate and sustain motivation. It can result in difficulties making decisions, negative effects on mood, poor task performance, and reduced productivity."*

The true 85 items from questionnaire (not including the three attention checks), together with the above definition, was distributed to seek input on whether the items were relevant to the construct of interest, and were of high quality (Boateng et al., 2018). This conceptual clustering data collection was conducted in parallel to the data collected for Study 1 and Study 2 and did not affect how I collected the data for these two studies. Instead, this task provided a different way to examine how individuals were responding to the items and determine whether the four factors appeared sound enough to continue on with the CFA.

Graduate students (MSc and PhD) in psychology and neuroscience were asked to review the items for clarity, readability, and understanding. From this initial item review five items were revised based on choice of words or lack of clarity. I then asked naïve graduate student raters to organize the 85 items into four piles based on provided definitions of cognitive control, cognition, emotion (which I previously called "affection"), and motivation (see Appendix B2 for the definitions provided for the raters). A fifth pile was provided for raters to place any items they were unsure of or did not believe fit into the other four categories. If multiple items were consistently grouped together across piles, this would suggest that such items were potentially tapping into the same construct (see Appendix B3 for a table detailing the conceptual clustering). A lack of consistency in the grouping of an item across raters revealed a failure of the item to either reliably measure a common construct or be understood in the same way among raters. Items 9, 24, 27, 41, 46, 48, 51, 52, 63, 67, 68, 73, 81, and 84 were placed by at least two raters in this fifth pile. Importantly, no items were eliminated from the first draft of scale development

based on this conceptual clustering exercise. Items were not removed if they were placed in the fifth pile, given that previous studies suggest that item content is not required to strictly and perfectly fit the domain of interest, as later factor analytic work will eliminate items that are not loading in a desirable fashion (Boateng et al., 2018). These items were flagged for careful consideration pending subsequent analyses. Thirty of the 85 items had 50% or less of agreement among raters.

Criterion validity (i.e., "measuring the extent to which scores on the measure were correlated with other variables that one would expect them to be correlated with", Price et al., 2014, p. 91) was assessed by examining correlations between responses on the EIMFS and other similar measures, that were obtained at the same time (concurrent validity).

Convergent validity ("when new measures positively correlate with existing measures of the same constructs", Price et al., 2014, p. 91) was assessed by analyzing correlations between responses on the EIMFS and existing measures of fatigue. The Fatigue Severity Scale (FSS; Krupp, 1989) and the Fatigue Impact Scale (FIS; Fisk et al., 1994) were used. However, it is important to recognize that there are limitations to these measures that may make them suboptimal for assessing mental fatigue (refer to Appendix B1). The four subfactors that make up the EIMFS may relate to other indices of fatigue in predictable ways.

Discriminant validity ("the extent to which scores on a measure are not correlated with measures of variables that are conceptually distinct", Price et al., 2014, p. 91) was assessed by examining the correlations with measures that assess constructs that should be distinct from mental fatigue.

Participants & Procedure

Participants

The scale's initial factor structure and psychometric properties were examined in a sample of healthy controls. Four hundred health participants (a sample size that was large enough to provide adequate power; Kyriazos, 2018) were recruited through the third-party website CloudResearch, which aids researchers in conducting studies on the online forum MTurk (see Appendix A1; Litman et al., 2017). We exceeded the recommended sample size of over 300 (Kyriazos, 2018), to account for any invalid data, participant drop out, and to ensure data were of sufficient quality to facilitate scale development (Boateng et al., 2018). Participants were eligible

if they were between 18-50 years of age, spoke English as a first language, and were living in the United States of America.

After removing participants who met exclusion criteria the final sample size was n = 365 (170 females, 188 males, 3 non-binary, 1 transgender, 2 not listed, 1 prefer not to say; age range = 19-49 [Mean = 35.55]). Demographic information is described in Appendix B4. Participants were excluded based on inadequate completion of the survey (e.g., missing data), indicated that they had not given reliable data in the 'honesty check', failed attention checks, completed the questionnaire more than once (in these cases, both attempts were deleted), or failed to meet the inclusion criteria (e.g., did not speak English as a first language). Supplementary information (i.e., headphone check, how long a participant was experiencing mental fatigue etc.) is described in Appendix B5.

Recruitment Process

Participants were recruited through CloudResearch. CloudResearch is a platform associated with the global online worker platform MTurk, where individuals can complete tasks called Human Intelligence Tasks (HITs) that are posted by recruiters. Research has shown that the CloudResearch Approved group is a valid predictor of quality data (Hauser et al., 2022).

The study was described as a 60-minute survey asking individuals to report on their current experience surrounding mental fatigue and the impact it has on their daily life. Participants were also informed that there would be questions on demographics, quality of sleep, mood, and whether statements about cognition and cognitive tasks were characteristic of them. Interested participants were directed to the Qualtrics platform where they read through the letter of information and either consented to participate and began the study or exited the study (see Appendix A2). The study was approved by the Western University NMREB Ethics Board (Protocol #120091).

Task Administration

If participants consented, they were automatically directed to the online server Pavlovia. On this platform they were instructed to complete two tasks, an auditory memory task (approximately 10 minutes in duration) and a matrix-reasoning task (participants were given 30 minutes to complete it). These cognitive tasks were also administered at the end of the study after the questionnaire portion was completed as it was predicted that performance on this task would diminish with presumed increased fatigue over the course of the study.

After the first set of cognitive tasks were completed, the participants were re-directed back to the Qualtrics platform where they answered the questionnaires. To validate my scale against existing scales, the following established scales were administered in the following order: The Fatigue Severity Scale (FSS; Krupp, 1989), The Fatigue Impact Scale (FIS; Shahid et al., 2011), The Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995b), The Need for Cognition Scale (Cacioppo & Petty, 1982), The Sleep Quality Scale (SQS; Yi et al., 2006), The Single Item Fatigue Measure (Chan, 2003). Following these measures participants completed demographic questions. This portion of the study took approximately 10-20 minutes. Lastly, participants were informed that they would be directed to the third part of the study where they would complete the two cognitive tasks once more before being debriefed.

Upon completing the study, participants received $10.00 CAD per hour as compensation, and were provided a debriefing form outlining the purpose of the study (see Appendix A3).

Additional Ancillary Measures

The State-Trait Inventory for Cognitive Fatigue TI-CF (STI-CF; Shuman-Paretsky et al., 2017) and the Situational Fatigue Scale (SFS; Yang & Wu, 2005) (discussed on pp. 8-9) were not used for ancillary measures. The STI-CF has little variation in the items, with each subscale containing only four highly similar items (i.e., the mental effort subscale: “right now I am approaching all my activities with vigor/intensity”, “I am putting forth as much mental effort as possible even for difficult tasks”, “I am putting forth as much mental effort as possible on repetitive/monotonous tasks”, and “I am putting forth as much mental effort as I am able”). Instead, the Fatigue Severity Scale (FSS) and the Fatigue Impact Scale (FIS) both include a broader range of items to assess fatigue.

The SFS was not used given its imposition of precise time frames on the items (e.g., “watching TV for two hours”). This could make it difficult for a participant to judge where on the rating scale their level of fatigue would be most accurate, especially when asked to rate items over the past month. In addition, this measure does not include items that address relevant aspects of mental fatigue (i.e., motivation, emotion, cognition, effort) instead just focusing on the level of fatigued experienced during the listed activities (e.g., “playing a ball game for 30 min”, “reading for 1 hour”, “watching TV for 2 hours”; Yang & Wu, 2005). The FSS and the FIS don’t provide specific time lengths for the activities described in the items, and assess characteristics of fatigue such as motivation, mental functioning, stress, and emotional issues.

Importantly, future research should assess whether the validity of the EIMFS is superior to that of these scales.

The Fatigue Severity Scale

Participants completed the nine-item Fatigue Severity Scale, using a 7-point Likert scale (1 = *completely disagree* to 7 = *completely agree*) (Krupp, 1989). Example items include "my motivation is lower when I am fatigued", and "fatigue interferes with carrying out certain duties and responsibilities" (see Appendix A5; Krupp, 1989). The FSS is a commonly used scale, assessing the influence of fatigue on various types of functioning (Hernandez-Ronquillo et al., 2011; Krupp, 1989). Previous research examining the psychometric properties of this measure have indicated high internal consistency, support for test-retest reliability, and sensitivity over time (Hernandez-Ronquillo et al., 2011; Krupp, 1989). Responses were averaged to produce an overall score, with higher scores indicating more severe fatigue.

The Fatigue Impact Scale

Participants completed the 20-item Fatigue Impact Scale, in which they were asked "Please rate how much of a problem fatigue has caused you during the past month, including today" using a Likert scale (0 = *no problem* to 4 = *extreme problem*) (Fisk et al., 1994). Example items include "I have to reduce my workload and responsibilities", and "I am less motivated to engage in social activities" (see Appendix A6; Fisk et al., 1994). Responses were averaged to produce an overall score, with higher scores reflecting greater levels of fatigue severity.

The Depression Anxiety Stress Scales

Participants completed the 21-item version of The Depression Anxiety Stress Scales self-report state measure (DASS; Lovibond & Lovibond, 1995b) in which they were asked to indicate how much eat statement applied to them over the past week using a four-point Likert scale (0 = *did not apply to me at all* to 3 = *applied to me very much or most of the time*). The DASS is designed to assess the constructs of depression, anxiety, and stress (Lovibond & Lovibond, 1995b). Example items include "I felt that I had nothing to look forward to" (Depression), "I felt scared without any good reason" (Anxiety), and "I found it difficult to relax (Stress) (see Appendix A7; Lovibond & Lovibond, 1995b). Previous research examining the psychometric properties of this measure have supported good internal consistency, construct validity, convergent validity, and concurrent validity (Gillies & Dozois, 2021). Responses were averaged to produce an overall mean score for each individual subscale. Recommendations in the literature

suggest that responses to the three DASS scales are summed (7 items per scale) and then the score obtained for each scale is multiplied by two to make it comparable to the corresponding DASS-42 score. However, other studies calculate the mean values for these subscales when quantifying the magnitude of treatment effects (Ronk et al., 2013; Yohannes et al., 2019). Moreover, DASS scale scores and mean scale scores show similar patterns in nonclinical versus clinical samples, and mean scale scores generally correspond to the severity categories specified by Lovibond and Lovibond (1995) (Lu et al., 2018; Gillies & Dozois, 2021).

The Need for Cognition Scale

Participants completed the 18-item version of the Need for Cognition Scale, in which they were asked to indicate the extent to which they felt each item was characteristic of them using a Likert scale (1 = *extremely uncharacteristic* to 5 = *extremely characteristic*) (Cacioppo & Petty, 1982). The Need for Cognition Scale quantitatively measures "the tendency for an individual to engage in and enjoy thinking" (Cacioppo & Petty, 1982, p. 116). Example items include "I would prefer complex to simple problems", "thinking is not my idea of fun" (see Appendix A8; Cacioppo & Petty, 1982). Prior research examining the psychometric properties of the Need for Cognition Scale support its reliability and validity (Cacioppo & Petty, 1982; Cacioppo et al., 1984; Cacioppo et al., 1996; Sadowski & Gulgoz, 1992). Nine of the 18 items on the scale are reverse scored. Responses to the 18 items were summed, with higher scores reflecting an individual who likes to think about various topics, enjoys the process of thinking, and has the desire to apply their thinking skills readily.

The Sleep Quality Scale

Participants completed a subscale of The Sleep Quality Scale (SQS; Yi et al., 2006); specifically the 12 items that composed factor 1 "Daytime Dysfunction." These items capture symptoms resulting from poor sleep such as "difficulty in thinking due to poor sleep", and "decrease of interest in work or others due to poor sleep" (see Appendix A9; Yi et al., 2006). Participants were asked to answer the items based on their sleep over the last month by indicating how often they experienced each statement based on the following ratings: Rarely (none to 1-3 times a month), Sometimes (1-2 times a week), Often (3-5 times a week), Almost always (6-7 times a week) (Yi et al., 2006). Researchers have confirmed the construct and concurrent validity of the SQS, and results support a sufficiently high internal consistency and

test-retest reliability (Yi et al., 2006). Responses to the 12 items were summed for a global score, with a higher score indicating a lower sleep quality (Yi et al., 2006).

The Single Item Fatigue Measure

At the end of the study, participants rated their overall fatigue with a single item. Participants were asked to answer the question "in general how much of an effect has fatigue had on you during the past 4 weeks?" by indicating on a Likert scale (0 = *none* to 10 = *a severely disabling effect*) (see Appendix A10; Chan et al., 2003). This item was used in a study by Chan and colleagues (2003) and was shown to correlate (r = 0.68) with the five-item Fatigue Impact Scale score.

Demographics & Checks

Participants answered questions on how long they had been experiencing mental fatigue (see Appendix A11), demographic questions (e.g., age, gender, ethnicity, prior history of psychoeducational or neuropsychological issues, country of residence, first language, and highest degree or level of school completion; see Appendix A12), whether they answered the survey questions honestly (see Appendix A13), and their use of headphones when completing the auditory memory task (see Appendix A14).

The n-back working memory task (letters)

The *n*-back task was first reported by (Kirchner, 1958). It is a computerized successive letter memory task where participants indicate whether a lower-case letter in a sequence is the same as a previous stimulus shown *n* items ago (Jacola et al., 2014; Kane et al., 2007; Miller et al., 2009). One sequence (10 trials) of the one-back condition was administered, and three sequences of the two-back condition (with breaks of up to 90 seconds in between) were conducted.

The Ravens Advanced Progressive Matrices

Participants were asked to examine a pattern series that is presented across three rows of designs, and then to select a piece (from eight options) that best completes the pattern (Arthur & Day, 1994). Participants were presented with a series of 12 items that increase in an ascending order of difficulty over the course of the task (Arthur & Day, 1994). This version of the APM has been shown to retain the psychometric properties of the original version despite its shorter administration time (average 15 minutes for completion) (Arthur & Day, 1994). Correlational results revealed a strong correlation between the short version and the original version (r = 0.90,

$p < 0.001$) and lower but moderate reliability (Cronbach's alpha = .72 in comparison to .84 for the long version) (Arthur & Day, 1994). The Raven's was administered twice in error both in the first set of objective indices that were presented before the questionnaire section, and in the second set of objective indices that were presented after the questionnaire section. I did not predict that any change would occur from time one to time two, and if anything, there would have been a practice effect.

Results

Prior evidence for, and theory about, the different constructs related to mental fatigue provided a firm and substantive empirical basis to guide model specification (Brown, 2015). I predicted that four subfactors would underlie the construct of mental fatigue: impaired cognitive control, impaired cognition, emotion, and decreased motivation. Therefore, a confirmatory factor analysis (CFA) was conducted on the EIMFS (using Jamovi version 2.3.2.1.0). For the CFA I specified a four-factor model, but additionally specified the items that would belong on each factor. Appendix B12 details which item I placed under each hypothesized factor.

The steps for conducting the CFA followed the recommendations put forth by Brown (2015) and Harrington (2009). These sources acted as guidelines for model specification (including conceptual/empirical justification for the hypothesized model, the items for each factor, factor loadings, and cross-loadings), input data (description of sample characteristics and the type of data used, tests of estimator assumptions, information on missing data), model estimation (statistical software/version, the estimator used), and model evaluation (overall goodness-of-fit, localized areas of fit, and parameter estimates) (Brown, 2015; Harrington, 2009).

Although the four-factor specified model met some of the goodness-of-fit criteria, it did not meet other fitness class recommendations (i.e., CFI; Bentler, 1990; TLI; Tucker & Lewis, 1973). The same results occurred when three-factor and two-factor models were conducted. Moreover, the correlations between the factors were extremely high, suggesting that the factors (or the items that were loading onto each of the factors) were not distinct enough (see Appendix B9). However, efforts to improve model fit by respecifying through modifications resulted in solutions that far exceeded modification recommendations and were too complex. Importantly, once respecification began, the work was then considered to have moved out of a CFA

framework and into an exploratory framework (Brown, 2015). Therefore, the analysis strategy pivoted to analyzing the data with an exploratory factor analysis (EFA).

Exploratory Factor Analysis of the EIMFS

An exploratory factor analysis (EFA) was conducted on the EIMFS using Jamovi version 2.3.2.1.0. The purpose of this analysis was to test two research questions: (1) how many reliable and interpretable factors are there in the data set? and (2) What is the best interpretation of the factors (what is their underlying meaning)? The steps for conducting the statistical analysis followed the recommendations put forth by Finch (2013), Brown (2015), and Navarro and Foxcroft (2018). In line with Brown's (2015) suggestions for conducting a maximum likelihood (ML) EFA, we estimated the factor model several times, each specifying a different number of factors to compare the fit of the solutions. The data for the ancillary scales are not analyzed in this section and is presented in Chapter 4.

Assumptions of Suitability of the Data

Sample Size

The EIMFS was administered to $N = 400$ participants recruited through CloudResearch on the online forum MTurk. Out of 400 recruited participants $n = 365$ were included in the final dataset. Participants were removed if they did not start or finish a certain phase of the study or did not complete certain questions.

There is minimal guidance in the literature for the appropriate sample size that should be collected to meet adequate statistical power of the model's parameter estimates and provide reliable indices of overall model fit (Brown, 2015). Although the sample size for this study ($n = 365$) is a sufficient medium sample size according to broad "rules of thumb" recommendations (Brown, 2015; Harrington, 2009; Kline, 2005), conclusions should still be interpreted with caution as results may be influenced by low power.

Normality

To determine normality for each item, the distribution of responses (on a 7-point Likert scale) for each item were examined, and an item was determined to be poor if it had little variance (see Appendix B6 for proportion of responses for each item). Skewness and kurtosis values were also checked to ensure overall consistency (refer to in Appendix B7 for these indices). Items were only removed if they had severe and obvious low variation or had skew

index values greater than three and kurtosis index values greater than 10 (Kline, 2005). Based on these criteria, none of the variables in this analysis were problematic, and no items were removed. The data therefore appear to be sufficiently normally distributed. Although this univariate normality does not guarantee multivariate normality, given that the ML estimation method is robust to minor non-normality, the adequacy of the kurtosis indices, and the absence of extreme instances of non-normality, it seemed appropriate to proceed with the ML estimation (Harrington, 2009).

Outliers

I assume that "outlier" data points are capturing normal variation and reflecting the true sensitivity of the model. Thus, no outliers were removed from the dataset. Moreover, ML estimation have been shown to be robust to non-normal data (Brown, 2015).

Missing Data

In the dataset there were some missing data on the EIMFS variables. Out of the 88 EIMFS items, four were missing data. Missing values in the EIMFS items did not exceed 1.5% for any single case. The SPSS software (version 28 1.1.1 [14]) Missing Values Analysis (MVA) was used to check for the extent and pattern of missing data. The missing data did not appear to cluster around any one variable. For this research, the CFA analyses were performed on the raw data (including the missing data) with no statistical imputation. The missing data were accommodated using the full information maximum likelihood (ML) method in Jamovi. This method allowed for the software to estimate parameters (Brown, 2015). Table 1 provides the number of respondents who did not answer each EIMFS item for which incomplete data were obtained.

Table 1

Missing Values for EIMFS Items

EIMFS Item	Count	Percent (%)
11 – I don't have the drive to work hard	3	0.8
24 – I make slips of the tongue when speaking	3	0.8
36 – It is hard for me to keep track of conversations in social settings	4	1.1
72 – It is hard for me to see the point in doing chores like the dishes	3	0.8

Item Relationship

The strength of the relationship among items was determined by examining the correlation matrix, which showed that there were a few items whose inter-correlations were greater than 0.30. This suggests that there is some structure that can be captured by a factor analysis.

Factorability of the Data

Factorability of the data was assessed through two statistical measures: Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's test of Sphericity.

KMO Measure of Sampling Adequacy. This measure assesses the adequacy of the sample size for each variable, as well as for the entire model (Shrestha, 2021). An acceptable KMO value to indicate sampling adequacy is between 0.8 to 1.0 (Shrestha, 2021). Individual indicator values as well as the overall value were all above 0.9, indicating that sample is suitable for factor analysis.

Bartlett's Test of Sphericity. This statistical measure tests whether a dataset is appropriate for conducting factor analysis (Pett et al., 2003). Specifically, it tests the null hypothesis that the variables are orthogonal, and that the correlation matrix is an identity matrix (meaning the variables are unrelated and not adequate for analyzing the structure). Conversely, the alternative hypothesis states that the variables are not orthogonal. Instead, they are correlated to the extent that the correlation matrix deviates significantly from the identity matrix. The Bartlett's test had a significant value < .05 ($\chi^2[3570] = 39430$, $p < .001$), suggesting that there are significant correlations among some of the variables in the correlation matrix (they are not orthogonal), and indicating that the data set would be well suited to a factor analysis (Shrestha, 2021).

Extraction Method

Three common factor selection procedures were used. All these procedures are based on eigenvalues (an eigenvalue can be defined as "representing the variance in the indicators explained by the successive factors" Brown, 2015, p. 22, or "conveying whether a given factor explains a considerable portion of the total variance of the observed measures", Brown, 2015, p. 23). These three methods were: (1) the *Kaiser-Guttman rule* (or *the Kaiser criterion* or *the eigenvalues > 1.0 rule*), (2) parallel analysis, and (3) the *Scree test* (Brown, 2015). Importantly, given the limitations of all these methods (Brown, 2015), the results of these procedures were reviewed as a whole and interpreted in conjunction with one another.

Kaiser's (Eigenvalue) Criterion

The Kaiser-Guttman rule was based on obtaining eigenvalues from the input correlation matrix (Guttman, 1944). Values that were greater than 1.0 were used to indicate the number of nontrivial latent dimensions in the data (values less than 1.0 would indicate that the variance explained by the factor is less than the variance of any one item; Brown, 2015). As seen in Table 3, the results from the input correlation matrix yield a four-factor solution, suggesting a multidimensional latent structure.

Table 2

Eigenvalues for EFA Model

Factor	Eigenvalue	Factor	Eigenvalue	Factor	Eigenvalue
1	48.41	30	0.01	59	-0.21
2	2.39	31	-0.00	60	-0.22
3	1.57	32	-0.01	61	NA
4	1.23	33	-0.02	62	-0.23
5	0.93	34	-0.03	63	-0.23
6	0.85	35	-0.05	64	-0.24
7	0.68	36	-0.05	65	-0.24
8	0.60	37	NA	66	-0.25
9	0.50	38	-0.07	67	-0.25
10	0.45	39	-0.08	68	-0.26
11	0.43	40	-0.09	69	-0.26
12	0.37	41	-0.09	70	-0.27
13	0.33	42	-0.09	71	-0.28
14	NA	43	-0.10	72	-0.29
15	0.29	44	-0.11	73	-0.29
16	0.29	45	-0.12	74	-0.30
17	0.26	46	-0.12	75	-0.31
18	0.23	47	-0.13	76	-0.33
19	0.19	48	-0.14	77	-0.33
20	0.18	49	-0.15	78	-0.34
21	0.13	50	-0.16	79	-0.35
22	0.10	51	-0.16	80	-0.36
23	0.09	52	-0.17	81	-0.37
24	0.06	53	-0.18	82	-0.37
25	0.05	54	-0.18	83	-0.39
26	0.05	55	-0.18	84	-0.40
27	0.04	56	-0.19	85	-0.41
28	0.03	57	-0.19	86	-0.48
29	0.02	58	-0.20	87	-0.51
				88	-0.59

Note. Factors 14, 37, and 61 have NA written instead of an eigenvalue as these indicators were attention checks and not true items on the EIMFS.

Parallel Analysis

The second procedure for guiding factor selection was *parallel analysis* (Horn, 1965). This procedure can be defined as an approach that is: "based on a scree plot of the eigenvalues obtained from the sample data against eigenvalues that are estimated from a dataset of random numbers" Brown, 2015, p. 24). The theory of parallel analysis is that the factor should account for a greater amount of variance than can be expected by chance (Brown, 2015). The parallel analysis suggests a four-factor solution for the model.

Scree Test

Finally, the Scree test (Cattell, 1966) was used to determine the number of factors that should be retained. The Scree test plots the eigenvalues on the Y axis and the factors on the X axis (Cattell, 1966). The graph was inspected to determine location of the final decline in the magnitude of the eigenvalues (where the slope evens out) (Brown, 2015). There was no distinctive levelling out of the data, but the results indicate either a one-, three- or four-factor solution.

Goodness-of-Fit Interpretation

ML estimation allowed for the inclusion of goodness of fit indices to guide how well the factor solutions fit the data. The purpose of these statistics is to test "the null hypothesis that the factor solution fits the data" (Finch, 2013, p. 180). Notably, the statistical software that was used to conduct the EFA only provides the chi-square test, RMSEA, and TLI statistics and does not calculate SRMR or CFI.

Four-factor solution. The chi-square test (χ^2) was significant (see Table 4), which suggests that the four-factor model does not provide a reasonable fit to the data (Brown, 2015). More specifically, the significance of the test suggests that the correlation matrix predicted by the factor model parameter estimates *does* differ from the sample correlation matrix (Brown, 2015). However, the limitations associated with χ^2 meant that the significance was not worrisome, as it would not be used as the sole index of overall model fit (Brown, 2015). Importantly, the factor selection utilized prior theory in addition to goodness of fit to determine the appropriateness of the solution. Considerations such as whether a factor was poorly defined (e.g., with only one or two items having strong primary loadings), and item examination (e.g.,

whether an item did not load meaningfully onto any one factor or flagging items that had high-cross loadings across multiple factors) were taken into account (Brown, 2015).

Based on the fit statistics (see Table 4) it can be hesitantly concluded that the four-factor model, three-factor model, and two-factor model all provide a reasonable fit to the data. Because model fit indices progressively got poorer as the number of factors in the model solution were reduced, because we hypothesized a four-factor model and because the K-G test, the parallel analysis and the Scree test (although not as clearly) all indicated a four-factor model, I chose to extract four factors.

Table 3

Goodness-of-fit Indices for EFA Models

Model	$\chi^2(df)$	RMSEA (90% CI)	TLI
4	$\chi^2(3236) = 6535, p < .001$	0.06 (CI = 0.06-0.06)	0.86
3	$\chi^2(3318) = 7169, p < .001$	0.06 (CI = 0.06-0.06)	0.84
2	$\chi^2(3401) = 7947, p < .001$	0.07 (CI = 0.06-0.07)	0.81

Note. Goodness-of-fit indices for four-factor, three-factor, & two-factor EFA models.

Intercorrelations

The correlation matrix for the four-factor model was used to examine the factor pairs. The factor pairs in the four-factor solution all presented positive non-zero correlation, with the highest correlation between Factors 1 and 2 ($r = 0.67$). Thus, these results support the use of an oblique rotation over an orthogonal rotation (Carpenter, 2018; Shrestha, 2021).

Factor Rotation & Interpretation

Rotation

Given that all items in an EFA load on all factors, the extracted factors for each of the solutions were then rotated to increase the ease of their interpretability (through maximizing factor loadings closer to one and minimizing factor loadings closer to zero; Brown, 2015). An oblique rotation was used to improve the intercorrelation between the items within the factors and obtain a truer representation of the magnitude of these relationships (Brown, 2015). A direct oblimin rotation (a method for oblique rotation) was used, which minimizes the cross-loadings to simplify the factors (Field, 2013; Tabachnick & Fidell, 2019). The final reasoning for using an oblique rotation over an orthogonal rotation was that a CFA was going to be conducted in Study 2 based on the factor solutions of the EFA. Oblique solutions have an increased chance of generalizing to a CFA compared to orthogonal solutions (Brown, 2015).

Interpretation

The *pattern matrix* was used to examine the loadings for each of the items. The loadings in this matrix indicate the unique relationship between a factor and an item, while also accounting for the influence of the other factors in the model (Brown, 2015). Interpretation of the factor loadings was based on the results of the data as well as the expected number of factors based on theory (Finch, 2013). Factor loadings < 0.30 were suppressed (to interpret more easily which factor an item predominantly loaded onto; Navarro & Foxcroft, 2018) and loadings greater than 0.4 were deemed stable and interpreted as salient such that the indicator was meaningfully associated with either a primary or secondary factor (Brown, 2015; Field, 2013; Guadagnoli & Velicer, 1988; Tabachnick & Fidell, 2019). The number of factors were optimized, by examining the pattern matrix and determining how many factors met the minimum requirement of having at least three items with loadings greater than 0.40. Items that cross-loaded (loaded above 0.4 onto more than one factor) were considered a *complex variable* given their correlation with several factors (as opposed to a *pure variable* which loaded above 0.4 with a single factor) (Tabachnick & Fidell, 2019). If an item cross-loaded, the item in which it had a higher loading was considered the primary factor. If all the factors in the model met the criterion of having at least three items with loadings greater than 0.40, then the model was examined to determine which items may be removed to help streamline the measure. Items were removed based on three steps:

1. I began by removing items that did not load at 0.4 or above on any of the factors.
2. I then examined the items for similar cross-loadings, where the difference in loading value was negligible (e.g., 0.456 and 0.408). I began by removing the item that had the lowest loadings.
3. The standard approach to factor analysis recommends that there be a relatively equal number of items on each factor. If a factor had a surplus of items in comparison to the other factors, I began removing items from the factor to streamline the overall measure. Specifically, I examined if an item had a very similar loading to another item on the factor. The retained item was based off the following: overall "fit" with the other items on the factor, which item was more clear and less open to interpretation, and whether an item seemed more "state" rather than "sustained over time"). Again, I started with the lowest loading item and would re-run the analysis after every item removal.

4. I returned to steps 1 and 2 to determine if any more items needed to be removed based on these criteria.

To start, a four-factor solution was run, but did not meet the pre-specified criteria listed above. From here, I re-ran the analysis and specified a three-factor solution. However, this factor structure was also not appropriated as results violated the rules that had been specified for determining a stable and strong factor. A two-factor solution was then run and after following steps one through four, the final model contained 78 items. Factor 1 had 72 items. Given the high proportion of items contained in this factor that are meant to capture cognitive control and cognition, this item was labelled as *cognition*. Factor 2 contained six items, and through examining these items altogether, it appears that they best describe motivation and believing in oneself (e.g., "I can accomplish tasks that require thinking if I put my mind to them") and therefore was labelled *determination*. However, this factor did not seem to truly encompass the experience of mental fatigue, rather, it could likely be considered an individual trait that allows an individual to persevere through the feeling of mental fatigue. Given this, these six items were removed. Following this, Kaiser, scree, and parallel analysis methods all suggested a three-factor model. However, this factor model did not meet the list of specified rules and was not proceeded with.

For exploratory purposes I fixed the number of factors at five to explore whether a large factor solution would help determine the true model. After removing the items that made up the *determination* factor, I ran a fixed five-factor model. This model appeared promising, as item loadings appeared more dispersed than in previous models. From here, I completed steps 1 and 2. Following this, it became clear that factor 1 had a surplus of items compared to the other three factors. I therefore moved to step 3 and then completed step 4. The final model ended up being a four-factor solution that had 22 items (see Table 5).

Table 4

Final Four-Factor Model

Item	Factor				
	1	2	3	4	Uniqueness
80) I feel anxious because of mental fatigue.	**0.84**				0.26
58) I get frustrated that I can't do things because I'm mentally fatigued.	**0.73**				0.17
59) I am less confident because of mental fatigue.	**0.72**				0.17
52) I feel lonely because of mental fatigue.	**0.63**				0.35
76) It is hard to make plans because I can’t predict when I will be mentally fatigued.	**0.55**	0.31			0.29
2) I feel sad because of mental fatigue.	**0.53**				0.43
83) I feel like my brain is not functioning the way it should.	**0.42**		0.32		0.23
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.		**0.87**			0.16
72) It is hard for me to see the point in doing chores like the dishes.		**0.77**			0.35
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.		**0.75**			0.37
67) It takes me a long time to decide to do something.		**0.61**			0.27
5) It is difficult to make daily decisions, like what to make for dinner.		**0.54**			0.52
69) I feel guilty because I cannot do most things that I am supposed to do.	0.36	**0.49**			0.18
9) I feel slowed down in my thinking.			**0.87**		0.14
8) I feel like my ability to learn has decreased.			**0.73**		0.30
6) When I try to do 'brain problems' I find it difficult to concentrate.		0.33	**0.45**		0.38
3) I don't believe I can do well on tasks because I am too mentally fatigued.	0.35		**0.42**		0.41
26) Every task takes longer to complete than it usually would.	0.32		**0.40**		0.33
15) I do not have the will to do anything.				**0.74**	0.30
16) I have lost interest in the work that I used to do.				**0.70**	0.25
40) I do not feel engaged in my work.				**0.62**	0.26
65) I have lost the feeling of wanting to try at anything.		0.39		**0.43**	0.24

Note. The final four-factor EFA model included 22 of the original EIMFS items.

EFA Conclusion: Final Four-factor Model

The purpose of the exploratory factor analysis was to determine the latent structure underlying the model, and to also reduce the larger set of intercorrelated items down to a smaller set of composite variables (Brown, 2015). The final four-factor model included 22 of the original 85 items (see Table 6).

Table 5

Final 22 Items of the EIMFS & Associated Factors

Factor	Item
1 – Emotional Consequences	2) I feel sad because of mental fatigue.
	52) I feel lonely because of mental fatigue.
	58) I get frustrated that I can't do things because I'm mentally fatigued.
	59) I am less confident because of mental fatigue.
	80) I feel anxious because of mental fatigue.
	83) I feel like my brain is not functioning the way it should.
2 – Daily Life Impact	5) It is difficult to make daily decisions, like what to make for dinner.
	33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.
	66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.
	67) It takes me a long time to decide to do something.
	69) I feel guilty because I cannot do most things that I am supposed to do.
	72) It is hard for me to see the point in doing chores like the dishes.
3 – Cognitive Difficulties	3) I don't believe I can do well on tasks because I am too mentally fatigued.
	6) When I try to do 'brain problems' I find it difficult to concentrate.
	8) I feel like my ability to learn has decreased.
	9) I feel slowed down in my thinking.
	26) Every task takes longer to complete than it usually would.
4 – Motivation & Engagement	15) I do not have the will to do anything.
	16) I have lost interest in the work that I used to do.
	40) I do not feel engaged in my work.
	65) I have lost the feeling of wanting to try at anything.

Factor 1 contained six items. Given that many of the items appeared to encapsulate the notion of emotion, mood, or feelings, this factor was labelled *emotional consequences*. Factor 2 also contained six items. Through examining these items altogether, there is a consistent theme

of struggling with daily life and tasks, and therefore was labelled *daily life impact*. Five items made up factor 3, which all seem to share the common theme of struggling to complete cognitive tasks, and so this factor was labelled *cognitive difficulties*. Finally, the fourth factor included four items. When considering the wording of these items, the label *motivation and engagement* was an appropriate fit.

The results of the four-factor solution support the construct validity (defined as "the overarching principle of validity, referring to the extent to which a psychological measure in fact measures the concept it purports to measure", Brown, 2015, p. 187) of all four factors (evidenced by convergent and discriminant validity). As seen in Table 5, the items representing each of the constructs load onto separate factors. Although seven of the 22 items do cross-load, these loadings are all below 0.40, and the item has a substantially higher loading onto its primary factor. The factor loadings are also consistently large (range = 0.40-0.87), indicating that the items are moderately to strongly related to their purported latent construct (convergent validity). At the same time, there is sufficient discriminant validity, as the correlations among the factors are not excessively high (range = 0.58-0.76; Table 7) (Brown, 2015). Finally, model fit measures were also examined. The final four-factor model had excellent fit indices ($\chi^2(149) = 347$, $p < .001$, RMSEA = 0.06 [CI = 0.05-0.07], TLI = 0.96) supporting the null hypothesis that the factor solution fits the data.

Table 6

Inter-Factor Correlations for Four-Factor EFA Model

	1	2	3	4
1	-	0.76	0.71	0.70
2		-	0.62	0.67
3			-	0.58
4				-

The next step will focus on replicating this model in an independent sample in Study 2. It is worth noting that factor 4 has only four items (one of which cross-loads onto factor 2). Hence, this factor may be underdetermined, and it may not replicate across the different population in Study 2 (Brown, 2015).

Chapter 3: Study 2 – A Replication of Study 1

The goal of Study 2 was to conduct a replication of the item analyses completed in Study 1. A new sample of participants was collected, and the same version of the 88 EIMFS items (85 "true items" and three attention checks) was used (i.e., no changes to item wording, item order, etc.). Although participants responded to all 88 items, the statistical analyses were conducted based on the reduced number of items (22) determined at the end of Study 1. This was done to determine whether there was consistency across the factor structure.

Methods

Participants & Procedure

Participants were undergraduate students recruited from Western University on the online forum SONA (see Appendix C1). In Study 1, participants that were recruited from CloudResearch and were limited to those who resided in the United States of America. Conducting this replication study with students at a Canadian university allowed for generalizability of the results and confirmation of the factor structure in an independent population. Upon indicating interest in the study, participants were redirected to complete the informed consent form and survey on the online platform Qualtrics (see Appendix C2). As in Study 1, the study was described as a 60-minute survey that would ask individuals to report on their current experience surrounding mental fatigue and the impact it has on their daily life. Participants were informed on the types of surveys they would complete. Participants were eligible if they were currently enrolled in first- or second-year psychology courses, spoke English as a first language, and were between 18-50 years-old. Following completion of the study, participants were debriefed (see Appendix C3) and received 1.0% course credit as compensation. The study was approved by the Western University NMREB Ethics Board (Protocol #120091).

Three hundred and eighteen participants completed the survey. After removing participants who met exclusion criteria the final sample size was n = 243 (189 females, 54 males; age range = 17-38 [Mean = 18.7]). Demographic information and supplementary information (i.e., headphone check, how long they have been experiencing fatigue) are described in Appendices D1 and D2. Participants were excluded based on inadequate completion of the survey (e.g., missing data), indicated that they had not given reliable data in the 'honesty check',

failed attention checks, had duplicate cases, or failed to meet the inclusion criteria (e.g., did not speak English as a first language).

Statistical Analysis Procedure

Using the specified set of EIMFS items determined at the end of Study 1, a CFA was conducted (using Jamovi version 2.3.2.1.0).

Model Fit

To evaluate model fit, a maximum likelihood estimation method (ML; see Lawley 1940; Lawley and Maxwell, 1963) was used to estimate model parameters. Once again, goodness-of-fit approaches (developed by: Bentler, 1990; Cochran, 1952; Henseler et al., 2014; Steiger & Lind, 1980; Tucker & Lewis, 1973) were used to identify a factor solution that (1) surpasses the reproduced observed correlations from a model with fewer factors, and (2) is equal (or superior) in its ability to reproduce these observed relationships in comparison to a model with more factors (Brown, 2015). The goodness-of-fit criterion was a: Chi-square/*df* ratio ≤ 3 (Cochran, 1952; Kline, 2016; Kyriazos, 2018), the standardized root mean square residual (SRMR ≤ 0.08; Henseler et al., 2014), the root mean square error of approximation (RMSEA $\leq 0.06, [90\% \, CI \leq 0.06]$; Steiger, 1990; Steiger & Lind, 1980), the Tucker-Lewis index (TLI ≥ 0.95; Bentler & Bonett, 1980; Tucker & Lewis, 1973), and the comparative fit index (CFI ≥ 0.95; Bentler, 1990) (Brown, 2015; Hu & Bentler, 1999).

Measures

The same surveys, attention checks, and objective measures were used as in Study 1. These included: the original 85 items from the Experiential Impact of Mental Fatigue Scale (EIMFS), The Fatigue Severity Scale (FSS; Krupp, 1989), The Fatigue Impact Scale (FIS; Fisk et al., 1994), The Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995b), The Need for Cognition Scale (Cacioppo & Petty, 1982), The Sleep Quality Scale (SQS; Yi et al., 2006), The Single Item Fatigue Measure (Chan et al., 2003), the *N*-back (Kirchner, 1958), and the 12-item version of the Raven's Advanced Progressive Matrices Test (APM; Arthur & Day, 1994).

Results

Overview of Data Analyses

The purpose of Study 2 was to determine whether the EFA factor structure from Study 1 could be replicated in a new sample. The goal was to test the research question: Does the factor solution determined at the end of Study 1 replicate in this independent, Canadian sample? The CFA was run on 22 items in a four-factor solution. As with Study 1, the steps for conducting the statistical analysis followed the recommendations put forth by Brown (2015) and Harrington (2009).

Input Data: Sample Characteristics, Data Type, Tests of Estimator Assumptions, & Missing Data

As specified in the "Methods" section, the EIMFS was administered to $N = 318$ participants recruited through the online forum SONA through the University of Western Ontario. Out of 318 participants recruited $n = 243$ were included in the final dataset.

Missing Data

Some data were missing on the EIMFS variables. Out of the 22 EIMFS items, only one item did not contain any missing data. The SPSS (version 28.0.1.1 [14]) Missing Values Analysis (MVA) was used to check for the extent and pattern of missing data. The missing data did not appear to be clustering around any one variable. For this reason, the CFA analyses were performed on the raw data (including the missing data) with no statistical imputation. The missing data were accommodated using the full information maximum likelihood (ML) method in Jamovi. Table 8 provides the number of respondents who did not answer the item for each EIMFS item.

Table 7

Missing values for EIMFS items

EIMFS Item	Count	Percent (%)
2) I feel sad because of mental fatigue.	1	0.4
3) I don't believe I can do well on tasks because I am too mentally fatigued.	2	0.8
5) It is difficult to make daily decisions, like what to make for dinner.	2	0.8
6) When I try to do 'brain problems' I find it difficult to concentrate.	1	0.4
8) I feel like my ability to learn has decreased.	2	0.8
9) I feel slowed down in my thinking.	1	0.4
15) I do not have the will to do anything.	3	1.2
16) I have lost interest in the work that I used to do.	2	0.8
26) Every task takes longer to complete than it usually would.	2	0.8

33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	0	0
40) I do not feel engaged in my work.	1	0.4
52) I feel lonely because of mental fatigue.	1	0.4
58) I get frustrated that I can't do things because I'm mentally fatigued.	3	1.2
59) I am less confident because of mental fatigue.	2	0.8
65) I have lost the feeling of wanting to try at anything.	1	0.4
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.	1	0.4
67) It takes me a long time to decide to do something.	2	0.8
69) I feel guilty because I cannot do most things that I am supposed to do.	1	0.4
72) It is hard for me to see the point in doing chores like the dishes.	1	0.4
76) It is hard to make plans because I can't predict when I will be mentally fatigued.	3	1.2
80) I feel anxious because of mental fatigue.	3	1.2
83) I feel like my brain is not functioning the way it should.	2	0.8

Model Estimation and Data Screening

The same steps for model estimation and data screening were taken as in Study 1. A ML estimation was used for this model (Brown, 2015; Harrington, 2009). Before running the analysis, the raw data were evaluated to see if the three key assumptions for ML estimation (multivariate normally distributed indicators, large sample sizes, and continuous levels of measurement) were met. The model was determined to be univariate normally distributed (refer Appendix D3 for information on skewness and kurtosis for the normality assumption, and Appendix D4 for the proportion of responses for the 22 items), no outliers were removed from the dataset, the final sample (n = 243) was considered medium in size (although conclusions should be interpreted with caution as results may be influenced by low power), and there were continuous levels of measurement. Thus, the ML assumptions were all met, and the sample variance-covariance matrix was analyzed with Jamovi and an ML estimation function.

Model Evaluation Overview

Once again, the CFA solution was evaluated based on three aspects: "(1) overall goodness of fit; (2) the presence of absence of localized areas of strain in the solution (i.e., specific points of ill fit); and (3) the interpretability, size, and statistical significance of the model's parameter estimates" (Brown, 2015, p. 96).

Four-Factor Model Fit Results

Goodness-of-Fit Indices

When examining fit classes (absolute fit, parsimony correction, and comparative fit), the initial four-factor CFA model provides a "good" fit to the data: $\chi^2(203) = 498$, $p < .001$., SRMR = 0.05, RMSEA = 0.08(90% CI = 0.07-0.08), TLI = 0.90, CFI = 0.91. The SRMR informs us that there is not a large discrepancy between the observed correlation and the model implied correlation matrix (i.e., the value is ≤ 0.08; Hensler et al., 2014). As in the original CFA model in Study 1 the RMSEA value indicates a reasonable model-data fit (≤ 0.08), but not a "close fit" (≤ 0.06) (Browne & Cudeck, 1993; Jöreskog & Sörbom, 1993). Despite the TLI and CFI values not reaching a value ≥ 0.95 (Hu & Bentler, 1999), the values are larger than those provided by the original CFA in Study 1 (which were 0.80).

Parameter Estimates

Parameter estimates were examined for the four-factor model (refer to Appendix D5). The factor loadings for the freely estimated parameters were all greater than 0.40 (rang = 0.49-0.86), and statistically significant ($p < .001$). These estimates generally revealed that items for all four factors were moderately to strongly related to their purported construct and the that items significantly load onto the expected factor.

Model Respecification

Model modification was conducted by examining localized areas of misfit through the *modification indices* (MI), and the interpretability, strength, and statistical significance of the parameter estimates (Brown, 2015). The freeing of parameters to improve model fit was not based on data alone but bearing in mind the empirical and conceptual context of the item.

Modification indices were assessed in conjunction with parameter indices. Modification indices of 3.84 (rounded up to 4) or greater (reflecting the critical value of χ^2 at $p < .05, 1\ df$) supported freely estimating the constrained parameter. Modifications were also determined by examining the direction, magnitude, and significance of the parameter estimates (Brown, 2015). The standardized estimates and *p*-values for each parameter were interpreted and suggested they were making a decent contribution to the model if they were above 0.4. Parameter estimates that were nonsignificant were interpreted to indicate items that were poor indicators of the latent construct mental fatigue (Gallagher & Brown, 2013). Refer to Appendix D5 for information on factor loadings.

Specification began by considering the fixed parameter with standard estimates that had the largest modification index. If the item additionally had low parameter estimates, that further

supported the removal of the item. However, if freeing the parameter was not supported by a theoretically-based argument (i.e., *post hoc* rationalization), the next largest modification index was considered, and the process was repeated. After every modification was made, the model was rerun, and the MI tables were re-checked to determine if fit was improved.

The highest MI index was for item 69 ("I feel guilty because I cannot do most things that I am supposed to do"; MI = 22.37). The MI suggested that moving this item from factor 2 (*daily life impact*) to factor 1 (*emotional consequences*) would improve model fit. Relocating this item to factor 1 also made theoretical sense, given that the item appeared to better fit in with the descriptions depicted by the other items. Refer to Table 8 for the item loadings after the modification. After moving the item, the model fit was improved to the following: $\chi^2(203) = 511$, $p < .001$., SRMR = 0.05, RMSEA = 0.07 (90% CI = 0.07-0.08), TLI = 0.91, CFI = 0.92. After moving this item, item 26 ("Every task takes longer to complete than it usually would") cross-loaded highly from factor 3 (*cognitive difficulties*) onto factor 1 (MI = 26.42). It did not make theoretical sense to remove the item from Factor 3 as it fit well conceptually with the other items that were loading onto that factor. The standard parameter estimates for item 26 also indicated that it loaded highly onto factor 3 (0.68). One explanation for the high modification index onto factor 1 is because the CFA forced all the cross-loadings to be zero, when in reality, this is unlikely to be the case. As a solution, I tried including the item onto both factor 1 and factor 3. However, this led to the standard parameter estimate for item 26 to be 0.56 on factor 1 and 0.17 on factor 3. Placing the item on both factors also resulted in the many more suggested modifications based off the modification indices. Therefore, it was decided that the item should remain on factor 3 for now.

Table 8

Study 2 CFA Four-Factor Model Item Loadings after Modification

Factor	Item	Estimate	SE	Z	P	Standard. Estimate
1 – Emotional Consequences	80	1.55	0.11	14.62	< .001	0.79
	58	1.53	0.10	16.04	< .001	0.85
	59	1.62	0.10	16.05	< .001	0.85
	52	1.37	0.10	13.25	< .001	0.74
	76	1.17	0.11	10.57	< .001	0.63
	2	1.00	0.10	10.03	< .001	0.60
	83	1.58	0.10	15.76	< .001	0.83
	69	1.43	0.10	13.59		0.76
Factor 2 – Daily Life Impact	66	1.39	0.11	12.83	< .001	0.76
	72	1.02	0.12	8.72	< .001	0.56
	33	0.97	0.12	8.10	< .001	0.53
	67	1.14	0.10	11.41	< .001	0.70
	5	0.90	0.11	8.15	< .001	0.53
Factor 3 – Cognitive Difficulties	9	1.38	0.09	16.17	< .001	0.86
	8	1.53	0.10	15.81	< .001	0.85
	6	1.04	0.10	10.91	< .001	0.65
	3	0.97	0.09	10.43	< .001	0.63
	26	1.14	0.10	11.49	< .001	0.68
Factor 4 – Motivation & Engagement	15	1.27	0.10	13.19	< .001	0.75
	16	1.53	0.09	16.23	< .001	0.86
	40	1.19	0.09	13.47	< .001	0.76
	65	1.48	0.10	15.21	< .001	0.82

Note. The modification refers to moving item 69 from Factor 2 to Factor 1.

One-Factor Model

It is critical to acknowledge the high correlations between the factors that occur in the four-factor model (see Appendix D7). Due to this, a one-factor unidimensional model was also tested to determine which factor structure would be the better fit. The model fit statistics were not as strong (χ^2[209] = 686, p < .001., SRMR = 0.06, RMSEA = 0.10 [90% CI = 0.09-0.11], TLI = 0.84, CFI = 0.86) for the one-factor model as they were for the four-factor model. At present, although a total score may be best when administering the EIMFS, it is important to recognize that, theoretically, the scale does have different subfactors. Future research is needed to further explore the factor structure of the EIMFS to see if modifications to the measure can help to improve the high correlations between factors.

Conclusion

The goal of this analysis was to replicate the dimensions of mental fatigue that were determined in Study 1. A CFA was used to analyze the data using maximum likelihood (ML) with the oblique rotation method direct oblimin. A four-factor solution was confirmed, and results suggested it was an appropriate fit for the model. One discrepancy between the models was that item 69 was moved from factor 2 to factor 1 in Study 2. Overall, this final solution does match the foundational theory used to develop the scale and supports three of the four hypothesized constructs of mental fatigue. A notable difference is that the hypothesized factors *cognition* and *cognitive control* were combined into one factor (*cognitive difficulties*) in the final model. Additionally, the factor *daily life impact* was not originally hypothesized; however, the importance and relevance of this factor can be defended based on empirical support from the area of research.

Exploratory Analyses

Exploratory analysis examining the correlation between participants subjective rating of current mental fatigue and an objective measure (an auditory memory task: the *n*-back letter task) was conducted. Correlations between the objective measure and other relevant scales (such as the Need for Cognition measure [NFC]) were also examined. The Raven's Advanced Progressive Matrices was used as a covariate to reduce the size of the 'error' variance in performance on the *n*-back.

The correlations between a participant's rating of mental fatigue after the first (i.e., "mental fatigue trial 1") and second round of objective tests (i.e., "mental fatigue trial 2) and the

EIMFS support the validity of the measure. Individuals who were more mentally fatigued after completing the objective tasks had higher scores on the EIMFS (see Table 9). Correlations were slightly higher regarding the specific cognitive difficulties subscale of the EIMFS than the total scale. These results were consistent in Study 2 (see Table 10).

Results showed that rating level of mental fatigue after objective tests had small negative correlations with need for cognition. In Study 2 the rating level of mental fatigue was only significantly negatively correlated with the NFC after the second round of objective tests.

Across both studies, there was also small to moderate negative correlations between the EIMFS and the NFC. The need for cognition may be reported as lower when an individual is mentally fatigued.

The d'scores for the 2-back working memory test calculated with the following formula: z(H) – z(F) (where z(H) and z(F) are the z transforms of hit rate and false alarm rate) were subjected to a paired samples t-test. Two-back performance did not change significantly over the course of Study 1: participants' average performance did not significantly change from time 1 (M = 2.11, SD = 1.02) to time 2 (M = 2.21, SD = 1.09; t = -2.721, p = .007, d = =.15). Furthermore, d' for time 1 was significantly correlated with the d' for time 2 (r = +.73, p < .001). The results were similar for Study 2. Participants' average performance did not significantly change from time 1 (M = 1.94, SD = .86) to time 2 (M = 2.04, SD = 1.04; t = -1.97, p = 0.50, d = -.27), and these d' scores correlated significantly correlated (r = +.69, p <.001). If we take performance as indexing fatigue objectively, participants did not seem to be more fatigued at the end of the experimental session, compared to how they were approximately 40 minutes earlier, at the beginning of the session.

Table 9

Study 1 Pearson Zero-Order Correlations for Mental Fatigue & Other Objective Measures of Cognition

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	-	.66**	-.05	.02	-.02	.02	.00	-.07	-.08	.03	.01	.34**	.38**	-.12*
2		-	-.02	.06	.02	-.01	-.04	-.05	-.07	-.06	-.06	.40**	.44**	-.13*
3			-	.36**	.39**	-.23**	-.32**	.40**	.44**	-.37**	-.39**	-.05	-.05	.20**
4				-	.90**	-.29**	-.34**	.52**	.51**	-.27**	-.29**	-.10	-.09	.09
5					-	-.22**	-.31**	.62**	.64**	-.25**	-.27**	-.14**	-.13*	.09
6						-	.88**	-.15**	-.16**	.59**	.57**	.09	.11*	-.04
7							-	-.17**	-.21**	.73**	.75**	.09	.11*	-.04
8								-	.94**	-.12*	-.13*	-.11*	-.09	.09
9									-	-.19**	-.20**	-.14**	-.12*	.10
10										-	.95**	.07	.10	-.06
11											-	.06	.10	-.06
12												-	.91**	-.33**
13													-	-.34**
14														-

Note. 1 = Mental fatigue trial 1, 2 = Mental fatigue trial 2, 3 = Ravens Advanced Progressive Matrices, 4 = *n*-back (one back) hit trial 1) 5 = *n*-back (one back) hit trial 2, 6 = *n*-back (one back) false alarm trial 1, 7 = *n*-back (one back) false alarm trial 2, 8 = *n*-back (two back) hit trial 1, 9 = *n*-back (two back) hit trial 2, 10 = *n*-back (two back) false alarm trial 1, 11 = *n*-back (two back) false alarm trial 2, 12 = EIMFS, 13 = Cognitive Difficulties dimension of the EIMFS, 14 = Need for Cognition

Table 10

Study 2 Pearson Zero-Order Correlations for Mental Fatigue & Other Objective Measures of Cognition

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	-	.50**	-.21**	-.14**	-.15*	.11	.15*	-.21**	-.19**	.16*	.20**	.18**	.25**	-.07
2		-	-.17**	-.13*	-.18*	.15*	.19**	-.19**	-.22**	.20**	.25**	.18**	.20**	-.23**
3			-	.42**	.42**	-.27**	-.34**	.44**	.47**	-.37**	-.43**	-.10	-.14*	.34**
4				-	.88**	-.21**	-.31**	.52**	.57**	-.35**	-.37**	.12	.08	.13*
5					-	-.30**	-.40**	.62**	.72**	-.37**	-.37**	.12*	.11	.09
6						-	.86**	-.18**	-.26**	.40**	.44**	-.10	-.08	-.03
7							-	-.26**	-.33**	.53**	.64**	-.08	-.04	-.05
8								-	.92**	-.18**	-.22**	.02	.02	.03
9									-	-.24**	-.25**	.09	.07	.04
10										-	.90**	-.17**	-.11	-.11

11												-	-.14*	-.08	-.11
12													-	.89**	-.25**
13														-	-.26**
14															-

Note. 1 = Mental fatigue trial 1, 2 = Mental fatigue trial 2, 3 = Ravens Advanced Progressive Matrices, 4 = *n*-back (one back) hit trial 1) 5 = *n*-back (one back) hit trial 2, 6 = *n*-back (one back) false alarm trial 1, 7 = *n*-back (one back) false alarm trial 2, 8 = *n*-back (two back) hit trial 1, 9 = *n*-back (two back) hit trial 2, 10 = *n*-back (two back) false alarm trial 1, 11 = *n*-back (two back) false alarm trial 2, 12 = EIMFS, 13 = Cognitive Difficulties dimension of the EIMFS, 14 = Need for Cognition

Chapter 4: Examining the Psychometric Properties of the EIMFS

Following the CFA conducted in Study 2, I determined that four factors of the EIMFS reliably emerged across the two samples. I interpreted factor 1 (including eight items) as reflecting the construct *emotional consequences*, factor 2 (including six items) seems to reflect the construct *daily life impacts*, factor 3 (including five items), seems to reflect *cognitive difficulties*, and factor 4 (four items) seems to reflect *motivation and engagement*.

Methods

Please refer to Chapter 2 for a full review of the measures used to assess the validity of the EIMFS. These measures were collected in both Studies 1 and 2 and were administered following the EIMFS. Measures were always administered in the following order: The Fatigue Severity Scale (FSS; Krupp, 1989), The Fatigue Impact Scale (FIS; Fisk et al., 1994), The Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995b), The Need for Cognition Scale (Cacioppo & Petty, 1982), The Sleep Quality Scale (SQS; Yi et al., 2006), and The Single Item Fatigue Measure (Chan et al., 2003).

Results

Reliability

Reliabilities for three of the four subfactors (with the exception of factor 2 for Study 2) as well as the overall scale across Study 1 and 2 were satisfactorily high (Cronbach's $\alpha > 0.8$; Carmines & Zeller; 1979; Nunnally, 1978; Table 28), indicating that the items in the measure are highly correlated and that there are multiple items measuring the same underlying construct. This confirms the reliability of the questionnaire.

Notably, "α measures not only the homogeneity of the items, but also the homogeneity of what is being assessed," (Streiner, 2003, p. 102). In the EIMFS, mental fatigue was conceptualized as having four dimensions. Therefore, although the EIMFS can assess mental fatigue overall, given the four dimensions there is some degree of heterogeneity among the items. The items composing each of the four dimensions of the EIMFS are more homogenous than for the scale as a whole.

On the other hand, an alpha above 0.90 may suggest that items are repetitive, and that there is item redundancy rather than homogeneity (Streiner et al., 2003). In this case, the possibility that what is being assessed in the scale may be too restricted and narrow (Navarro &

Foxcroft, 2019). Based on Streiner's (2003) caution, the alphas for three of the four subscales (factor 2 α = 0.90; factor 3 α = 0.91; factor 4 α = 0.90) were only slightly too high (greater than the 0.90 cut-off; see Table 11). The exception to this was factor 1 where α = 0.95. These results were consistent across both studies (In Study 2: factor 1 α = 0.95; factor 2 α = 0.90; factor 3 α = 0.91; factor 4 α = 0.90). The fact that these four dimensions are supported in the EIMFS speaks against the construct of mental fatigue being very narrowly sampled.

The Omega (McDonald, 1999) in both samples (n = 365 for Study 1, n = 243 for Study 2) for the entire scale and the most of the subfactors (except for factor 2 in Study 2) were also sufficient as values were all above the recommend 0.8 criterion (Carmines & Zeller; 1979; Nunnally, 1978). To my knowledge, there are no suggestions in the literature on when an omega value would be considered too high.

Table 11

Inter-Item Reliabilities (Cronbach's α) for the Four Factors & Overall Scale Across Study 1 & Study 2

	Mean		SD		Cronbach's α		McDonald's ω	
Sample	1	2	1	2	1	2	1	2
Overall	3.3	4.2	1.5	1.3	0.97	0.95	0.97	0.95
Factor 1	3.3	4.3	1.8	1.5	0.95	0.91	0.95	0.92
Factor 2	3.2	4.0	1.6	1.3	0.90	0.75	0.90	0.76
Factor 3	3.6	4.4	1.6	1.3	0.91	0.85	0.91	0.85
Factor 4	2.9	3.7	1.6	1.5	0.90	0.87	0.90	0.87

Note. Factor 1 = Emotional consequences, Factor 2 = Daily Life Impact, Factor 3 = Cognitive difficulties, Factor 4 = Motivation & engagement

Validity

Construct Validity

The results of the exploratory and confirmatory factor analyses provide initial supportive evidence of the dimensionality of the scale (Müeller & Apps, 2019). Each of the four dimensions of mental fatigue – *emotional consequences*, *daily life impact*, *cognitive difficulties*, *motivation and engagement* – correlated positively with all of the others (Tables 12 and 13). In general, one looks for low to moderate correlations among dimensions of a construct (Brown, 2015). Most of the correlations between the factors are greater than the general guidelines for moderate correlations: 0.40-0.69 (Schober, 2018). This indicates that these variables are highly related. However, Brown (2015) proposes that only factor correlations >0.80 would suggest the factors are highly overlapping and that there is poor discriminant validity. Although it is possible that

the four dimensions are not distinct enough from each other, the exploratory factor analysis in Study 1, and the confirmatory factor analysis in Study 2, both support the EIMFS being a multidimensional rather than unidimensional scale. The implications of these results on the utilization of the EIMFS are addressed in Chapter 5 (discussion).

Table 12

Pearson Zero-Order Correlations for Dimensions of Mental Fatigue for Study 1

	EIMFS	F1 – Emotional Consequences	F2 – Impact on Daily Life	F3 – Cognitive Difficulties	F4 – Motivation & Engagement
EIMFS	-	.97**	.90**	.91**	.89**
F1		-	.82**	.85**	.83**
F2			-	.74**	.77**
F3				-	.74**
F4					-

Note. **. Correlation is significant at the 0.01 level (2-tailed). n = 365.

Table 13

Pearson Zero-Order Correlations for Dimensions of Mental Fatigue for Study 2

	EIMFS	F1 – Emotional Consequences	F2 – Impact on Daily Life	F3 – Cognitive Difficulties	F4 – Motivation & Engagement
EIMFS	-	.94**	.82**	.89**	.88**
F1		-	.66**	.78**	.77**
F2			-	.66**	.67**
F3				-	.73**
F4					-

Note. **. Correlation is significant at the 0.01 level (2-tailed). n = 243.

Content Validity. Evidence for content validity came from the judgements of the raters (see Chapter 2), and the conceptual clustering, which assessed the degree to which each of the items were judged to represent their purported construct (see Appendix B3). Naive raters were asked to organize the 85 items into four piles based on the provided definitions of each construct. Consistency in the grouping of items across the piles suggested they were appropriately reflecting their construct. Inconsistency in the grouping of an item suggested the item did not reliably capture a common construct. No items were eliminated or removed based on this process. The items that were grouped inconsistently (50% agreement or less) were flagged for potential ambiguity (see Chapter 2 for a more thorough description of this process). Of the 22-items included in the final version of the EIMFS six had less than 50% of rater agreement.

Criterion Validity. There were four hypotheses for criterion validity:

- Given that the Need for Cognition is a trait variable (capturing an individual's desire to engage in intellectual problems), it was hypothesized that responses on this measure would predict experienced mental fatigue. Scoring high on Need for Cognition would likely make an individual more cognisant of impacts of fatigue on their mental function. Therefore, individuals high in Need for Cognition will score higher on the EIMFS.
- The experience of mental fatigue would be related to sleep quality since poor sleep will likely lead to mental fatigue. Therefore, individuals scoring high on the Sleep Quality Scale would also score high on the EIMFS.
- The factor *emotional consequences* should be positively correlated with the depression, anxiety, and stress subscales of the DASS. Therefore, those who score high on the emotional consequences of mental fatigue will also obtain high scores on all three EIMFS subscales.

A simple linear regression was conducted to determine whether the Need for Cognition measure predicted responses on the EIMFS. All assumptions (linear relationship, multivariate normality, no multicollinearity, no auto-correlation, and homoscedasticity) were met for both studies (see Appendices: E1, E2, E3, E4, E5, E6, E7, E8). The correlation between Need for Cognition and the outcome of mental fatigue was small but significant at $p < .001$ ($r = .33$, $r = .25$). Only a small amount of the variability in mental fatigue scores were accounted for by need for cognition (10.6% and 6.1%). This effect could be attributed to the Need for Cognition measuring a trait variable, whereas the EIMFS is measuring a state variable. In Study 1 the difference between the R Square and the Adjusted R Square was .001 (~ 0.1%), indicating that if the model were taken from the population as opposed to the sample, it would account for approximately 0.1% less variance. The difference between R Square and Adjusted R Square in Study 2 was approximately 0.4%. Both sets of results indicate that the data generalize. The results showed that the initial model in the Study 1 significantly improves our ability to predict the outcome of mental fatigue ($F[1, 363] = 43.50$, $p < .001$; $F[1, 239] = 15.43$, $p < .001$) (although by a larger amount in Study 1 than Study 2; Appendices E1 and E2). Thus, there is a less than 0.1% chance that the F-ratio would be this size if the null hypothesis were true.

Predictably, the EIMFS had a moderate positive correlation with the SQS across both studies (Table 14 and 15). These results suggest that the SQS is an appropriate ancillary measure for the EIMFS.

As hypothesized, higher scores on the *emotional consequences* factor of the EIMFS was positively moderately correlated with all three of the DASS subscales in Study 1 (see Table 14). This factor had stronger correlations with the DASS than any of the other factors. These results were similar in Study 2. Emotional consequences had the greatest correlations with the DASS anxiety and stress subscales; however, in Study 2 the factor *motivation and engagement* had a higher correlation with the DASS depression subscale than in Study 1 (see Table 15). Importantly, Study 1 and 2 cannot be statistically compared, and whether these are true reliable differences cannot be concluded.

Convergent Validity

There were three hypotheses for convergent validity:

- The EIMFS and its four subfactors would all be positively correlated (a moderate to strong effect size) with the FSS and the FIS. Higher scores on the EIMFS should be related to higher scores on these measures.
- The factor *cognitive difficulties* would be more strongly correlated with the cognitive subscale of the FIS than the overall FIS or the psychosocial subscale of the FIS. This factor will also be more strongly correlated to the cognitive subscale of the FIS than the other subfactors.
- The factors *daily life impact, emotional consequences,* and *motivation and engagement* would all be positively (moderate to strong effect sizes) correlated with the psychosocial subscale of the FIS.

Results from Studies 1 and 2 show that the EIMFS, as well as its four subfactors, all have moderate to strong positive correlations with both the FSS and the FIS (see Table 14 and 15). These significant and meaningful correlations demonstrate that different operationalizations of the same construct (mental fatigue) generalize.

As predicted, in both studies the *cognitive difficulties* factor was most strongly related to the cognitive subscale of the FIS than psychosocial subscale of the FIS. The factors *emotional consequences, daily life impact,* and *motivation and engagement* from the EIMFS demonstrated moderate to strong correlations with the psychosocial subscale of the FIS.

Table 14

Pearson Correlations Between Four Forms of Mental Fatigue & other Validated Indices of Fatigue & Related Constructs for Study 1

	FSS	FSS-P	FIS	FIS-P	FIS-C	NFC	SQS	DASS-D	DASS-A	DASS-S
EIMFS	.81**	.63**	.80**	.78**	.78**	-.33**	.68**	.76**	.64**	.74**
F1	.82**	.62**	.81**	.79**	.78**	-.29**	.68**	.76**	.65**	.76**
F2	.68**	.54**	.71**	.69**	.69**	-.27**	.61**	.63**	.58**	.67**
F3	.76**	.61**	.68**	.66**	.69**	-.34**	.58**	.63**	.51**	.60**
F4	.68**	.51**	.69**	.67**	.67**	-.32**	.58**	.75**	.57**	.65**

Note. FSS = Fatigue Severity Scale, FSS-P = Fatigue Severity Scale Physical Subscale, FIS = Fatigue Impact Scale, FIS-P = Fatigue Impact Scale Psychosocial Subscale, FIS-C = Fatigue Impact Scale Cognitive Subscale, NFC = Need for Cognition Scale, SQS = Sleep Quality Scale, DASS-D = DASS Depression Subscale, DASS-A = DASS Anxiety Subscale, DASS-S = DASS Stress Subscale.

Table 15

Pearson Correlations Between Four Forms of Mental Fatigue & other Validated Indices of Fatigue & Related Constructs for Study 2

	FSS	FSS-P	FIS	FIS-P	FIS-C	NFC	SQS	DASS-D	DASS-A	DASS-S
EIMFS	.79**	.62**	.78**	.76**	.75**	-.25**	.59**	.71**	.55**	.62**
F1	.78**	.61**	.73**	.71**	.70**	-.21**	.55**	.68**	.53**	.61**
F2	.61**	.64**	.64**	.62**	.61**	-.16**	.47**	.53**	.47**	.51**
F3	.69**	.52**	.68**	.64**	.71**	-.26**	.51**	.61**	.46**	.51**
F4	.67**	.52**	.72**	.72**	.65**	-.27**	.56**	.70**	.48**	.56**

Note. FSS = Fatigue Severity Scale, FSS-P = Fatigue Severity Scale Physical Subscale, FIS = Fatigue Impact Scale, FIS-P = Fatigue Impact Scale Psychosocial Subscale, FIS-C = Fatigue Impact Scale Cognitive Subscale, NFC = Need for Cognition Scale, SQS = Sleep Quality Scale, DASS-D = DASS Depression Subscale, DASS-A = DASS Anxiety Subscale, DASS-S = DASS Stress Subscale.

Discriminant Validity

Finally, there were two hypotheses for discriminant validity:

- It is expected that the EIMFS maybe weakly to moderately positively correlated with measures of physical fatigue. However, I predict that none of the four subfactors of the EIMFS, should be *strongly* related to physical fatigue. The EIMFS score should therefore not strongly correlate with the items on the FSS that assess physical fatigue (weak to moderate sizes). Instead, the EIMFS should correlate more strongly with other measures such as the FSS, the FIS, the FIS-P, and the FIS-C. A preliminary CFA was conducted on the FSS to determine whether the nine items could be divided into two subscales (mental

versus physical). As expected, the factor covariances were very high (0.92), however, this was not surprising given that this scale is cited in the literature (and used widely as) a unidimensional measure. That said, the model fit was very good: $\chi^2(26) = 176$, $p < .001$., SRMR = 0.04, RMSEA = 0.13 (90% CI = 0.11-0.14), TLI = 0.93, CFI = 0.95 suggesting that the scale could be split into two subscales.

- The factor *cognitive difficulties* of the EIMFS should not be strongly related to any of the subscales on the DASS (depression, anxiety, or stress).

Overally, this form of validity was supported. The correlation between the EIMFS and physical fatigue was significant and meaningful (with moderate effect sizes). Higher scores on the EIMFS were associated with being more likely to experience physical fatigue. However, the EIMFS and the four subfactors all had higher correlations with other measures of fatigue (with the exception being factor 2 in Study 2). The factor *cognitive difficulties* was moderately, but not strongly, correlated with the DASS subscales. The correlation coefficients are all displayed in Tables 14 and 15.

Chapter 5: General Discussion

Mental fatigue can be a debilitating symptom that negatively affects many aspects of an individual's quality of life (Dobryakova et al., 2015; Flensner et al., 2013). Yet, defining and measuring mental fatigue is difficult (Billones et al., 2021; Tyson & Brown, 2014; Kohl et al., 2009; Matthews, 2012; Penner & Paul, 2017). Existing measures of mental fatigue are inadequate given insufficient psychometric validation, as well as their failure to consider constructs associated with or reflective of mental fatigue (i.e., cognitive effort, emotion, motivation) (Shuman-Paretsky et al., 2017; Whitehead et al., 2016). In addition, current scales do not capture the specific experiences and contexts in which mental fatigue occurs, conflate mental fatigue with other types of fatigue (such as physical fatigue), and measure sustained rather than state mental fatigue. The current research approaches the measurement and conceptualization of the impact of mental fatigue in a new way, considering the contexts in which mental fatigue is experienced, and focusing only on measuring mental fatigue, as a temporary state.

This research was founded on the premise that the impact of mental fatigue is a complex phenomenon that includes facets related to motivation, cognition, cognitive control, and emotion. The objective of this research was to develop a measure of the impact of mental fatigue, titled the Experiential Impact of Mental Fatigue (EIMFS), to assess the daily contexts in which mental fatigue manifests. To my knowledge, no adequate measure of this sort currently exists in the literature.

The present studies provide empirical support for assessing the impact of mental fatigue with this new measure. Twenty-two items were included in the final version of the EIMFS, with 4 to 6 items per subscale. It was hypothesized that the four factors would be: *impaired cognitive control*, *impaired cognition*, *emotion*, and *decreased motivation*. However, EFA and CFA analyses yielded four subfactors that were somewhat different from what was postulated: *emotional consequences* (factor 1), *daily life impacts* (factor 2), *cognitive difficulties* (factor 3), and *motivation and engagement* (factor 4). Five of the items for the factor *emotional consequences* were originally designed to tap into the construct of *emotion*, one item was designed to tap into *cognitive control*, and one to tap into the construct of *cognition*. Therefore, this factor is consistent with the predicted factor *emotions*. The second factor, *daily life impact* was not originally predicted at all. The third factor *cognitive difficulties* included items that were originally created to reflect cognitive control and cognition. Therefore, the two expected factors

cognition and *cognitive control* were combined into this single factor. Finally, the fourth factor, *motivation and engagement*, included items that were designed to tap into cognitive control, cognition, and motivation. However, there were other items that were originally designed to reflect motivation that were ultimately eliminated and not included in this factor.

Although the four-factor model from Study 1 was shown to be confirmable in Study 2, the correlations between the factors were high, and more supportive of a unidimensional model rather than a multidimensional model.

The items that survived culling do accurately reflect how the impact of mental fatigue was conceptualized. Specifically, that *it can result in difficulties making decisions, negative effects on mood, poor task performance, and reduced productivity*.

- Items such as "it is hard to make plans because I can't predict when I will be mentally fatigued" (item 76), "it takes me a long time to decide to do something (item 67), and "it is difficult to make daily decisions, like what to make for dinner" (item 5) capture the impact of mental fatigue on an individual's ability to make decisions.
- Six items (80, 58, 59, 52, 2, and 69) address the negative effects mental fatigue can have on mood. For example, "I feel anxious because of my mental fatigue (item 80), and "I get frustrated that I can't do things because I am mentally fatigued" (item 59).
- Poor task performance is captured in items such as "I feel slowed down in my thinking" (item 9), "I feel like my ability to learn has decreased (item 8), "when doing 'brain problems' I find it difficult to concentrate" (item 6), and "I don't believe I can do well on tasks because I am too mentally fatigued (item 3).
- Finally, five items (15, 16, 65, 40, 72, 66, and 33) all tap into the aspect of reduced productivity. For example, "I do not have the will to do anything" (item 15), "I have lost interest in the work that I used to do" (item 16), and "I have lost the feeling of wanting to try at anything" (item 65).

Importantly, all the items are likely to address multiple aspects of the mental fatigue experience. For instance, "I feel like my brain is not functioning the way it should" (item 83) may capture the negative impacts on mood, productivity, and performance. The impact of mental fatigue on the completion of tasks (e.g., "every task takes longer to complete than it usually would"; item 26) could be due to either the diminished desire to finish a task efficiently (i.e., productivity) or a decline in cognition (i.e., performance).

The construct validity of the EIMFS was established by considering various validation procedures and types of evidence. The psychometric analysis revealed that all items assess the same underlying construct (mental fatigue), while continuing to remain relatively distinct from one another. Psychometric assessments of inter-item reliability indicated that the EIMFS is a reliable and valid tool to assess the occurrence of the experiential impact of mental fatigue. This suggests that the items contributing to the four subfactors were sound and share common meaning with other items loading onto the same factor. Although the EFA and CFA both yielded four subfactors, these factors are highly correlated (range = 0.575-0.755) suggesting that the constructs are too similar to be sufficiently differentiated (Brown, 2015).

The EIMFS shows convergent validity with previously established measures of mental fatigue. This was expected given that existing scales of mental fatigue (such as the FSS and the FIS) were used as a basis for item development.

The Sleep Quality Scale (SQS) was an appropriate ancillary measure for the EIMFS, and sleep quality was not distinct from the impact of mental fatigue. This finding is consistent with work that has shown that mental fatigue is associated with, and can be significantly predicted by, subjective sleep quality (Lavidor et al., 2003; Pastier et al., 2021). Temporary fatigue can also be linked to lifestyle factors such as poor sleep quality (Matthews, 2012; Pattyn et al., 2018; Shahid et al., 2010; Shen et al., 2006). One possible explanation for the moderate correlation between the EIMFS and the Sleep Quality Scale (SQS) is that poor sleep quality results in mental fatigue and these two constructs are experienced as synonymous. Participants may be experiencing poor sleep quality given their high ratings on depression, and the link between sleep quality and mental health difficulties (Scott et al., 2021).

I observed a moderate correlation between the EIMFS and the physical fatigue subscale of the FSS. This is not surprising: mental fatigue has been difficult to distinguish from physical fatigue in the literature. Indeed, there is debate about whether mental and physical fatigue are a single state (Matthews, 2012). Though there can be separate causes of mental fatigue compared to physical fatigue (e.g., an overall healthy individual who has just had a traumatic brain injury), the impacts of the fatigue will likely be both mental and physical, and we will be unable to separate them completely in measurement.

The study predicted that emotional consequences (i.e., feelings of sadness, loneliness, frustration, guilt) would likely be a significant feature of the experiential impact of mental

fatigue. Criterion validity was supported as the factors were related to the DASS measure. I provided evidence that the *emotional consequences* dimension of mental fatigue is related to depression, anxiety, and stress. This dimension had the strongest association with the DASS (except for its correlation with the DASS depression subscale in Study 2). These findings are consistent with past research demonstrating that psychological fatigue is linked to stress and emotional experiences associated with depression and anxiety (Aaronson et al., 1999; Lee et al., 1991). Similarly, the strong relationship between mental fatigue and the stress subscale of the DASS is in line with other research that has shown that the experience of mental fatigue, and its unpredictability, can be highly distressing, as individuals are unable to sustain concentration or complete mentally strenuous tasks (Chaudhuri et al., 2004; Whitehead, 2016).

Exploratory analyses found that individuals who were more mentally fatigued after completing the objective *n*-back tasks had higher scores on the EIMFS. Mental fatigue following the *n*-back also had a small negative correlation with Need for Cognition (NFC) scale. Hence, an individual may be more aware of their need for cognition (or lack therefore) when their mental fatigue is higher. Intuitively this makes sense, as individuals are less likely to seek out difficult problems or want to engage in problem solving when they are fatigued.

Across both studies, there was also small to moderate negative correlations between the EIMFS and the NFC scale. Even though the EIMFS was designed to be sensitive to the measurement of state mental fatigue, this finding suggests that trait contamination may be occurring. How an individual is feeling in the moment may be affected by how they feel in general. There is also likely to be state contamination in the NFC scale. How they are feeling in the moment (as mental fatigue increases) is influencing how they are rating the trait measure of need for cognition (which decreases).

Finally, paired *t*-tests revealed that that the *n*-back two-back performance did not change significantly over the course of either Study 1 or 2. Thus, participants did not seem to be more fatigued at the end of the experimental session in comparison to the beginning of the session.

Future Directions

Confirm the Robustness of the EIMFS

Objective validity. Objective measurements have several limitations. For example, they do not give researchers the ability to diagnose the origin of mental fatigue (Matthews, 2012). It is also possible that performance measures may not be sufficiently sensitive to capture the mental

fatigue an individual is experiencing. Diminished performance correlates inconsistently with the subjective experience of mental fatigue. Specific task situations may not elicit feelings of fatigue for some individuals; others will report increased feelings of fatigue and exhibit reduced performance efficiency, others increased feelings of mental fatigue but no decrease in performance efficiency, and others will report no increased feelings of mental fatigue but a decline in performance efficiency (Matthews, 2012).

Objective measures can also be influenced by non-fatigue factors. Task characteristics such as difficulty, engagement, level of interest, time length, and enjoyment or dislike (a motivational factor related to effort allocation) can also influence whether a task engenders mental fatigue and may be mediating the influence of mental fatigue on performance (Hockey, 1997; Van Custem & Marcora, 2021).

Predictive validity. A common reason for clinicians to measure the mental fatigue experienced by a patient is to determine what has led them to seek out care (Matthews, 2012). Yet it is equally important to determine the effectiveness of this care in ameliorating symptoms and increasing quality of life. Could the EIMFS be used to predict the success of the interventions based on the type of symptoms an individual is expressing? The EIMFS could be used as an outcome measure, by monitoring responses to the EIMFS either during the treatment or following.

Mental Fatigue in Neuropsychological Populations

I plan to administer the EIMFS in various neuropsychological populations, in particular people to with epilepsy (PWE). Fatigue occurs more frequently in individuals with temporal-lobe epilepsy than in the general population, however, it is often not considered to be a prominent clinical characteristic of this disorder (Lagogianni et al., 2021). Patients report metal fatigue, particularly post-seizure and during treatments with some medications, and this undoubtably diminishes quality of life (Akosile et al., 2021; Kwon & Park, 2016; Yan et al., 2016). Despite general fatigue being a common symptom for PWE, research remains limited, especially in contrast to other conditions in which fatigue symptoms have been extensively investigated (Lagogianni et al., 2021). Further, the extent, degree, and phenomenology of fatigue in epileptic individuals is unknown (Hernandez-Ronquillo et al., 2011; Lagogianni et al., 2021). The effects of fatigue within the epilepsy population have not been studied at length, impeding the field's progress in understanding best practice for management in PWE (Akosile et al., 2021; Yan et al.,

2016). Mental fatigue in PWE has never been systematically evaluated, and more research is needed to explore the correlations between mental fatigue and other symptoms experienced by this group such as low sleep quality, anxiety, and depression (Dittner et al., 2004; Neu et al., 2010; Yan et al., 2016). This study has demonstrated the link between the experience of mental fatigue and performance on the *n*-back measure. However, the relationship between individual differences in cognition on other behavioural measures and scores on the EIMFS warrants further investigation (Lagogianni et al., 2021).

Broadening our understanding of the experience of mental fatigue in PWE will help increase efficacy of treatment regimens and patient management (Kwon et al., 2017; Lagogianni et al., 2021). Recent publications have recommended that future studies on epilepsy incorporate measures of fatigue, which would include mental fatigue, as it is possible that this construct may act as a mediator relating epilepsy to overall quality of life (Lagogianni et al., 2021). In order to do so, however, an agreed-upon measure of mental fatigue that has demonstrated adequate psychometric properties for this specific population is required. At present, no mental fatigue scale developed for this population of individuals exists (Lagogianni et al., 2021). The three scales that have been validated for use with this population (Fatigue Symptoms Inventory-FSI, Fatigue Assessment Instrument-FAI, and the Fatigue Severity Scale-FSS), though commonly used, fail to capture the daily situational contexts in which mental fatigue may occur. The EIMFS may be an ideal measure to fill this gap in the literature. These recommendations could also extend to other populations such as individuals with hearing loss, and those who have suffered from traumatic brain injuries.

Finally, fatigue and mood or anxiety disorders have been cited in different illnesses such as multiple sclerosis (MIS; Siegert & Abernathy, 2005), chronic fatigue syndrome (CFS; Matthews, 2012), and cancer (Tchekmedyian et al., 2003). Future research could explore whether mental fatigue profiles differ between clinically depressed or anxious individuals and non-clinically depressed or anxious individuals (Lagogianni et al., 2021).

Limitations

The present findings should be considered within the context of the limitations of this study. Recruitment through CloudResearch required that participants only be sampled from the United States of America, which may limit the sample's generalizability. It is also likely that the CloudResearch sample shared some characteristics that may not be representative of the larger

population (e.g., reliable internet, computer access). That said, the use of this platform allowed the study to be filtered to participants that had a higher approval rating than other workers on the platform MTurk, increasing confidence in the reliability and adequacy of the data recruited from the platform.

In a similar vein, the sample from SONA at Western University in Canada may also not be generalizable to the larger population given the characteristics this sample likely shared (e.g., higher education, increased socioeconomic status, computer access, reliable internet). However, the use of this sample in combination with the sample received in Study 1 is likely to encompass a larger breadth of the population. In addition, the use of this student sample allowed for the replication of the findings from Study 1 in a sample that was not limited to the geographic location of the USA. However, there is a need for future work to confirm the current structure of the EIMFS in other demographic populations.

No qualitative study was conducted prior to the development of the EIMFS. Although focus groups with the target population would have been ideal to determine the relevance of the chosen items, given resource restrictions a review of the qualitative literature on mental fatigue was conducted, and psychology and neuroscience graduated students at The University of Western Ontario were consulted (Boateng et al., 2018). Finally, the EIMFS was developed as a self-report, and this subjective form of measurement has several limitations. For one, subjective measures cannot allow a clinician to diagnose the origin of mental fatigue, merely the experience of the individual completing the EIMFS. For this reason, the EIMFS is not sensitive enough to detect mental fatigue that an individual is not able to consciously identify and reflect about. As in every empirical study that is based on individual perceptions of what the question is asking, it is possible that the participants did not provide accurate information or incorrectly interpreted the question.

Conclusion

Fatigue has remained "one of the most puzzling enigmas in all of psychology" (Matthews, 2012, p. 3), and our present comprehension of fatigue has remained relatively unchanged over 100 years – we do not understand it very well at all (Kohl et al., 2009). Fatigue is prevalent in a variety of conditions and can be classified in many ways. Part of the reason mental fatigue is hard to define can be credited to the complex experience of mental fatigue, which includes other facets such as motivation, emotion, and thinking (Van der Linden, 2011).

Despite fatigue promoting the likelihood of an individual experiencing a variety of negative health outcomes, it is often overlooked within clinical settings, with few options for treatment (Chaudhuri & Behan, 2004; National Advisory Committee on Health and Disability, 2007).

Notwithstanding the limitations of the research, the present study suggests that the EIMFS is valid and reliable. The EIMFS shows promise in overcoming some of the limitations of previous mental fatigue scales. It considers the situational context in which constructs reflective of mental fatigue (i.e., emotions, effort, cognition, motivation) manifest, which is not addressed in existing measures. Moreover, it measures solely the impact of mental fatigue, and does not conflate it with other types of fatigue (such as physical fatigue). This measure provides a theoretically informed and effective tool for the detection and characterization of the impact of mental fatigue. Our findings support the contribution of this measure to the literature on mental fatigue by highlighting four subfactors that display the unique ways in which the impact of mental fatigue manifests across daily life experiences and contexts.

Future work should explore the influence of mental fatigue on information processing and performance and determine the efficacy of interventions (Matthews, 2021). In addition, there is the need to further establish construct validity by testing the EIMFS with different populations and across various situations and contexts (Kline, 2005; Muller & Knapp, 2019).

Considering the incidence rates and detrimental impacts of mental fatigue, the assessment, adequate management, and recognition of the fatigue experience within health care is critical for effective patient care (Sharpe & Wilkes, 2002; Whitehead, 2016; Whitehead, 2004). The fact that fatigue often precedes a host of negative health outcomes reinforces the importance in bolstering our knowledge on how mental fatigue manifests, the optimal tools for measuring the construct, and developing early interventions (Knoop, 2021). There is progress to be made when it comes to understanding the basic processes underlying mental fatigue, and theory should utilize the range of modern tools designed to study neural processes (including brain imaging), in conjunction with self-report measures to inform insight on the experience of mental fatigue (Bess et al., 2014). Accordingly, this could help aid in creating diagnostic tools to distinguish the various neurological origins of mental fatigue, which could then be used for individual patient assessment, and to help develop interventions and prevention strategies (Dantzer et al., 2014; Lagogianni et al., 2021; Manjaly, 2019; Penner & Paul, 2017).

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Appendix A: Appendices for Study 1 Materials

Appendix A1

CloudResearch Recruitment Notice

Title: The Experience of Mental Fatigue

Description.
If you decide to participate this study will take place online and will involve the completion of an online survey that should take approximately 20-minutes in total. The questionnaires will ask you about your experiences surrounding mental fatigue and the impact it has on your daily life. You will also be asked to answer some questions about sleep, your overall mood, and whether statements about cognition and cognitive tasks are characteristic of you. Finally, the survey portion will end with demographic questions on gender, age, ethnic background, whether you have ever been diagnosed with ADHD, dyslexia, epilepsy, or any kind of other psycho educational or neuropsychological issue.

You will then be directed to the second part of the study which will take place on the online server Pavlovia. You will be instructed to complete two tasks, an Auditory Memory Task and a Matrix Reasoning Task.

Eligibility Requirements.
Please note that you must be between 18-50 years of age and be fluent in speak to participate in this study.

Risks.
There are no known or anticipated risks or discomforts associated with participating in this study.

Duration and Locale.
60 minutes in a setting where you have access to a computer.

Compensation.
You will receive a $10.00 CAD.

Researchers: Olivia Richards, researcher, (email: redacted); Dr. Ingrid Johnsrude, supervisor (email: redacted)

Version date: 2022-01-06

Appendix A2

Informed Consent

Welcome! Please read over the following letter of information and consent before proceeding.

Who do you contact if you have questions?
Should you have questions or concerns related to your involvement in this research, please contact:

Researcher contact information:
Name: Olivia Richards
Role: Graduate student
Department: Psychology
The University of Western Ontario
Email: redacted

Supervisor contact information:
Name: Dr. Ingrid Johnsrude
Role: Faculty member, supervisor
Department: Psychology
The University of Western Ontario
Tel: redacted
Email: redacted

Project Title: The Experience of Mental Fatigue

Research Personnel. The researcher running this study is Olivia Richards in the Department of Psychology at the University of Western Ontario. She is working under the supervision of Dr. Ingrid Johnsrude in the Department of Psychology.

Introduction.
You are being invited to participate in this research study about the experience of mental fatigue because you indicated on Cloud Research on the online platform MTurk that you would be interested in participating. Please note that you must be 18-50 years of age and speak English as a first language to participate in this study.

Why is this study being done?
The purpose of this research is to examine the ways in which individuals experience mental fatigue, and how mental fatigue impacts their lives. Taking these perceptions into account can help us determine how mental fatigue manifests in individuals. For example, does motivation effect mental fatigue? Does the amount of effort required for a task impact mental fatigue? These factors likely influence our engagement in and successfully completion of cognitively strenuous tasks. To assess this, we asked you to respond to a series of questions describing cognitive fatigue.

How long will you be in this study?
It is expected that you will be in the study approximately 60 minutes to complete.

What will happen during this study and what is the study procedure?
If you decide to participate this study will take place online and will involve the completion of eight questionnaires that should take approximately 20-minutes in total. Three of the questionnaires will ask you about your experiences surrounding fatigue and the impact it has on your daily life. You will also be asked to answer some questions about sleep, your overall mood, and whether or not statements about cognition and cognitive tasks are characteristic of you. Finally, the survey portion will with demographic questions on gender, age, ethnic background, whether you have ever been diagnosed with ADHD, dyslexia, epilepsy, or any kind of other psycho educational or neuropsychological issue, what country you reside in, and what your first language is.

You will then be directed to the second part of the study which will take place on the online server Pavlovia. You will be instructed to complete two tasks, an Auditory Memory Task (which will take approximately 10 minutes to complete) and a Matrix Reasoning Task (you will have 30 minutes to complete this task however it is likely you will finish much faster than this).

- In the auditory memory task you will hear a sequence of letters. The letters will be presented one a time and a new sound will play ever 2.5 seconds. Your job will be to listen closely to these sounds for specific kinds of repeats.
- The Matrix Reasoning Task is a pattern completion task. You will be presented with patterns, one pattern at a time. One piece of the pattern will be missing, and your job is to select the best option that completes the pattern.

Whether you complete the Auditory Memory Task first or the Matrix Reasoning Task first will be randomized.

What are the risks and harms of participating in this study?
There are no known or anticipated risks or discomforts associated with participating in this study.

What are the benefits of participating in this study?
Fatigue can act as one of the most severe symptoms expressed in neurological and healthy populations (Dobryakova et al., 2013). That said, our understanding of mental fatigue remains relatively minimal, and it appears more research needs to be conducted to expand our knowledge and bridge gaps in the literature (Chaudhuri & Behan, 2004; DeLuca, 2005). You may not directly benefit from this study. However, by participating in this study, you would be helping researchers in their goal of better understanding how to measure mental fatigue and increasing knowledge of the phenomenon of mental fatigue.

Can participants choose to leave the study?
You have the right to end your participation during the study at any time. You can choose not to answer particular questions. If you withdraw from the study, all information you have provided will be immediately destroyed. Due to the anonymous nature of your data, once your responses have been submitted the researchers will be unable to withdraw your data as all submitted data

will not contain identifiers. You can **only withdraw during the study**.

Anonymity/confidentiality.
All responses are anonymous. You should not put any identifying information on the survey. All research data will be stored on the Qualtrics server. Research data will only be accessible by the researchers involved in the project and the research supervisor.

Delegated institutional representatives of Western University and its Non-Medical Research Ethics board may require access to your study-related records to monitor the conduct of the research in accordance with regulatory requirements.

Once the project is completed all data will be collected anonymously and neither the researchers nor anyone else will be able to identify you as a research participant. The data will be stored on a secure server at The University of Western Ontario and will be retained for 7-10 years. Your data will not be distributed to others.

These data may be used for teaching and research publications, presentations, and theses. If the results of the study are published, your name will not be used.

Data Collection.
Your data will be collected online through a third party. Despite these parties taking the steps to secure your data, please note that nothing over the internet is every 100% safe.

- The online forum **Qualtrics** will be used to collect your survey data. For researchers at Canadian institutions, Qualtrics stores their data in Ireland. Their privacy policy can be accessed here.
- The online forum Pavlovia will be used to collect your Auditory Memory Task data and your Matrix Reasoning Task data. The server hardware for Pavlovia is in the United Kingdom. Their privacy policy can be accessed here.

Compensation.
You will be compensated $10 CAD for your participation in this study. You will receive your compensation through MTURK. If you do not complete the entire study, you will still be compensated. If you need to withdraw from the study **before** completion, contact Olivia Richards (email: redacted) to arrange a compensation HIT.

What are your rights as a participant?
Your participation in this study is voluntary. You may decide not to be in this study. Even if you consent to participate you have the right to not answer individual questions or to withdraw from the study at any time. If you choose not to participate or to leave the study at any time it will have no effect on you or your compensation. You do not waive any legal right by consenting to this study.

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics phone number: redacted, email: redacted This office oversees the ethical conduct of research studies and is not part of the study team. Everything that you discuss will be kept confidential.

This letter is yours to keep for future reference.

Version: 2022-01-27

By indicating that you want to proceed with the study by clicking on the "next" button, you are choosing and consenting to participate this study. If you do not want to proceed with the study please exit the browser now.

Appendix A3

CloudResesarch Debriefing

Study Title: The Experience of Mental Fatigue

What if I have questions later?
If you have any remaining concerns, questions, or comments about the experiment, please feel free to contact Olivia Richards at: redacted; or Dr. Ingrid Johnsrude (Faculty Sponsor & Supervisor) at: redacted.

Thank you for participating in this research!

Version: 2022-01-06

Appendix A4

The Western Mental Fatigue Scale

Instructions: Please read each statement carefully. For each of the statements below, please indicate the extent to which you agree with the statement being characteristic of you or your experience **in this moment** by rating it on the provided scale of 1 to 7. For example, if the statement is extremely uncharacteristic of you or of what your experience (you disagree strongly) please choose the option "1". If the statement is extremely characteristic of you or your experience has been like (you agree strongly) please choose the option "7".

Please note that some of the questions will ask about your experience with ‘brain problems’ or ‘tasks that require thinking.’ When we use these terms, we mean activities such as writing a letter, doing a crossword, doing sudoku, completing desk work, reading a textbook, playing the game wordle, or doing other challenging problems that involve the use of the brain.

1. When I am trying to focus, I am easily distracted.
2. I feel sad because of mental fatigue.
3. I don't believe I can do well on tasks because I am too mentally fatigued.
4. I try to keep going even when I get mentally fatigued.
5. It is difficult to make daily decisions, like what to make for dinner.
6. When I try to do 'brain problems' I find it difficult to concentrate.
7. I feel no desire to use my brain.
8. I feel like my ability to learn has decreased.
9. I feel slowed down in my thinking.
10. I get mentally fatigued more quickly doing tasks when I am sad.
11. I don't have the drive to work hard.
12. I am not able to finish tasks that require thinking.
13. When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.
14. Please select number 5 on the rating scale.
15. I do not have the will to do anything.
16. I have lost interest in the work that I used to do.
17. If I am struggling with a task that requires thinking, I give up easily.
18. I find it hard to pay attention for a long time.
19. I find it more difficult than usual to find the correct word.
20. I am not able to do the things that I used to do because I am mentally fatigued.
21. I can be bribed into doing things I don’t have the motivation to do.
22. I am convinced that I don’t have the mental energy to carry out the rest of the day.
23. I am not motivated to do tasks that require thinking.
24. I make slips of the tongue when speaking.
25. When I am stressed while during work, I get mentally fatigued quickly.
26. Every task takes longer to complete than it usually would.
27. When doing a task, I get distracted more than I used to.
28. I feel like I can't be productive.
29. When doing activities, I get less mentally fatigued when I am in a good mood.

30. When I am doing tasks that require thinking, I can concentrate quite well.
31. I have problems thinking clearly.
32. I need to take long breaks between tasks to gain back my mental energy.
33. Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.
34. When I am stuck on a problem, I try harder.
35. It takes more effort to do typical activities where I need to think.
36. It is hard for me to keep track of conversations in social settings.
37. Please select number 1 on the rating scale.
38. I believe that my will is strong enough to complete most tasks.
39. I can accomplish tasks that require thinking if I put my mind to them.
40. I do not feel engaged in my work.
41. If I were watching TV right now it would be hard to focus because my thoughts tend to drift.
42. I am more forgetful than usual.
43. I get stuck more often than most people when working through problems that require a lot of thought.
44. I feel helpless because of mental fatigue.
45. I feel like I have a small amount of mental energy that I need to budget across tasks.
46. My motivation is lower than usual.
47. I feel I am always one step behind.
48. It is hard for me to keep up my effort.
49. I have trouble doing even basic things like getting dressed.
50. The thought of doing basic self-care like brushing my teeth or taking a shower is too much.
51. I feel like I can’t be bothered to do activities that I used to enjoy.
52. I feel lonely because of mental fatigue.
53. I find I am less able than usual to start tasks that require thinking.
54. I feel like I need to leave tasks unfinished to complete tomorrow.
55. I feel useless because I don't have the mental energy to do things.
56. I find it hard to think straight.
57. I feel like I can't organize my thoughts enough to properly complete tasks.
58. I get frustrated that I can't do things because I'm mentally fatigued.
59. I am less confident because of mental fatigue.
60. It is hard for me to answer emails efficiently.
61. Please select number 7 on the rating scale.
62. I can't make myself do the work that I know I should.
63. I find it hard to follow conversations.
64. I find that I procrastinate more than I used to.
65. I have lost the feeling of wanting to try at anything.
66. I struggle to do tasks that need to be done, like doing the laundry or getting groceries.
67. It takes me a long time to decide to do something.
68. When I sit down to do work, I feel like my thoughts are all over the place.
69. I feel guilty because I cannot do most things that I am supposed to do.
70. It is easy for me to become mentally overwhelmed.
71. I don't have the mental energy to socialize with others.

72. It is hard for me to see the point in doing chores like the dishes.
73. It takes me longer than it used to get engaged in my work.
74. When I am concentrating, I get exhausted sooner than I used to.
75. I am making many mistakes.
76. It is hard to make plans because I can’t predict when I will be mentally fatigued.
77. It is hard to remember relevant information that I need to do my work.
78. Tasks that I could usually do without thinking now require more effort.
79. I can't keep going even if I really want to because of my fatigue.
80. I feel anxious because of mental fatigue.
81. I can't follow movies with complex plots because it is hard for me to keep track of what is going on.
82. I need to divide jobs up so that I don't do too much in one day.
83. I feel like my brain is not functioning the way it should.
84. The idea of writing a text message to someone on my phone is too exhausting.
85. It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.
86. I have trouble remembering names or passwords for my accounts.
87. My brain feels numb.
88. When I try to read, I must read the same line over and over because I can't process the words.

Appendix A5

Fatigue Severity Scale

Instructions: Please rate the following items on a scale of 1-7 (strongly disagree-strongly agree)

1. My motivation is lower when I am fatigued.
2. Exercise brings on my fatigue.
3. I am easily fatigued.
4. Fatigue interferes with my physical functioning.
5. Fatigue causes frequent problems for me.
6. My fatigue prevents sustained physical functioning.
7. Fatigue interferes with carrying out certain duties and responsibilities.
8. Fatigue is amongst my three most disabling symptoms.
9. Fatigue interferes with my work, family, or social life.

Appendix A6

Fatigue Impact Scale

Please rate how much of a problem fatigue has caused you during the past month, including today, in reference to the statements listed below. Please indicate the appropriate response for each on the scale of 0 to 4 (0 = no problem; 1 = small problem; 2 = moderate problem; 3 = big problem; 4 = extreme problem).

Because of my fatigue:

1. I feel less alert.
2. I feel that I am more isolated from social contact.
3. I have to reduce my workload or responsibilities.
4. I have difficulty paying attention for a long period.
5. I am more moody.
6. I feel like I cannot think clearly.
7. I work less effectively (this applies to work inside or outside the home).
8. I have to rely more on others to help me or do things for me.
9. I find that I am more forgetful.
10. I am more irritable and more easily angered.
11. I find it hard to concentrate.
12. I am less motivated to engage in social activities.
13. I find it difficult to make decisions.
14. Normal day-to-day events are stressful for me.
15. I feel slowed down in my thinking.
16. I avoid situations that are stressful for me.
17. I am less motivated to do anything that requires thinking.
18. I have difficulty dealing with anything new.
19. I feel unable to meet the demands that people place on me.
20. I am less able to finish tasks that require thinking.
21. I am less able to provide financial support for myself and my family.
22. I engage in less sexual activity.
23. I am less able to deal with emotional issues.
24. I have difficulty participating fully in family activities.
25. I find it difficult to organize my thoughts when I am doing things at home or at work.
26. I have few social contacts outside of my home.
27. I am not able to provide as much emotional support to my family as I should.
28. Minor difficulties seem like major difficulties.
29. I have difficulty planning activities ahead of time.
30. My ability to travel outside my home is limited.

Appendix A7

Depression Anxiety Stress Scales (DASS)

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree or a good part of time
3 Applied to me very much or most of the time

Questions:

1. I found it hard to wind down
2. I was aware of dryness of my mouth
3. I couldn't seem to experience any positive feeling at all
4. I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)
5. I found it difficult to work up the initiative to do things
6. I tended to over-react to situations
7. I experienced trembling (e.g. in the hands)
8. I felt that I was using a lot of nervous energy
9. I was worried about situations in which I might panic and make a fool of myself
10. I felt that I had nothing to look forward to
11. I found myself getting agitated
12. I found it difficult to relax
13. I felt down-hearted and blue
14. I was intolerant of anything that kept me from getting on with what I was doing
15. I felt I was close to panic
16. I was unable to become enthusiastic about anything
17. I felt I wasn't worth much as a person
18. I felt that I was rather touchy
19. I was aware of the action of my heart in the absence of physical exertion (e.g. sense of heart rate increase, heart missing a beat)
20. I felt scared without any good reason
21. I felt that life was meaningless

Appendix A8

Need for Cognition Scale

Instructions: For each of the statements below, please indicate whether or not the statement is characteristic of you or of what you believe. For example, if the statement is extremely uncharacteristic of you or of what you believe about yourself (not at all like you) please place a "1" on the line to the left of the statement. If the statement is extremely characteristic of you or of what you believe about yourself (very much like you) please place a "5" on the line to the left of the statement. You should use the following scale as you rate each of the statements below.

1. I prefer complex to simple problems.
2. I like to have the responsibility of handling a situation that requires a lot of thinking.
3. Thinking is not my idea of fun.*
4. I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.*
5. I try to anticipate and avoid situations where there is likely a chance I will have to think in depth about something.*
6. I find satisfaction in deliberating hard and for long hours.
7. I only think as hard as I have to.*
8. I prefer to think about small, daily projects to long-term ones.*
9. I like tasks that require little thought once I've learned them.*
10. The idea of relying on thought to make my way to the top appeals to me.
11. I really enjoy a task that involves coming up with new solutions to problems.
12. Learning new ways to think doesn't excite me very much.*
13. I prefer my life to be filled with puzzles that I must solve.
14. The notion of thinking abstractly is appealing to me.
15. I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.
16. I feel relief rather than satisfaction after completing a task that required a lot of mental effort.*
17. It's enough for me that something gets the job done; I don't care how or why it works.*
18. I usually end up deliberating about issues even when they do not affect me personally.

Appendix A9

Sleep Quality Scale

The following survey is to know the quality of sleep you had for the last one month. Read the questions and check the closest answer based on the following ratings: Rarely (none of 1-3 times a month), Sometimes (1-2 times a week), Often (3-5 times a week), Almost always (6-7 times a week).

1. Difficulty in thinking due to poor sleep.
2. Difficulty in concentrating due to poor sleep.
3. Increase of mistakes due to poor sleep.
4. Irritated feeling due to poor sleep.
5. Decrease of interest in work or others due to poor sleep.
6. Getting tired easily at work due to poor sleep.
7. Sleepiness that interferes with daily life.
8. Painful life due to poor sleep.
9. Decrease of desire due to poor sleep.
10. Increase of forgetfulness due to poor sleep.
11. Headache due to poor sleep.
12. Decrease of appetite due to poor sleep

Appendix A10

Single-Item Fatigue Measure

Please answer the following question.

In general, how much of an effect has mental fatigue had on you during the past 4 weeks?

0 – None
1
2
4
5
6
7
8
9
10 – A severely disabling effect.

Appendix A11

Mental Fatigue Timeframe Question

How long have you been experiencing mental fatigue?

Less than 1 week.
2 weeks.
More than 1 month.
Between 2-4 months.
More than 6 months.

Appendix A12

Demographics

Instructions: We would like to gather some demographic information. All information you provide will be completely confidential and will not be associated in any way with your identity. Please answer the questions below.

1. What is your gender:
   Female
   Male
   Transgender
   Non-binary
   Prefer not to say
   Not listed (please specify) _____

2. What is your Age: _____(in years)

3. Which of the following best describes your ethnicity
   Arab
   Black
   Chinese
   Filipino
   Indigenous
   Japanese
   Korean
   Latin American
   South Asian
   Southeast Asian
   West Asian
   White
   Mixed Ethnicity
   Not listed (please specify): _____
   Prefer not to answer

4. Have you ever been diagnosed with ADHD, dyslexia, epilepsy, dementia, or any kind of other psycho educational or neuropsychological issue?

   Yes ☐

   No ☐

5. What country do you currently reside in?: _____

6. What is your first language?: _____

7. What is the highest degree or level of school you have completed? (If you're currently enrolled in school, please indicate the highest degree you have *received*).

Less than a high school diploma
High school degree or equivalent (e.g., GED)
Some college, no degree
Associate degree (e.g., AA, AS)
Bachelor's degree (e.g., BA, BS)
Master's degree (e.g., MA, MS, MEd)
Professional degree (e.g., MD, DDS, DVM)
Doctorate (e.g., PhD, EdD)

Appendix A13

Honesty Question

Instructions: Please check the box to either yes or no. Please answer honestly. You will be compensated for your participation regardless of how you respond to the following question.

Question: I provided honest and high-quality answers to the survey questions.

Yes ☐

No ☐

Appendix A14

Headphone Check

Did you use headphones when completing the auditory memory task?

Yes ☐

No ☐

I can't remember ☐

Appendix B: Appendices for Supplementary Materials for Chapter 2

Appendix B1

Table 16

Details of Existing Fatigue Questionnaires that Incorporate Elements Related to Mental Fatigue

Measure Name	Mental Fatigue Elements	Strengths	Limitations
Brief Fatigue Inventory (BFI; Mendoza et al., 1999)	Influence of fatigue on mood, relationships.	Reliability: • Internal consistency: 0.82-0.96 (Shahid et al., 2010; Whitehead, 2009). • Test-rest: *r* = 0.79-0.91 (Whitehead, 2009). Validity: • Construct (Whitehead, 2009) • Convergent with Cancer Fatigue Scale (*r* = 0.64-0.76) and POMS fatigue scale (*r* = 0.60-0.70) (Whitehead, 2009) • Concurrent: tested with POMS-F, FACT-F (Shahid et al., 2010). Other benefits: • Used for quick assessment of fatigue severity in clinical screening and trials.	• Timeframe: past 24 hours, sustained fatigue (Whitehead, 2009). • Generic, not validated in noncancer population (Whitehead, 2009). • Discriminant validity unknown. • Scale items are abstract, not specific, & not relating to everyday activities
Fatigue Assessment Instrument (FAI; Schwartz et al., 1993) (also known as the Fatigue Severity Inventory or Fatigue	Influence of fatigue on cognitive elements, mood.	Reliability: • Internal consistency: 0.70-0.91 (Dittner et al., 2004). • Test-retest reliability: moderate at 0.29-0.69 (Dittner et al., 2004) Validity: • Convergent validity: FSS (*r* = 0.98; Dittner et al., 2004).	• Timeframe: past two weeks, sustained fatigue. • The Fatigue severity subscale corresponds almost exactly with the FSS (sharing 8 of the original 9 items) • Measure includes 4 subscales (fatigue severity, situation specificity, consequences

Assessment Inventory)		• Concurrent validity: Subscale 1 and the Vitality Index, subscale 3 weakly with Enervation Scale (Dittner et al., 2004). • Construct: most of the items loaded on to the first two factors and only Severity and Consequences subscales demonstrated concurrent validity based on other measures of fatigue and energy level (Dittner et al., 2004). • Discriminant: distinguish healthy subjects from patients and differences between patients with different diagnoses (in some cases) (Dittner et al., 2004	of fatigue, responsiveness to rest/sleep; Dittner et al., 2004).
Fatigue Assessment Scale (FAS; (Michielsen et al., 2003)	How an individual usually feels regarding their cognitive abilities, motivation.	Reliability: • Internal consistency: 0.90 (Whitehead, 2009). Validity: • Convergent with CIS (r = 0.83), FS (r = 0.82) (Whitehead, 2009)	• Timeframe: how a person usually feels, sustained fatigue • Mixed reports on whether the scale is unidimensional or multidimensional • Scale items are abstract & not relating to everyday activities. • Test-retest reliability unknown, needs to be further validated.
Fatigue Impact Scale (FIS; Fisk et al., 1994a). Also called the Fisk Fatigue Severity Score (FFSS).	Influence of fatigue on concentration, attention, cognition, motivation.	Reliability: • Internal consistency: 0.87-0.98 (Shahid et al., 2010; Whitehead, 2009) Validity: • Concurrent: sickness impact profile (r = 0.51) (Whitehead, 2009; Shahid et al., 2010), extended version of FSS (Shahid et al., 2010).	• Timeframe: Present time and some items relating to past month, both state and sustained fatigue (Whitehead, 2009). • Scale items are abstract & not relating to everyday activities. • Measures multiple subscales/factors (physical, cognitive, psychosocial). • Wording assumes that the patient is suffering from fatigue (“because of my fatigue…”),

		• Discriminative: significant difference between scores of MS and hypertensive patients on all scales (Whitehead, 2009) Other strengths: • Effective for assessing the influence of fatigue on patients' lives (Dittner et al., 2004)	however, this also allows a measure of attribution (Dittner et al., 2004)
Fatigue Questionnaire (FQ; Chalder et al., 1993) (also referred to as the FRS, Chalder Fatigue Scale, and the FS)	Measures difficulty concentrating, cognitive ability, memory.	Reliability: • Internal consistency: 0.88-0.98 (Chalder et al., 1993; Gawron, 2016; Whitehead, 2009) Validity: • Scale structure has been replicated (Dittner et al., 2004). • Good clinical validity (Dittner et al., 2004) • Validated with non-fatigued employees (Gawron, 2016), Chronic fatigue syndrome patients from general population (Cella & Chalder, 2010; Gawron, 2016). • Concurrent: Revised Clinical Interview Schedule (CIS-R) fatigue question (Whitehead, 2009; Dittner et al., 2004). • Discriminative: between patients with and without fatigued assessed on the CIS (Whitehead, 2009) Other strengths: • Useful for assessing fatigue in a variety of medical disorders (Dittner et al., 2004)	• Timeframe: not stated. • Ceiling effect noted (Whitehead, 2009) • Measures multiple subscales/factors (mental and physical fatigue). • Notably, primary physical or cognitive dysfunction in the patient may confound interpretation of the responses (Dittner et al., 2004)

Fatigue Symptom Inventory (FSI; Hann et al., 1998)	Measures interference of fatigue on work, cognitive abilities, mood.	Reliability: • Internal consistency: 0.93-0.95 (Whitehead, 2009) Validity: • Convergent: correlation with POMS-fatigue scale (r = 0.51-0.86) for all groups (Whitehead, 2009). • Discriminative: differences in fatigue between active treatment, posttreatment, and healthy groups (Whitehead, 2009	• Timeframe: past week, sustained fatigue • Weak-moderate test-retest reliability (r=0.35-0.75) (Dittner et al., 2004; Gawron, 2016; Whitehead, 2009)
Fatigue Severity Scale (FSS; Krupp et al., 1989)	Impact of fatigue on specific types of functioning and behaviours (motivation, social relationships)	Reliability: • Internal consistency: 0.88-0.95 (Tyson & Brown, 2014; Whitehead, 2009), 0.81-0.89 (Shahid et al., 2010). • Test-rest: 0.84 (Whitehead, 2009). • Sensitive to change over time and after treatment (Dittner et al., 2004). Validity: • Construct (Whitehead, 2009) • Convergent: MAF (r = 0.75), VAS-F (r = 0.37), RFS (r = 0.03) (Whitehead, 2009). • Discriminative: between patients & healthy participants (Whitehead, 2009). • Concurrent: VAF (r = 0.68) (Shahid et al., 2010). Other strengths: • Widely used & recognized (Dittner et al., 2004). • High levels of scale usability and optimal clinical and research utility (Whitehead, 2009).	• No timeframe specified. • Imprecise for measuring very severe fatigue (Tyson & Brown, 2014). • Issues of item redundancy, confusing scoring structures, measurement of several constructs (Tyson & Brown, 2014). • Scale items are abstract & not relating to everyday activities

Multidimensional Assessment of Fatigue (MAF; Belza, 1993) (a revision of the Piper Fatigue Scale).	4: degree, severity, distress, impact on activities (Whitehead, 2009)	Reliability: • Internal consistency: 0.93 (Whitehead, 2009). • Test-retest: *r* = 0.47-0.73, *r* = 0.87 (Whitehead, 2009) Validity: • Construct: factor analysis did not support 4 factors (Whitehead, 2009). • Convergent: correlated with POMS fatigue (*r* = 0.78-0.84) and vigor (*r* = -0.60 to 0.62) subscales (Whitehead, 2009). Correlated with FSS (*r* = 0.74) (Whitehead, 2009). • Discriminative: detects differences in fatigue between patients and controls (Whitehead, 2009). Scale did not appear to be able to detect small changes in fatigue (Whitehead, 2009). Other strengths: • No floor or ceiling effects and final scale fits the Rasch model (Tyson & Brown, 2014).	• Timeframe: past week, sustained fatigue
Multidimensional Fatigue Inventory (MFI-20; Smets et al., 1995)	5: General fatigue, physical fatigue, reduced activity, reduced motivation, and mental fatigue (Whitehead, 2009).	Reliability: • Internal consistency: 0.53-0.93 (mean = 0.84) (Gawron, 2016; Whitehead, 2009. • Test-retest: *r* = 0.76 (total), 0.60-0.72 (subscales) (Whitehead, 2009).	• Timeframe: past few days, sustained fatigue. • Scale items are abstract & not relating to everyday activities. • Measures multiple dimensions (5 subscales/factors including General fatigue, physical fatigue, reduced activity, reduced motivation, and mental fatigue; Whitehead, 2009).

Multidimensional Fatigue Symptom Inventory (MFSI; Stein et al., 2004)	5: global, somatic, affective, cognitive, and behavioural symptoms of fatigue (Whitehead, 2009)	Reliability: • Internal consistency: rationally derived scale 0.87-0.92; empirically derived scales 0.85-0.96 (Whitehead, 2009). • Test-retest: r = 0.54-0.68 (rationally derived scales); r = 0.51-0.70 (empirically derived scales) (Whitehead, 2009). Validity: • Convergent: correlation with the POMS-F (r = 0.62-0.89); SF36 vitality scale (r = 0.45-0.80); STAI (r = 0.51-0.80) (Whitehead, 2009). • Discriminative: between cancer and noncancer patients (except mental fatigue) (Whitehead, 2009). • Factor structure: reasonable fit with originally conceptualized dimensions (but labelling is changed to General fatigue, Emotional fatigue, Physical fatigue, Mental fatigue, and Vigor) (Dittner et al., 2004). • Diagnostic validity: differences between scores of cancer patients and noncancer patients (subscales of General fatigue, Emotional fatigue, Physical fatigue, and Vigor (Dittner et al., 2004).	• Timeframe: past week, sustained fatigue. • Length of the MFSI may be problematic.
Revised Piper Fatigue Scale (PSF-R; Piper et al., 1998)	4: sensory, affective meaning, cognitive/mood,	Reliability: • Internal consistency: 0.80-0.99 (Whitehead, 2009).	

	behavioural/severity (Whitehead, 2009).	• Test-retest reliability (r = 0.98) Dittner et al., 2004 Validity: • Construct: factor analysis verified 4 factors (Whitehead, 2009). • Convergent: correlated with Fatigue Symptom Checklist (r = 0.55) and POMS-F (r = 0.42) (Whitehead, 2009); Fatigue questionnaire (r = 0.80) (Dittner et al., 2004). Other strengths: • Timeframe: measures state fatigue.	
Schedule of Fatigue & Anergia (SOFA; Hadzi-Pavlovic et al., 2000)	Used for the identification of patients with CFS in specialist clinics (Dittner et al., 2004).	Validity: • Discriminative: between patients with CFS and primary care patients (Whitehead, 2009). • Good diagnostic validity, demonstrating its utility as a screen instrument for patients with CFS and pronged fatigue syndrome (Dittner et al., 2004).	• Timeframe: Past few weeks, sustained fatigue • Reliability is unknown. • States that it is 1 subscale/factor but measures both physical and mental fatigue. • Scale items are abstract & not relating to everyday activities.
Situational Fatigue Scale (SFS; Yang & Wu, 2005).	Measures both mental and physical fatigue while considering the situational demands that occur in daily life (Yang & Wu, 2005).	Reliability: • Internal consistency: 0.90; PFS: 0.88; MFS: 0.89 (Yang & Wu, 2005). • Test-retest: reasonably consistent over a 3-4 week testing period (r = 0.65-0.67) (Yang & Wu, 2005). Validity: • Criteria-related validity: total scores on the SFS and FAI were moderately correlated (r = 0.47).	• Timeframe: past month, sustained fatigue. • Measures multiple subscales/factors (physical and mental fatigue). • One limitation is that participants may not have recent experience with the specific activities included on the scale (Yang & Wu, 2005). • The SFS may reflect an estimate level of fatigue rather than the actual level of fatigue experienced when doing daily life activities (Yang & Wu, 2005).

			• Validity of SFS for the general population needs to be fully evaluated in the future, as well as with different populations and sample sizes (Yang & Wu, 2005).
State-Trait Inventory for Cognitive Fatigue (Shuman-Paretsky et al., 2017)	Measure of cognitive fatigue (Shuman-Paretsky et al., 2017) 4 subscales/factors for both state & trait forms: cognitive fatigue, mental effort, motivation, and boredom (Shuman-Paretsky et al., 2017)	Reliability: • All components had good reliability (Shuman-Paretsky et al., 2017). Validity: • Convergent: strong positive relation between cognitive fatigue and a subjective measure of general fatigue (Shuman-Paretsky et al., 2017). • Construct (Shuman-Paretsky et al., 2017)	• Timeframe: measures both state and sustained fatigue. • Predictive validity needs to be established for functional and cognitive outcomes in older adults (Shuman-Paretsky et al., 2017). • Many relations with relevant outcome variables are weak (Shuman-Paretsky et la., 2017). • Findings need to be extended with more diverse samples (Shuman-Paretsky et al., 2017).
The Visual Analog Fatigue Scale (VAS-F; Lee et al., 1991) (also known as the Lee Fatigue Scale (LFS).	2: energy (5 items) and fatigue (13 items with 6 addressing behavioural manifestations of fatigue) (Gawron, 2016; Shen et al., 2006	Timeframe: now, state fatigue. Reliability: • Internal Consistency: 0.96 (Gawron, 2016, Whitehead, 2009) and (0.91) (Whitehead, 2009) for fatigue measured in the morning and the evening. • Internal consistency: $r = 0.96$ for both mothers and fathers over 5 data collection times (Whitehead, 2009). Validity: • Concurrent validity was established using the Stanford Sleepiness Scale and the POMS-F (Whitehead, 2009).	• Believed it would be a useful tool for longitudinal but not cross-sectional purposes (Shahid et al., 2010).

Appendix B2

Table 17

Definitions Provided to the Graduate Student Raters

Construct	Definition
Cognitive Control	Cognitive control is a set of processes that organize, plan, and schedule mental operations. Cognitive control is critical to one's ability to achieve most goals and allows us to perform purposive behaviour. We experience cognitive control as mentally effortful, and cognitive control usually drives cognitive effort, exerting more cognitive control allows us to preserve task performance and resolve conflict but would lead to a higher effort cost.
Cognition	Cognition refers to the process of coming to know and understand; of encoding, perceiving, storing, processing, and retrieving information. It is generally associated with the question of 'what.'
Emotion	The emotional interpretation of perceptions, information, or knowledge.
Motivation	The forces that drive and direct behavior.

Appendix B3

Table 18

Conceptual Clustering of the 88 EIMFS Items into Similar Piles Across Five Graduate Student Raters

Rater 0	Rater 1	Rater 2	Rater 3	Rater 4	Rater 5	Agreement %
1	1	1	1	1	1	100%
2	2	2	2	2	2	83%
3	3	3	3	3	3	50%
4	4	4	4	4	4	83%
5	5	5	5	5	5	83%
6	6	6	6	6	6	100%
7	7	7	7	7	7	83%
8	8	8	8	8	8	67%
9	9	9	9	9	9	67%
10	10	10	10	10	10	83%
11	11	11	11	11	11	83%
12	12	12	12	12	12	50%
13	13	13	13	13	13	83%
14	14	14	14	14	14	NA
15	15	15	15	15	15	67%
16	16	16	16	16	16	100%
17	17	17	17	17	17	67%
18	18	18	18	18	18	67%
19	19	19	19	19	19	83%
20	20	20	20	20	20	100%
21	21	21	21	21	21	83%
22	22	22	22	22	22	50%
23	23	23	23	23	23	100%
24	24	24	24	24	24	83%
25	25	25	25	25	25	50%
26	26	26	26	26	26	67%
27	27	27	27	27	27	100%
28	28	28	28	28	28	50%
29	29	29	29	29	29	83%
30	30	30	30	30	30	67%
31	31	31	31	31	31	83%
32	32	32	32	32	32	50%
33	33	33	33	33	33	83%
34	34	34	34	34	34	50%
35	35	35	35	35	35	67%
36	36	36	36	36	36	67%
37	37	37	37	37	37	NA
38	38	38	38	38	38	50%
39	39	39	39	39	39	33%
40	40	40	40	40	40	33%

41	41	41	41	41	41	83%
42	42	42	42	42	42	83%
43	43	43	43	43	43	33%
44	44	44	44	44	44	100%
45	45	45	45	45	45	50%
46	46	46	46	46	46	100%
47	47	47	47	47	47	67%
48	48	48	48	48	48	33%
49	49	49	49	49	49	50%
50	50	50	50	50	50	33%
51	51	51	51	51	51	50%
52	52	52	52	52	52	100%
53	53	53	53	53	53	33%
54	54	54	54	54	54	50%
55	55	55	55	55	55	100%
56	56	56	56	56	56	67%
57	57	57	57	57	57	50%
58	58	58	58	58	58	100%
59	59	59	59	59	59	83%
60	60	60	60	60	60	67%
61	61	61	61	61	61	NA
62	62	62	62	62	62	83%
63	63	63	63	63	63	67%
64	64	64	64	64	64	33%
65	65	65	65	65	65	83%
66	66	66	66	66	66	33%
67	67	67	67	67	67	67%
68	68	68	68	68	68	67%
69	69	69	69	69	69	100%
70	70	70	70	70	70	50%
71	71	71	71	71	71	33%
72	72	72	72	72	72	83%
73	73	73	73	73	73	50%
74	74	74	74	74	74	67%
75	75	75	75	75	75	83%
76	76	76	76	76	76	50%
77	77	77	77	77	77	83%
78	78	78	78	78	78	50%
79	79	79	79	79	79	50%
80	80	80	80	80	80	100%
81	81	81	81	81	81	83%
82	82	82	82	82	82	83%
83	83	83	83	83	83	50%
84	84	84	84	84	84	33%
85	85	85	85	85	85	100%
86	86	86	86	86	86	83%

87	87	87	87	87	87	33%
88	88	88	88	88	88	67%

Note. The different colours represent different grouping 'piles.' Pink = cognition, beige = cognitive control, green = affect, turquoise = motivation, blue = unsure. Items 14, 37, and 61 were attention checks and therefore not included the the grouping of 'piles'.

Appendix B4

Table 19

Demographics for Study 1 Sample

	Frequency	Percent (%)
Gender		
Female	170	46.6
Male	188	51.5
Non-binary	3	0.8
Transgender	1	0.3
Not listed	2	0.5
Prefer not to say	1	0.3
Ethnicity		
Arab	7	2.9
Black	1	.4
Chinese	30	12.3
Filipino	1	.4
Indigenous	2	.8
Korean	4	1.6
Latin American	1	.4
Mixed Ethnicity	17	7.0
South Asian	33	13.6
Southeast Asian	2	.8
White	138	56.8
Not listed	2	.8
Prefer not to answer	5	2.1
Neuropsychological Diagnosis		
No	321	87.9
Yes	43	11.8
Education Level		
Associate degree (e.g., AA, AS)	35	9.7
Bachelor's degree (e.g., BA, BS)	154	42.2
High school degree or equivalent (e.g., GED)	53	14.5
Master's degree (e.g., MA, MS, Med)	39	10.7
Some college, no degree	69	18.9
Doctorate (e.g., PhD, EdD)	2	0.5
Less than a high school diploma	8	2.2

Appendix B5

Table 20

Supplementary Information for Study 1

	Frequency	Percent
Headphone Check		
I can't remember if I used headphones	0	0
I used headphones the first time but not the second	3	0.8
I used headphones the second time but not the first	2	0.5
No, I did not use headphones	150	41.1
Yes, I used headphones	209	57.3
Effect of Mental Fatigue (past 4 weeks)		
0 – None	14	3.8
1	36	9.9
2	51	14
3	50	13.7
4	55	15.1
5	46	12.6
6	50	13.7
7	34	9.3
8	0	0
9	12	3.3
10 – A severely disabling effect	17	4.7
How Long Mental Fatigue		
Less than 1 week	77	21.1
Two weeks	48	13.2
More than 1 month	51	14
Between 2-4 months	48	13.2
More than 6 months	140	38.4

Note. Although the questionnaire included the question "how long have you experienced mental fatigue" the framing of this question was not deemed appropriate as it assumed the experience of mental fatigue, and so the data were not analysed.

Appendix B6

Table 21

Proportion of Responses for the 88 EIMFS Items

Item	Frequency	Percent
1) When I am trying to focus, I am easily distracted.		
1 – Disagree Strongly	43	11.8
2	100	27.4
3	60	16.4
4	27	7.4
5	82	22.5
6	34	9.3
7 – Agree Strongly	19	5.2
2) I feel sad because of mental fatigue.		
1 – Disagree Strongly	90	24.7
2	72	19.7
3	43	11.8
4	25	6.8
5	77	21.1
6	43	11.8
7 – Agree Strongly	15	4.1
3) I don't believe I can do well on tasks because I am too mentally fatigued.		
1 – Disagree Strongly	58	15.9
2	70	19.2
3	45	12.3
4	51	14.0
5	64	17.5
6	59	16.2
7 – Agree Strongly	18	4.0
4) I try to keep going even when I get mentally fatigued.		
1 – Disagree Strongly	8	2.2
2	6	1.6
3	14	3.8

4	24	6.6
5	73	20.0
6	142	38.9
7 – Agree Strongly	98	26.8
5) It is difficult to make daily decisions, like what to make for dinner.		
1 – Disagree Strongly	82	22.5
2	101	27.7
3	49	13.4
4	32	8.8
5	51	14.0
6	27	7.4
7 – Agree Strongly	22	6.0
6) When I try to do 'brain problems' I find it difficult to concentrate.		
1 – Disagree Strongly	53	14.5
2	83	22.7
3	56	15.3
4	46	12.6
5	71	19.5
6	31	8.5
7 – Agree Strongly	24	6.6
7) I feel no desire to use my brain.		
1 – Disagree Strongly	150	41.1
2	67	18.4
3	45	12.3
4	31	8.5
5	39	10.7
6	17	4.7
7 – Agree Strongly	15	4.1
8) I feel like my ability to learn has decreased.		
1 – Disagree Strongly	74	20.3
2	68	18.6
3	38	10.4
4	32	8.8

5	72	19.7
6	54	14.8
7 – Agree Strongly	27	7.4
9) I feel slowed down in my thinking.		
1 – Disagree Strongly	67	18.4
2	63	17.3
3	34	9.3
4	38	10.4
5	85	23.3
6	51	14.0
7 – Agree Strongly	25	6.8
10) I get mentally fatigued more quickly doing tasks when I am sad.		
1 – Disagree Strongly	39	10.7
2	34	9.3
3	26	7.1
4	42	11.5
5	87	23.8
6	82	22.5
7 – Agree Strongly	55	15.1
11) I don't have the drive to work hard.		
1 – Disagree Strongly	93	22.5
2	81	22.2
3	63	17.3
4	40	11.0
5	52	14.2
6	19	5.2
7 – Agree Strongly	14	3.8
12) I am not able to finish tasks that require thinking.		
1 – Disagree Strongly	111	30.4
2	106	29.0
3	41	11.2
4	41	11.2
5	26	7.1

6	27	7.4
7 – Agree Strongly	13	3.6
13) When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.		
1 – Disagree Strongly	58	15.9
2	56	15.3
3	42	11.5
4	50	13.7
5	75	20.5
6	44	12.1
7 – Agree Strongly	40	11.0
15) I do not have the will to do anything.		
1 – Disagree Strongly	149	40.8
2	95	26.0
3	40	11.0
4	32	8.8
5	22	6.0
6	14	3.8
7 – Agree Strongly	12	3.3
16) I have lost interest in the work that I used to do.		
1 – Disagree Strongly	105	28.81
2	79	21.6
3	48	13.2
4	31	8.5
5	41	11.2
6	36	9.9
7 – Agree Strongly	24	6.6
17) If I am struggling with a task that requires thinking, I give up easily.		
1 – Disagree Strongly	110	30.1
2	90	24.7
3	57	15.6
4	36	9.9
5	36	9.9

6	22	6.0
7 – Agree Strongly	13	3.6
18) I find it hard to pay attention for a long time.		
1 – Disagree Strongly	69	18.9
2	69	18.9
3	49	13.4
4	35	9.6
5	77	21.1
6	40	11.0
7 – Agree Strongly	24	6.6
19) I find it more difficult than usual to find the correct word.		
1 – Disagree Strongly	81	22.2
2	82	22.5
3	42	11.5
4	42	11.5
5	64	17.5
6	31	8.5
7 – Agree Strongly	22	6.0
20) I am not able to do the things that I used to do because I am mentally fatigued.		
1 – Disagree Strongly	76	20.8
2	86	23.6
3	45	12.3
4	49	13.4
5	61	16.7
6	32	8.8
7 – Agree Strongly	16	4.4
21) I can be bribed into doing things I don’t have the motivation to do.		
1 – Disagree Strongly	56	15.3
2	55	15.1
3	38	10.4
4	44	12.1
5	77	21.1
6	64	17.5

7 – Agree Strongly	31	8.5
22) I am convinced that I don't have the mental energy to carry out the rest of the day.		
1 – Disagree Strongly	107	29.3
2	102	27.9
3	51	14.0
4	24	6.6
5	45	12.3
6	24	6.6
7 – Agree Strongly	12	3.3
23) I am not motivated to do tasks that require thinking.		
1 – Disagree Strongly	89	24.4
2	85	23.3
3	52	14.2
4	37	10.1
5	60	16.4
6	21	5.8
7 – Agree Strongly	21	5.8
24) I make slips of the tongue when speaking.		
1 – Disagree Strongly	68	18.6
2	68	18.6
3	47	12.9
4	35	9.6
5	88	24.1
6	40	11.0
7 – Agree Strongly	16	4.4
25) When I am stressed while during work, I get mentally fatigued quickly.		
1 – Disagree Strongly	36	9.9
2	35	9.6
3	41	11.2
4	51	14.0
5	73	20.0
6	85	23.3
7 – Agree Strongly	44	12.1

26) Every task takes longer to complete than it usually would.		
1 – Disagree Strongly	61	16.7
2	72	19.7
3	67	18.4
4	34	9.3
5	77	21.1
6	39	10.7
7 – Agree Strongly	14	3.8
27) When doing a task, I get distracted more than I used to.		
1 – Disagree Strongly	64	17.5
2	75	20.5
3	41	11.2
4	47	12.9
5	77	21.1
6	33	9.0
7 – Agree Strongly	27	7.4
28) I feel like I can't be productive.		
1 – Disagree Strongly	93	25.5
2	74	20.3
3	53	14.5
4	32	8.8
5	59	16.2
6	31	8.5
7 – Agree Strongly	23	6.3
29) When doing activities, I get less mentally fatigued when I am in a good mood.		
1 – Disagree Strongly	13	3.6
2	18	4.9
3	28	7.7
4	40	11.0
5	83	22.7
6	112	30.7
7 – Agree Strongly	71	19.5
30) When I am doing tasks that require thinking, I can concentrate quite well.		

1 – Disagree Strongly	17	4.7
2	24	6.6
3	46	12.7
4	58	15.9
5	94	25.8
6	86	23.6
7 – Agree Strongly	39	10.7
31) I have problems thinking clearly.		
1 – Disagree Strongly	85	23.3
2	78	21.4
3	57	15.6
4	50	13.7
5	47	12.9
6	31	8.5
7 – Agree Strongly	16	4.4
32) I need to take long breaks between tasks to gain back my mental energy		
1 – Disagree Strongly	56	15.3
2	80	21.9
3	57	15.6
4	37	10.1
5	77	21.21
6	37	10.1
7 – Agree Strongly	20	5.5
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.		
1 – Disagree Strongly	82	22.5
2	70	19.2
3	56	15.3
4	36	9.9
5	54	14.8
6	51	14.0
7 – Agree Strongly	16	4.4
34) When I am stuck on a problem, I try harder.		
1 – Disagree Strongly	15	4.1

2	16	4.4
3	39	10.7
4	58	15.9
5	97	26.6
6	88	24.1
7 – Agree Strongly	51	14.0
35) It takes more effort to do typical activities where I need to think.		
1 – Disagree Strongly	58	15.9
2	55	15.1
3	40	11.0
4	47	12.9
5	107	29.3
6	35	9.6
7 – Agree Strongly	21	5.8
36) It is hard for me to keep track of conversations in social settings.		
1 – Disagree Strongly	91	24.9
2	81	22.2
3	47	12.9
4	37	10.1
5	50	13.7
6	38	10.4
7 – Agree Strongly	17	4.7
38) I believe that my will is strong enough to complete most tasks.		
1 – Disagree Strongly	16	4.4
2	8	2.2
3	19	5.2
4	57	15.6
5	90	24.7
6	109	29.9
7 – Agree Strongly	66	18.1
39) I can accomplish tasks that require thinking if I put my mind to them.		
1 – Disagree Strongly	6	1.6
2	5	1.4

3	26	7.1
4	39	10.7
5	77	21.1
6	126	34.5
7 – Agree Strongly	86	23.6
40) I do not feel engaged in my work.		
1 – Disagree Strongly	78	21.4
2	80	21.9
3	49	13.4
4	50	13.7
5	53	14.5
6	33	9.0
7 – Agree Strongly	22	6.0
41) If I were watching TV right now it would be hard to focus because my thoughts tend to drift.		
1 – Disagree Strongly	66	18.1
2	67	18.4
3	50	13.7
4	22	6.0
5	75	20.5
6	49	13.4
7 – Agree Strongly	34	9.3
42) I am more forgetful than usual.		
1 – Disagree Strongly	76	20.8
2	70	19.2
3	42	11.5
4	36	9.9
5	87	23.8
6	29	7.9
7 – Agree Strongly	25	6.8
43) I get stuck more often than most people when working through problems that require a lot of thought.		
1 – Disagree Strongly	72	19.7
2	66	18.1

3	43	11.8
4	51	14.0
5	78	21.4
6	39	10.7
7 – Agree Strongly	15	4.1
44) I feel helpless because of mental fatigue.		
1 – Disagree Strongly	101	27.7
2	79	21.6
3	47	12.9
4	40	11.0
5	48	13.2
6	30	8.2
7 – Agree Strongly	18	4.9
45) I feel like I have a small amount of mental energy that I need to budget across tasks.		
1 – Disagree Strongly	63	17.3
2	57	15.6
3	52	14.2
4	45	12.3
5	54	14.8
6	57	15.6
7 – Agree Strongly	37	10.1
46) My motivation is lower than usual.		
1 – Disagree Strongly	67	18.4
2	67	18.4
3	44	12.1
4	44	12.1
5	61	16.7
6	48	13.2
7 – Agree Strongly	32	8.8
47) I feel I am always one step behind.		
1 – Disagree Strongly	84	23.0
2	65	17.8
3	48	13.2

4	34	9.3
5	71	19.5
6	28	7.7
7 – Agree Strongly	33	9.0
48) It is hard for me to keep up my effort.		
1 – Disagree Strongly	74	20.3
2	68	18.6
3	38	10.4
4	53	14.5
5	73	20.0
6	34	9.3
7 – Agree Strongly	23	6.3
49) I have trouble doing even basic things like getting dressed.		
1 – Disagree Strongly	202	55.3
2	65	17.8
3	24	6.6
4	15	4.1
5	28	7.7
6	19	5.2
7 – Agree Strongly	12	3.3
50) The thought of doing basic self-care like brushing my teeth or taking a shower is too much.		
1 – Disagree Strongly	170	46.6
2	67	18.4
3	40	11.0
4	26	7.1
5	34	9.3
6	19	5.2
7 – Agree Strongly	9	2.5
51) I feel like I can’t be bothered to do activities that I used to enjoy.		
1 – Disagree Strongly	106	29.0
2	73	20.0
3	37	10.1
4	31	8.5

5	59	16.2
6	29	7.9
7 – Agree Strongly	29	7.9
52) I feel lonely because of mental fatigue.		
1 – Disagree Strongly	126	34.5
2	71	19.5
3	33	9.0
4	31	8.5
5	45	12.3
6	28	7.7
7 – Agree Strongly	29	7.9
53) I find I am less able than usual to start tasks that require thinking.		
1 – Disagree Strongly	90	24.7
2	76	20.8
3	42	11.5
4	40	11.0
5	62	17.0
6	33	9.0
7 – Agree Strongly	20	5.5
54) I feel like I need to leave tasks unfinished to complete tomorrow.		
1 – Disagree Strongly	83	22.7
2	74	20.3
3	53	14.5
4	36	9.9
5	68	18.6
6	35	9.6
7 – Agree Strongly	16	4.4
55) I feel useless because I don't have the mental energy to do things.		
1 – Disagree Strongly	109	29.9
2	73	20.0
3	37	10.1
4	29	7.9
5	58	15.9

6	32	8.8
7 – Agree Strongly	27	7.4
56) I find it hard to think straight.		
1 – Disagree Strongly	96	26.3
2	77	21.1
3	44	12.1
4	43	11.8
5	42	11.5
6	38	10.4
7 – Agree Strongly	24	6.6
57) I feel like I can't organize my thoughts enough to properly complete tasks.		
1 – Disagree Strongly	108	29.6
2	79	21.6
3	35	9.6
4	35	9.6
5	61	16.7
6	30	8.2
7 – Agree Strongly	17	4.7
58) I get frustrated that I can't do things because I'm mentally fatigued.		
1 – Disagree Strongly	82	22.5
2	73	20.0
3	35	9.6
4	28	7.7
5	61	16.7
6	56	15.3
7 – Agree Strongly	30	8.2
59) I am less confident because of mental fatigue.		
1 – Disagree Strongly	91	24.9
2	76	20.8
3	21	5.8
4	25	6.8
5	61	16.7
6	55	15.1

7 – Agree Strongly	35	9.6
60) It is hard for me to answer emails efficiently.		
1 – Disagree Strongly	128	35.1
2	81	22.2
3	33	9.0
4	28	7.7
5	45	12.3
6	31	8.5
7 – Agree Strongly	19	5.2
62) I can't make myself do the work that I know I should.		
1 – Disagree Strongly	96	26.3
2	70	19.2
3	41	11.2
4	30	8.2
5	76	20.8
6	36	9.9
7 – Agree Strongly	15	4.1
63) I find it hard to follow conversations.		
1 – Disagree Strongly	100	27.4
2	88	24.1
3	41	11.2
4	30	8.2
5	63	17.3
6	29	7.9
7 – Agree Strongly	14	3.8
64) I find that I procrastinate more than I used to.		
1 – Disagree Strongly	64	17.5
2	51	14.0
3	47	12.9
4	40	11.0
5	68	18.6
6	52	14.2
7 – Agree Strongly	43	11.8

65) I have lost the feeling of wanting to try at anything.

1 – Disagree Strongly	105	28.8
2	81	22.2
3	45	12.3
4	33	9.0
5	52	14.2
6	29	7.9
7 – Agree Strongly	19	5.2

66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.

1 – Disagree Strongly	101	27.7
2	71	19.5
3	42	11.5
4	41	11.2
5	56	15.3
6	29	7.9
7 – Agree Strongly	24	6.6

67) It takes me a long time to decide to do something.

1 – Disagree Strongly	76	20.8
2	60	16.4
3	53	14.5
4	39	10.7
5	65	17.8
6	44	12.1
7 – Agree Strongly	28	7.7

68) When I sit down to do work, I feel like my thoughts are all over the place.

1 – Disagree Strongly	69	18.9
2	73	20.0
3	33	9.0
4	51	14.0
5	69	18.9
6	38	10.4
7 – Agree Strongly	31	8.5

69) I feel guilty because I cannot do most things that I am supposed to do.

1 – Disagree Strongly	98	26.8
2	71	19.5
3	43	11.8
4	33	9.0
5	55	15.1
6	36	9.9
7 – Agree Strongly	29	7.9
70) It is easy for me to become mentally overwhelmed.		
1 – Disagree Strongly	60	16.4
2	53	14.5
3	54	14.8
4	36	9.9
5	68	18.6
6	44	12.1
7 – Agree Strongly	49	13.4
71) I don't have the mental energy to socialize with others.		
1 – Disagree Strongly	75	20.5
2	52	14.2
3	44	12.1
4	32	8.8
5	54	14.8
6	51	14.0
7 – Agree Strongly	57	15.6
72) It is hard for me to see the point in doing chores like the dishes.		
1 – Disagree Strongly	138	37.8
2	72	19.7
3	42	11.5
4	25	6.8
5	42	11.5
6	24	6.6
7 – Agree Strongly	19	5.2
73) It takes me longer than it used to get engaged in my work.		
1 – Disagree Strongly	81	22.2

2	68	18.6
3	30	8.2
4	43	11.8
5	68	18.6
6	49	13.4
7 – Agree Strongly	25	6.8
74) When I am concentrating, I get exhausted sooner than I used to.		
1 – Disagree Strongly	73	20.0
2	80	21.9
3	24	6.6
4	28	7.7
5	74	20.3
6	58	15.9
7 – Agree Strongly	28	7.7
75) I am making many mistakes.		
1 – Disagree Strongly	88	24.1
2	95	26.0
3	55	15.1
4	46	12.6
5	37	10.1
6	29	7.9
7 – Agree Strongly	15	4.1
76) It is hard to make plans because I can’t predict when I will be mentally fatigued.		
1 – Disagree Strongly	101	27.7
2	82	22.5
3	28	7.7
4	48	13.2
5	41	11.2
6	37	10.1
7 – Agree Strongly	26	7.1
77) It is hard to remember relevant information that I need to do my work.		
1 – Disagree Strongly	94	25.8
2	95	26.0

3	48	13.2
4	27	7.4
5	53	14.5
6	31	8.5
7 – Agree Strongly	17	4.7
78) Tasks that I could usually do without thinking now require more effort.		
1 – Disagree Strongly	82	22.5
2	66	18.1
3	44	12.1
4	32	8.8
5	76	20.8
6	42	11.5
7 – Agree Strongly	22	6.0
79) I can't keep going even if I really want to because of my fatigue.		
1 – Disagree Strongly	108	29.6
2	78	21.4
3	48	13.2
4	36	9.9
5	52	14.2
6	27	7.4
7 – Agree Strongly	16	4.4
80) I feel anxious because of mental fatigue.		
1 – Disagree Strongly	98	26.8
2	63	17.3
3	44	12.1
4	20	5.5
5	65	17.8
6	38	10.4
7 – Agree Strongly	36	9.9
81) I can't follow movies with complex plots because it is hard for me to keep track of what is going on.		
1 – Disagree Strongly	129	35.3
2	95	26.0

3	28	7.7
4	32	8.8
5	36	9.9
6	25	6.8
7 – Agree Strongly	19	5.2
82) I need to divide jobs up so that I don't do too much in one day.		
1 – Disagree Strongly	76	20.8
2	76	20.8
3	34	9.3
4	38	10.4
5	65	17.8
6	46	12.6
7 – Agree Strongly	30	8.2
83) I feel like my brain is not functioning the way it should.		
1 – Disagree Strongly	101	27.7
2	58	15.9
3	27	7.4
4	35	9.6
5	66	18.1
6	42	11.5
7 – Agree Strongly	36	9.9
84) The idea of writing a text message to someone on my phone is too exhausting.		
1 – Disagree Strongly	158	43.3
2	73	20.0
3	38	10.4
4	21	5.8
5	36	9.9
6	21	5.8
7 – Agree Strongly	17	4.7
85) It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.		
1 – Disagree Strongly	105	28.8
2	74	20.3
3	37	10.1

4	34	9.3
5	54	14.8
6	28	7.7
7 – Agree Strongly	32	8.8
86) I have trouble remembering names or passwords for my accounts.		
1 – Disagree Strongly	94	25.8
2	75	20.5
3	40	11.0
4	32	8.8
5	62	17.0
6	32	8.8
7 – Agree Strongly	28	7.7
87) My brain feels numb.		
1 – Disagree Strongly	123	33.7
2	60	16.4
3	39	10.7
4	42	11.5
5	48	13.2
6	28	7.7
7 – Agree Strongly	25	6.8
88) When I try to read, I must read the same line over and over because I can't process the words.		
1 – Disagree Strongly	86	23.6
2	68	18.6
3	56	15.3
4	35	9.6
5	63	17.3
6	31	8.5
7 – Agree Strongly	26	7.1

Appendix B7

Table 22

Descriptive Statistics for the 88 EIMFS Items for Study 1

Item	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
1) When I am trying to focus, I am easily distracted.	365	3.5	1.8	3.15	.30	.13	-1.11	.26
2) I feel sad because of mental fatigue.	365	3.3	1.9	3.72	.26	.13	-1.33	.26
3) I don't believe I can do well on tasks because I am too mentally fatigued.	365	3.7	1.9	3.48	.06	.13	-1.26	.26
4) I try to keep going even when I get mentally fatigued.	365	5.6	1.3	1.77	-1.45	.13	2.34	.26
5) It is difficult to make daily decisions, like what to make for dinner.	364	3.1	1.9	3.46	.61	.13	-.83	.26
6) When I try to do 'brain problems' I find it difficult to concentrate.	364	3.5	1.8	3.28	.27	.13	-1.04	.26
7) I feel no desire to use my brain.	364	2.6	1.8	3.27	.92	.13	-.32	.26
8) I feel like my ability to learn has decreased.	365	3.6	2.0	4.00	.10	.13	-1.38	.26
9) I feel slowed down in my thinking.	363	3.7	2.0	3.80	-.02	.13	-1.33	.26
10) I get mentally fatigued more quickly doing tasks when I am sad.	365	4.6	2.0	3.59	-.56	.13	-.82	.26
11) I don't have the drive to work hard.	362	3.0	1.7	3.04	.60	.13	-.68	.26
12) I am not able to finish tasks that require thinking.	365	2.7	1.8	3.07	.90	.13	-.27	.26
13) When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.	365	3.9	2.0	3.83	-.01	.13	-1.21	.26
14) Please select number 5 on the rating scale.	365	5.0	.2	.03	-11.95	.13	145.78	.26
15) I do not have the will to do anything.	364	2.4	1.6	2.72	1.24	.13	.65	.26
16) I have lost interest in the work that I used to do.	364	3.1	2.0	3.86	.59	.13	-.96	.26

17) If I am struggling with a task that requires thinking, I give up easily.	364	2.8	1.7	3.02	.81	.13	-.37	.26
18) I find it hard to pay attention for a long time.	363	3.6	1.9	3.66	.17	.13	-1.24	.26
19) I find it more difficult than usual to find the correct word.	364	3.3	1.9	3.59	.37	.13	-1.11	.26
20) I am not able to do the things that I used to do because I am mentally fatigued.	365	3.3	1.8	3.31	.37	.13	-1.05	.26
21) I can be bribed into doing things I don't have the motivation to do.	365	4.0	1.9	3.77	-.14	.13	-1.26	.26
22) I am convinced that I don't have the mental energy to carry out the rest of the day.	365	2.8	1.8	3.09	.82	.13	-.48	.26
23) I am not motivated to do tasks that require thinking.	365	3.1	1.8	3.40	.53	.13	-.87	.26
24) I make slips of the tongue when speaking.	362	3.5	1.9	3.44	.09	.13	-1.27	.26
25) When I am stressed while during work, I get mentally fatigued quickly.	365	4.4	1.9	3.43	-.43	.13	-.93	.26
26) Every task takes longer to complete than it usually would.	364	3.5	1.8	3.19	.20	.13	-1.14	.26
27) When doing a task, I get distracted more than I used to.	364	3.6	1.9	3.58	.18	.13	-1.17	.26
28) I feel like I can't be productive.	365	3.2	1.9	3.70	.45	.13	-1.06	.26
29) When doing activities, I get less mentally fatigued when I am in a good mood.	365	5.1	1.6	2.50	-.90	.13	.17	.26
30) When I am doing tasks that require thinking, I can concentrate quite well.	364	4.7	1.6	2.56	-.53	.13	-.44	.26
31)I have problems thinking clearly.	364	3.1	1.8	3.26	.48	.13	-.89	.26
32) I need to take long breaks between tasks to gain back my mental energy.	364	3.5	1.8	3.31	.22	.13	-1.14	.26
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	365	3.3	1.9	3.63	.30	.13	-1.22	.26
34) When I am stuck on a problem, I try harder.	364	4.9	1.6	2.43	-.64	.13	-.14	.26
35) It takes more effort to do typical activities where I need to think.	363	3.8	1.8	3.31	-.12	.13	-1.14	.26
36) It is hard for me to keep track of conversations in social settings.	361	3.2	1.9	3.58	.47	.13	-1.06	.26

37) Please select number 1 on the rating scale.	365	2.0	2.0	.04	13.07	.13	180.15	.26
38) I believe that my will is strong enough to complete most tasks.	365	5.2	1.5	2.27	-.98	.13	.74	.26
39) I can accomplish tasks that require thinking if I put my mind to them.	365	5.5	1.4	1.86	-1.01	.13	.79	.26
40) I do not feel engaged in my work.	365	5.5	1.9	3.50	.40	.13	.79	.26
41) If I were watching TV right now it would be hard to focus because my thoughts tend to drift.	363	3.7	2.0	4.03	.11	.13	-1.35	.26
42) I am more forgetful than usual.	365	3.5	1.9	3.67	.19	.13	-1.22	.26
43) I get stuck more often than most people when working through problems that require a lot of thought.	364	3.5	1.8	3.37	.11	.13	-1.22	.26
44) I feel helpless because of mental fatigue.	363	3.0	1.9	3.51	.56	.13	-.92	.26
45) I feel like I have a small amount of mental energy that I need to budget across tasks.	365	3.8	2.0	3.97	.07	.13	-1.29	.26
46) My motivation is lower than usual.	363	3.7	2.0	3.90	.15	.13	-1.27	.26
47) I feel I am always one step behind.	363	3.4	2.0	3.95	.29	.13	-1.19	.26
48) It is hard for me to keep up my effort.	363	3.5	1.9	3.58	.18	.13	-1.18	.26
49) I have trouble doing even basic things like getting dressed.	365	2.2	1.7	3.10	1.40	.13	.66	.26
50) The thought of doing basic self-care like brushing my teeth or taking a shower is too much.	365	3.3	1.7	3.00	1.07	.13	-.03	.26
51) I feel like I can’t be bothered to do activities that I used to enjoy.	364	3.2	2.0	4.10	4.74	.13	-1.13	.26
52) I feel lonely because of mental fatigue.	363	3.0	2.0	4.15	.64	.13	-.97	.26
53) I find I am less able than usual to start tasks that require thinking.	363	3.2	2.0	3.65	.38	.13	-1.13	.26
54) I feel like I need to leave tasks unfinished to complete tomorrow.	365	3.3	1.9	3.50	.33	.13	-1.14	.26
55) I feel useless because I don't have the mental energy to do things.	365	3.2	2.0	4.07	.48	.13	-1.14	.26
56) I find it hard to think straight.	364	3.2	2.0	3.82	.49	.13	-1.05	.26
57) I feel like I can't organize my thoughts enough to properly complete tasks.	365	3.1	2.0	3.66	.50	.13	-1.08	.26

58) I get frustrated that I can't do things because I'm mentally fatigued.	363	3.5	2.1	4.25	.19	.13	-1.10	.26
59) I am less confident because of mental fatigue.	365	3.5	2.1	4.6	.21	.13	-1.41	.26
60) It is hard for me to answer emails efficiently.	365	2.9	1.9	3.78	.71	.13	-.85	.26
61) Please select number 7 on the rating scale.	365	7.0	.28	.08	.71	.13	150.40	.26
62) I can't make myself do the work that I know I should.	364	3.2	2.0	3.67	.30	.13	-.127	.26
63) I find it hard to follow conversations.	363	3.0	1.9	3.45	.52	.13	-1.03	.26
64) I find that I procrastinate more than I used to.	364	4.0	2.0	4.08	-.02	.13	-1.30	.26
65) I have lost the feeling of wanting to try at anything.	364	3.0	2.0	3.60	.58	.13	-.93	.26
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.	364	3.2	2.0	3.80	.46	.13	-1.07	.26
67) It takes me a long time to decide to do something.	365	3.6	2.0	3.83	.19	.13	-1.07	.26
68) When I sit down to do work, I feel like my thoughts are all over the place.	364	3.6	2.0	3.81	.17	.13	-1.24	.26
69) I feel guilty because I cannot do most things that I am supposed to do.	365	3.9	2.0	4.10	.41	.13	-1.18	.26
70) It is easy for me to become mentally overwhelmed.	364	3.9	2.0	4.10	.03	.13	-1.28	.26
71) I don't have the mental energy to socialize with others.	365	3.9	2.2	4.6	.04	.13	-1.43	.26
72) It is hard for me to see the point in doing chores like the dishes.	362	2.7	1.9	3.64	.82	.13	-.614	.26
73) It takes me longer than it used to get engaged in my work.	364	3.5	2.0	4.00	.14	.13	-1.35	.26
74) When I am concentrating, I get exhausted sooner than I used to.	365	3.6	2.0	4.16	.09	.13	-1.45	.26
75) I am making many mistakes.	365	3.0	1.8	3.14	.66	.13	-.65	.26
76) It is hard to make plans because I can’t predict when I will be mentally fatigued.	363	3.2	1.9	4.0	.50	.13	-1.09	.26
77) It is hard to remember relevant information that I need to do my work.	365	3.0	1.9	3.46	.61	.13	-.89	.26

78) Tasks that I could usually do without thinking now require more effort.	364	3.5	2.0	3.81	.19	.13	-1.30	.26
79) I can't keep going even if I really want to because of my fatigue.	365	3.0	2.0	3.44	.59	.13	-.88	.26
80) I feel anxious because of mental fatigue.	364	3.4	2.1	4.39	.32	.13	-1.33	.26
81) I can't follow movies with complex plots because it is hard for me to keep track of what is going on.	364	2.7	1.9	3.55	.88	.13	-.50	.26
82) I need to divide jobs up so that I don't do too much in one day.	365	3.5	2.0	4.0	.20	.13	-1.32	.26
83) I feel like my brain is not functioning the way it should.	365	3.5	2.0	4.5	.21	.13	-1.40	.26
84) The idea of writing a text message to someone on my phone is too exhausting.	364	2.5	1.9	3.5	1.02	.13	-.22	.26
85) It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.	364	3.2	2.0	4.1	.49	.13	-1.10	.26
86) I have trouble remembering names or passwords for my accounts.	363	3.3	2.0	3.98	.40	.13	-1.17	.26
87) My brain feels numb.	365	3.0	2.0	4.00	.55	.13	-1.02	.26
88) When I try to read, I must read the same line over and over because I can't process the words.	365	3.3	2.0	3.73	.37	.13	-1.10	.26

Note. Items 14, 37, and 61 were attention checks, explaining their low variance. These items were not included in the CFA. Possible range of mean scores are from 1 to 7.

Appendix B8

Table 23

Factor Loadings for Four-Factor CFA Model Study 1

Factor	Item	Estimate	SE	Z	P	Stand. Estimate
Factor – Cognitive Control	1) When I am trying to focus, I am easily distracted.	1.17	0.08	14.14	< .001	**0.65**
	3) I don't believe I can do well on tasks because I am too mentally fatigued.	1.37	0.08	16.41	< .001	**0.74**
	4) I try to keep going even when I get mentally fatigued.	-0.01	0.07	-0.08	0.938	-0.004
	5) It is difficult to make daily decisions, like what to make for dinner.	1.18	0.09	13.58	< .001	**0.64**
	6) When I try to do 'brain problems' I find it difficult to concentrate.	1.37	0.08	17.15	< .001	**0.76**
	11) I don't have the drive to work hard.	1.22	0.08	15.37	< .001	**0.70**
	13) When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.	0.91	0.10	9.35	< .001	**0.46**
	15) I do not have the will to do anything.	1.21	0.07	16.26	< .001	**0.73**
	17) If I am struggling with a task that requires thinking, I give up easily.	1.31	0.08	16.93	< .001	**0.75**
	22) I am convinced that I don’t have the mental energy to carry out the rest of the day.	1.35	0.08	17.53	< .001	**0.77**
	26) Every task takes longer to complete than it usually would.	1.45	0.08	18.91	< .001	**0.813**
	27) When doing a task, I get distracted more than I used to.	1.55	0.08	19.07	< .001	**0.82**
	28) I feel like I can't be productive.	1.57	0.08	19.16	< .001	**0.82**
	33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	1.38	0.09	16.16	< .001	0.73
	34) When I am stuck on a problem, I try harder.	-0.53	0.08	-6.66	< .001	-0.34

	38) I believe that my will is strong enough to complete most tasks.	-0.71	0.07	-9.56	< .001	-0.47
	41) If I were watching TV right now it would be hard to focus because my thoughts tend to drift.	1.19	0.10	12.43	< .001	**0.59**
	48) It is hard for me to keep up my effort.	1.66	0.08	21.40	< .001	**0.88**
	49) I have trouble doing even basic things like getting dressed.	1.20	0.08	14.83	< .001	**0.68**
	50) The thought of doing basic self-care like brushing my teeth or taking a shower is too much.	1.20	0.08	15.11	< .001	**0.69**
	54) I feel like I need to leave tasks unfinished to complete tomorrow.	1.46	0.08	18.06	< .001	**0.79**
	57) I feel like I can't organize my thoughts enough to properly complete tasks.	1.69	0.08	21.72	< .001	**0.89**
	62) I can't make myself do the work that I know I should.	1.60	0.08	19.77	< .001	**0.84**
	66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.	1.59	0.08	19.05	< .001	**0.82**
	67) It takes me a long time to decide to do something.	1.61	0.08	19.29	< .001	**0.82**
	72) It is hard for me to see the point in doing chores like the dishes.	1.41	0.09	16.49	< .001	**0.74**
	74) When I am concentrating, I get exhausted sooner than I used to.	1.74	0.09	20.40	< .001	**0.85**
	76) It is hard to make plans because I can’t predict when I will be mentally fatigued.	1.64	0.09	19.26	< .001	**0.82**
	79) I can't keep going even if I really want to because of my fatigue.	1.57	0.08	20.10	< .001	**0.85**
	82) I need to divide jobs up so that I don't do too much in one day.	1.48	0.09	16.56	< .001	**0.74**
	88) When I try to read, I must read the same line over and over because I can't process the words.	1.47	0.09	17.16	< .001	**0.76**
Factor 2 – Cognition	8) I feel like my ability to learn has decreased.	1.44	0.09	15.95	< .001	**0.72**
	9) I feel slowed down in my thinking.	1.52	0.09	17.87	< .001	**0.78**

12) I am not able to finish tasks that require thinking.	1.08	0.08	13.10	< .001	**0.62**
18) I find it hard to pay attention for a long time.	1.57	0.08	19.24	< .001	**0.82**
19) I find it more difficult than usual to find the correct word.	1.42	0.08	16.93	< .001	**0.75**
24) I make slips of the tongue when speaking.	1.23	0.09	14.13	< .001	**0.66**
30) When I am doing tasks that require thinking, I can concentrate quite well.	-0.78	0.08	-9.80	< .001	-0.49
31)I have problems thinking clearly.	1.51	0.08	19.73	< .001	**0.84**
32) I need to take long breaks between tasks to gain back my mental energy.	1.28	0.08	15.37	< .001	**0.70**
35) It takes more effort to do typical activities where I need to think	1.37	0.08	16.93	< .001	**0.75**
39) I can accomplish tasks that require thinking if I put my mind to them.	-0.64	0.07	-9.51	< .001	-0.47
40) I do not feel engaged in my work.	1.48	0.08	18.16	< .001	**0.79**
42) I am more forgetful than usual.	1.52	0.08	18.24	< .001	**0.79**
45) I feel like I have a small amount of mental energy that I need to budget across tasks.	1.55	0.09	17.70	< .001	**0.78**
47) I feel I am always one step behind.	1.69	0.08	20.42	< .001	**0.85**
51) I feel like I can’t be bothered to do activities that I used to enjoy.	1.59	0.09	18.10	< .001	**0.79**
53) I find I am less able than usual to start tasks that require thinking.	1.71	0.08	22.10	< .001	**0.90**
56) I find it hard to think straight.	1.75	0.08	22.11	< .001	**0.90**
60) It is hard for me to answer emails efficiently.	1.50	0.09	17.61	< .001	**0.77**
63) I find it hard to follow conversations.	1.50	0.08	18.88	< .001	**0.81**
64) I find that I procrastinate more than I used to.	1.53	0.09	17.07	< .001	**0.76**
68) When I sit down to do work, I feel like my thoughts are all over the place.	1.65	0.08	20.12	< .001	**0.85**
73) It takes me longer than it used to get engaged in my work.	1.73	0.08	20.97	< .001	**0.87**
75) I am making many mistakes.	1.38	0.08	17.81	< .001	**0.78**

	77) It is hard to remember relevant information that I need to do my work.	1.60	0.08	20.66	< .001	**0.86**
	78) Tasks that I could usually do without thinking now require more effort.	1.64	0.08	19.99	< .001	**0.84**
	81) I can't follow movies with complex plots because it is hard for me to keep track of what is going on.	1.35	0.09	15.89	< .001	**0.72**
	83) I feel like my brain is not functioning the way it should.	1.85	0.09	21.25	< .001	**0.88**
	84) The idea of writing a text message to someone on my phone is too exhausting.	1.36	0.08	16.28	< .001	**0.73**
	86) I have trouble remembering names or passwords for my accounts.	1.24	0.09	13.13	< .001	**0.62**
	87) My brain feels numb.	1.62	0.09	18.97	< .001	**0.81**
Factor 3 – Emotion	2) I feel sad because of mental fatigue.	1.4	0.09	16.58	< .001	**0.74**
	10) I get mentally fatigued more quickly doing tasks when I am sad.	1.11	0.09	12.21	< .001	**0.59**
	20) I am not able to do the things that I used to do because I am mentally fatigued.	1.55	0.08	20.26	< .001	**0.85**
	21) I can be bribed into doing things I don’t have the motivation to do.	0.62	0.10	6.25	< .001	0.32
	25) When I am stressed while during work, I get mentally fatigued quickly.	1.26	0.09	14.73	< .001	**0.68**
	29) When doing activities, I get less mentally fatigued when I am in a good mood.	0.08	0.08	1.00	0.317	0.05
	44) I feel helpless because of mental fatigue.	1.58	0.08	20.05	< .001	**0.85**
	52) I feel lonely because of mental fatigue.	1.59	0.09	17.79	< .001	**0.78**
	55) I feel useless because I don't have the mental energy to do things.	1.80	0.08	21.98	< .001	**0.89**
	58) I get frustrated that I can't do things because I'm mentally fatigued.	1.84	0.08	21.88	< .001	**0.89**
	59) I am less confident because of mental fatigue.	1.91	0.09	21.94	< .001	**0.89**

	69) I feel guilty because I cannot do most things that I am supposed to do.	1.77	0.08	21.30	< .001	**0.88**
	80) I feel anxious because of mental fatigue.	1.71	0.09	19.01	< .001	**0.82**
	85) It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.	1.66	0.09	19.06	< .001	**0.82**
Factor 4 – Motivation	7) I feel no desire to use my brain.	1.17	0.09	13.57	< .001	**0.65**
	16) I have lost interest in the work that I used to do.	1.50	0.09	17.08	< .001	**0.77**
	23) I am not motivated to do tasks that require thinking.	1.42	0.08	17.26	< .001	**0.77**
	46) My motivation is lower than usual.	1.67	0.08	19.77	< .001	**0.85**
	65) I have lost the feeling of wanting to try at anything.	1.63	0.08	20.39	< .001	**0.86**

Note. 'Maximum likelihood' estimation method was used. Factor loadings (i.e., stand. Estimates) greater than 0.40 are bolded.

Appendix B9

Table 24

Factor Covariances Final Four-Factor CFA Model for Study 1

		Estimate	SE	Z	p	Stand. Estimate
Factor 1 – Cognitive Control	Factor 1	1.00				
	Factor 2	0.99	0.002	470.0	<.001	0.99
	Factor 3	0.97	0.004	204.1	<.001	0.97
	Factor 4	0.96	0.008	110.1	<.001	0.96
Factor 2 – Cognition	Factor 2	1.00				
	Factor 3	0.97	0.004	224.2	<.001	0.97
	Factor 4	0.95	0.009	101.4	<.001	0.95
Factor 3 – Emotion	Factor 3	1.00				
	Factor 4	0.94	0.011	88.5	<.001	0.94
Factor 4 – Motivation	Factor 4	1.00				

Appendix B10

Table 25

Study 1 Four-Factor EFA Model Item Loadings

Item	Factor				
	1	2	3	4	Uniqueness
1) When I am trying to focus, I am easily distracted.	**.70**				.51
2) I feel sad because of mental fatigue.	**.73**				.46
3) I don't believe I can do well on tasks because I am too mentally fatigued.	**.74**				.38
4) I try to keep going even when I get mentally fatigued.	.34	**-.45**			.87
5) It is difficult to make daily decisions, like what to make for dinner.	**.50**				.52
6) When I try to do 'brain problems' I find it difficult to concentrate.	**.76**				.31
7) I feel no desire to use my brain.		**.59**			.43
8) I feel like my ability to learn has decreased.	**.58**				.45
9) I feel slowed down in my thinking.	**.73**				.31
10) I get mentally fatigued more quickly doing tasks when I am sad.	**.70**				.54
11) I don't have the drive to work hard.		**.69**			.29
12) I am not able to finish tasks that require thinking.		**.48**			.49
13) When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.	**.43**				.70
15) I do not have the will to do anything.		**.60**			.28
16) I have lost interest in the work that I used to do.	.39	.37		.34	.32
17) If I am struggling with a task that requires thinking, I give up easily.	.35	.57			.32
18) I find it hard to pay attention for a long time.	**.81**				.29
19) I find it more difficult than usual to find the correct word.	**.83**				.38
20) I am not able to do the things that I used to do because I am mentally fatigued.	**.69**				.25
21) I can be bribed into doing things I don’t have the motivation to do.					.85
22) I am convinced that I don’t have the mental energy to carry out the rest of the day.	**.48**	.38			.33
23) I am not motivated to do tasks that require thinking.	**.40**	**.50**			.34
24) I make slips of the tongue when speaking.	**.77**				.53

25) When I am stressed while during work, I get mentally fatigued quickly.	**.76**				.45
26) Every task takes longer to complete than it usually would.	**.77**				.28
27) When doing a task, I get distracted more than I used to.	**.73**				.30
28) I feel like I can't be productive.	**.57**	.32			.29
29) When doing activities, I get less mentally fatigued when I am in a good mood.		**-.40**			.83
30) When I am doing tasks that require thinking, I can concentrate quite well.	-.34	-.33			.65
31)I have problems thinking clearly.	**.83**				.22
32) I need to take long breaks between tasks to gain back my mental energy.	**.75**				.41
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	**.57**				.47
34) When I am stuck on a problem, I try harder.		**-.60**			.71
35) It takes more effort to do typical activities where I need to think.	**.76**				.39
36) It is hard for me to keep track of conversations in social settings.	**.73**				.42
38) I believe that my will is strong enough to complete most tasks.		**-.58**			.63
39) I can accomplish tasks that require thinking if I put my mind to them.		**-.66**			.53
40) I do not feel engaged in my work.	.38	**.40**		.33	.27
41) If I were watching TV right now it would be hard to focus because my thoughts tend to drift.	**.59**				.63
42) I am more forgetful than usual.	**.79**				.35
43) I get stuck more often than most people when working through problems that require a lot of thought.	**.85**				.21
44) I feel helpless because of mental fatigue.	**.70**				.29
45) I feel like I have a small amount of mental energy that I need to budget across tasks.	**.78**				.37
46) My motivation is lower than usual.	**.57**			**.40**	.21
47) I feel I am always one step behind.	**.73**				.26
48) It is hard for me to keep up my effort.	**.73**				.19
49) I have trouble doing even basic things like getting dressed.	.38		**.45**		.33
50) The thought of doing basic self-care like brushing my teeth or taking a shower is too much.	**.44**		**.45**		.36

51) I feel like I can’t be bothered to do activities that I used to enjoy.	**.57**			.28
52) I feel lonely because of mental fatigue.	**.62**			.39
53) I find I am less able than usual to start tasks that require thinking.	**.71**			.20
54) I feel like I need to leave tasks unfinished to complete tomorrow.	**.70**			.40
55) I feel useless because I don't have the mental energy to do things.	**.71**			.22
56) I find it hard to think straight.	**.86**			.18
57) I feel like I can't organize my thoughts enough to properly complete tasks.	**.84**			.19
58) I get frustrated that I can't do things because I'm mentally fatigued.	**.87**			.22
59) I am less confident because of mental fatigue.	**.92**			.21
60) It is hard for me to answer emails efficiently.	**.63**			.38
62) I can't make myself do the work that I know I should.	**.57**			.24
63) I find it hard to follow conversations.	**.78**			.28
64) I find that I procrastinate more than I used to.	**.67**			.36
65) I have lost the feeling of wanting to try at anything.	**.46**		.39	.20
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.	**.73**			.28
67) It takes me a long time to decide to do something.	**.76**			.31
68) When I sit down to do work, I feel like my thoughts are all over the place.	**.86**			.26
69) I feel guilty because I cannot do most things that I am supposed to do.	**.75**			.21
70) It is easy for me to become mentally overwhelmed.	**.96**			.22
71) I don't have the mental energy to socialize with others.	**.77**			.36
72) It is hard for me to see the point in doing chores like the dishes.	**.57**	**.40**		.36
73) It takes me longer than it used to get engaged in my work.	**.74**			.21
74) When I am concentrating, I get exhausted sooner than I used to.	**.95**			.63
75) I am making many mistakes.	**.70**			.53
76) It is hard to make plans because I can’t predict when I will be mentally fatigued.	**.81**			.27
77) It is hard to remember relevant information that I need to do my work.	**.85**			.63
78) Tasks that I could usually do without thinking now require more effort.	**.89**			.35
79) I can't keep going even if I really want to because of my fatigue.	**.73**			.21
80) I feel anxious because of mental fatigue.	**.87**			.29

81) I can't follow movies with complex plots because it is hard for me to keep track of what is going on.	**.65**		.37
82) I need to divide jobs up so that I don't do too much in one day.	**.81**		.21
83) I feel like my brain is not functioning the way it should.	**.85**		.26
84) The idea of writing a text message to someone on my phone is too exhausting.	**.58**	.32	.19
85) It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.	**.59**		.33
86) I have trouble remembering names or passwords for my accounts.	**.66**		.36
87) My brain feels numb.	**.70**		.28
88) When I try to read, I must read the same line over and over because I can't process the words.	**.77**		.39

Notes. Extraction method; maximum likelihood; Rotation method: Direct Oblimin. Loadings larger than .4 are in bold.

Appendix B11

Table 26

The 88 EIMFS Items and the Source of the Item Development

Items	Source for the Item Development
1. When I am trying to focus, I am easily distracted.	Adapted from the Volitional Exercise Questionnaire (VEQ; item 11 from the Volitional Facilitation – Unrelated Thoughts subscale) (Elsborg et al., 2017).
2. I feel sad because of mental fatigue.	Original item created for the EIMFS.
3. I don't believe I can do well on tasks because I am too mentally fatigued.	Adapted from the Volitional Exercise Questionnaire (VEQ; item 15 from the Volitional Facilitation – Self-Confidence subscale) (Elsborg et al., 2017).
4. I try to keep going even when I get mentally fatigued.	Original item created for the EIMFS.
5. It is difficult to make daily decisions, like what to make for dinner.	Adapted from Fatigue Impact Scale (FIS; item 5) (Fisk et al., 1994).
6. When I try to do 'brain problems' I find it difficult to concentrate.	Adapted from the Volitional Exercise Questionnaire (VEQ; item 28 from the Volitional Facilitation – Unrelated Thoughts subscale) (Elsborg et al., 2017).
7. I feel no desire to use my brain.	Adapted from item 8 from the Fatigue Assessment Scale (FAS; Michielsen et al., 2003).
8. I feel like my ability to learn has decreased.	Original item created for the EIMFS with inspiration taken from Larun & Malterud (2007).
9. I feel slowed down in my thinking.	Adapted from item 7 on the FIS (Fisk et al., 1994).
10. I get mentally fatigued more quickly doing tasks when I am sad.	Original item created for the EIMFS with inspiration taken from items 9 and 17 from the Fatigue Assessment Inventory (FAI) (Schwartz et al., 1993).
11. I don't have the drive to work hard.	Original item created for the EIMFS.
12. I am not able to finish tasks that require thinking.	Taken from the Fatigue Impact Scale (FIS; item 6) (Fisk et al., 1994).
13. When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued.	Original item created for the EIMFS.
14. Please select number 5 on the rating scale.	NA

15. I do not have the will to do anything.	Original item created for the EIMFS.
16. I have lost interest in the work that I used to do.	Adapted from item 14 from the Fatigue Scale (FS; Chalder et al., 1993).
17. If I am struggling with a task that requires thinking, I give up easily.	Original item created for the EIMFS.
18. I find it hard to pay attention for a long time.	Adapted from item 15 from the Multidimensional Fatigue Symptom Inventory-Short Form (MFSI-SF; Stein et al., 1998).
19. I find it more difficult than usual to find the correct word.	Adapted from item 12 from the Fatigue Scale (FS; Chalder et al., 1993).
20. I am not able to do the things that I used to do because I am mentally fatigued.	Original item created for the EIMFS with inspiration taken from Glaus et al. (1996).
21. I can be bribed into doing things I don't have the motivation to do.	Original item created for the EIMFS.
22. I am convinced that I don't have the mental energy to carry out the rest of the day.	Adapted from Volitional Exercise Questionnaire (VEQ; item 16 from the Volitional Facilitation – Self-Confidence subscale) (Elsborg et al., 2017).
23. I am not motivated to do tasks that require thinking.	Adapted from item 3 from the Fatigue Impact Scale (FIS; Fisk et al., 1994a).
24. I make slips of the tongue when speaking.	Adapted from item 11 from the Fatigue Scale (FS; Chalder et al., 1993).
25. When I am stressed while during work, I get mentally fatigued quickly.	Adapted based on item 8 from the Fatigue Assessment Inventory (FAI) (Schwartz et al., 1993).
26. Every task takes longer to complete than it usually would.	Original item created for the EIMFS.
27. When doing a task, I get distracted more than I used to.	Original item created for the EIMFS
28. I feel like I can't be productive.	Original item created for the EIMFS with inspiration taken from Glaus et al., 1996.
29. When doing activities, I get less mentally fatigued when I am in a good mood.	Adapted based on item 17 from the Fatigue Assessment Inventory (FAI) (Schwartz et al., 1993).
30. When I am doing tasks that require thinking, I can concentrate quite well.	Adapted from item 10 from the Fatigue Assessment Scale (FAS; Michielsen et al., 2003).
31. I have problems thinking clearly.	Item taken from the FAS (item 6; Michielsen et al., 2003).

32. I need to take long breaks between tasks to gain back my mental energy.	Original item created for the EIMFS with inspiration taken from the Barrow Neurological Institute (BNI) Fatigue Scale (Borgaro et al., 2004).
33. Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	Original item created for the EIMFS.
34. When I am stuck on a problem, I try harder.	Adapted from Volitional Exercise Questionnaire (VEQ; item 18 from the Volitional Facilitation – Coping with Failure subscale) (Elsborg et al., 2017).
35. It takes more effort to do typical activities where I need to think.	Adapted from item 13 from the Multidimensional Fatigue Inventory (MFI; Smets et al., 1995).
36. It is hard for me to keep track of conversations in social settings.	Original item with inspiration taken from the Volitional Exercise Questionnaire (VEQ; item 18 from the Volitional Facilitation – Coping with Failure subscale) (Elsborg et al., 2017).
37. Please select number 1 on the rating scale.	NA
38. I believe that my will is strong enough to complete most tasks.	Adapted from Volitional Exercise Questionnaire (VEQ; item 27 from the Volitional Facilitation – Self-Confidence subscale) (Elsborg et al., 2017).
39. I can accomplish tasks that require thinking if I put my mind to them.	Original item created for the EIMFS.
40. I do not feel engaged in my work.	Original item created for the EIMFS.
41. If I were watching TV right now it would be hard to focus because my thoughts tend to drift.	Adapted from Volitional Exercise Questionnaire (VEQ; item 28 from the Volitional Inhibition – Unrelated Thoughts subscale) (Elsborg et al., 2017).
42. I am more forgetful than usual.	Adapted from item 27 from the Multidimensional Fatigue Symptom Inventory-Short Form (MFSI-SF; Stein et al., 1998).
43. I get stuck more often than most people when working through problems that require a lot of thought.	Original item created for the EIMFS.
44. I feel helpless because of mental fatigue.	Original item created for the EIMFS with inspiration taken from Picariello et al. (2018).
45. I feel like I have a small amount of mental energy that I need to budget across tasks.	Original item created for the EIMFS.
46. My motivation is lower than usual.	Adapted from item 1 on the Fatigue Severity Scale (FSS; Kleinman et al., 2000).

47. I feel I am always one step behind.	Original item created for the EIMFS with inspiration taken from Primdahl et al., (2019)
48. It is hard for me to keep up my effort.	Original item created for the EIMFS.
49. I have trouble doing even basic things like getting dressed.	Original item created for the EIMFS.
50. The thought of doing basic self-care like brushing my teeth or taking a shower is too much.	Original item created for the EIMFS with inspiration taken from Magnusson et al. (1999).
51. I feel like I can’t be bothered to do activities that I used to enjoy.	Original item created for the EIMFS with inspiration taken from Picariello et al. (2018) and Ezekiel et al. (2021).
52. I feel lonely because of mental fatigue.	Original item created for the EIMFS with inspiration taken from Valentine & Meyers (2001).
53. I find I am less able than usual to start tasks that require thinking.	Original item created for the EIMFS with inspiration taken from Raymond et al. (2021).
54. I feel like I need to leave tasks unfinished to complete tomorrow.	Original item created for the EIMFS.
55. I feel useless because I don't have the mental energy to do things.	Original item created for the EIMFS.
56. I find it hard to think straight.	Original item created for the EIMFS with inspiration taken from White et al. (2012).
57. I feel like I can't organize my thoughts enough to properly complete tasks.	Original item created for the EIMFS.
58. I get frustrated that I can't do things because I'm mentally fatigued.	Original item created for the EIMFS. Picariello (2018) Raymond (2021)
59. I am less confident because of mental fatigue.	Original item created for the EIMFS with inspiration taken from White et al. (2012).
60. It is hard for me to answer emails efficiently.	Original item created for the EIMFS with inspiration taken from Valentine & Meyers (2001).
61. Please select number 7 on the rating scale.	NA
62. I can't make myself do the work that I know I should.	Original item created for the EIMFS.
63. I find it hard to follow conversations.	Original item created for the EIMFS with inspiration taken from Larun & Malterud (2007); Flinn & Stube (2010).
64. I find that I procrastinate more than I used to.	Original item created for the EIMFS with inspiration taken from Ezekiel et al. (2021).

65. I have lost the feeling of wanting to try at anything.	Original item created for the EIMFS with inspiration taken from Jaime-Lara et al. (2020); Ezekiel et al. (2021).
66. I struggle to do tasks that need to be done, like doing the laundry or getting groceries.	Original item created for the EIMFS with inspiration taken from Ezekiel et al. (2021); Flinn & Stube (2010).
67. It takes me a long time to decide to do something.	Original item created for the EIMFS with inspiration taken from Walthall et al. (2019).
68. When I sit down to do work, I feel like my thoughts are all over the place.	Original item created for the EIMFS with inspiration taken from Ezekiel et al. (2021).
69. I feel guilty because I cannot do most things that I am supposed to do.	Original item created for the EIMFS with inspiration taken from White et al. (2012).
70. It is easy for me to become mentally overwhelmed.	Original item created for the EIMFS with inspiration taken from Valentine & Meyers (2001).
71. I don't have the mental energy to socialize with others.	Original item created for the EIMFS with inspiration taken from Larun & Malterud (2007).
72. It is hard for me to see the point in doing chores like the dishes.	Original item created for the EIMFS with inspiration taken from items 13 and 22 from the Fatigue Assessment Inventory (FAI) (Schwartz et al., 1993).
73. It takes me longer than it used to get engaged in my work.	Original item created for the EIMFS with inspiration taken from Jaime-Lara et al. (2020).
74. When I am concentrating, I get exhausted sooner than I used to.	Adapted from the Fatigue Scale for Motor and Cognitive Functions (FSMC; item 1) (Penner et al., 2009).
75. I am making many mistakes.	Original item created for the EIMFS with inspiration taken from Jaime-Lara et al. (2020).
76. It is hard to make plans because I can’t predict when I will be mentally fatigued.	Original item created for the EIMFS.
77. It is hard to remember relevant information that I need to do my work.	Original item created for the EIMFS.
78. Tasks that I could usually do without thinking now require more effort.	Adapted from item 13 on the Multidimensional Fatigue Inventory (MFI; Smets et al., 1995).
79. I can't keep going even if I really want to because of my fatigue.	Original item created for the EIMFS.
80. I feel anxious because of mental fatigue.	Original item created for the EIMFS.

81. I can't follow movies with complex plots because it is hard for me to keep track of what is going on.	Original item created for the EIMFS.
82. I need to divide jobs up so that I don't do too much in one day.	Original item created for the EIMFS with inspiration taken from Jaime-Lara et al. (2020).
83. I feel like my brain is not functioning the way it should.	Original item created for the EIMFS with inspiration taken from Glaus et al. (1996).
84. The idea of writing a text message to someone on my phone is too exhausting.	Original item created for the EIMFS with inspiration taken from Ezekiel et al. (2021); Larun & Malterud, 2007.
85. I don't believe I can do well on tasks because I am too mentally fatigued.	Adapted from Volitional Exercise Questionnaire (VEQ; item 15 from the Volitional Facilitation – Self-Confidence subscale) (Elsborg et al., 2017).

Note. Refer to pp. 55-72 for a list of full references.

Appendix B12

Table 27

The Hypothesized Four Factors and their Items

Hypothesized Factor	Items Hypothesized to Load onto Factor
Factor 1 – Impaired Cognitive Control	
	1) When I am trying to focus, I am easily distracted. 3) I don't believe I can do well on tasks because I am too mentally fatigued. 4) I try to keep going even when I get mentally fatigued. 5) It is difficult to make daily decisions, like what to make for dinner. 6) When I try to do 'brain problems' I find it difficult to concentrate. 11) I don't have the drive to work hard. 13) When I am trying to focus, having distractions such as the TV on or people talking in the background makes me mentally fatigued. 15) I do not have the will to do anything. 17) If I am struggling with a task that requires thinking, I give up easily 22) I am convinced that I don’t have the mental energy to carry out the rest of the day. 26) Every task takes longer to complete than it usually would. 27) When doing a task, I get distracted more than I used to. 28) I feel like I can’t be productive. 33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list. 34) When I am stuck on a problem, I try harder. 36) It is hard for me to keep track of conversations in social settings. 38) I believe that my will is strong enough to complete most tasks. 41) If I were watching TV right now it would be hard to focus because my thoughts tend to drift. 48) It is hard for me to keep up my effort. 49) I have trouble doing even basic things like getting dressed. 50) The thought of doing basic self-care like brushing my teeth or taking a shower is too much. 54) I feel like I need to leave tasks unfinished to complete tomorrow. 57) I feel like I can’t organize my thoughts enough to properly complete tasks. 62) I can’t make myself do the work that I know I should.

65) I have lost the feeling of wanting to try at anything.
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.
67) It takes a long time to decide to do something.
72) It is hard for me to see the point in doing chores like the dishes.
73) It takes me longer than it used to get engaged in my work.
74) When I am concentrating, I get exhausted sooner than I used to.
76) It is hard to make plans because I can't predict when I will be mentally fatigued.
78) Tasks that I could usually do without thinking now require more effort.
79) I can't keep going even if I really want to because of my fatigue.
82) I need to divide jobs up so that I don't do too much in one day.
88) When I try to read, I must read the same line over and over because I can't process the words.

Factor 2 – Impaired Cognition

8) I feel like my ability to learn has decreased.
9) I feel slowed down in my thinking.
12) I am not able to finish tasks that require thinking.
18) I find it hard to pay attention for a long time.
19) I find it more difficult than usual to find the correct word.
24) I make slips of the tongue when speaking.
26) Every task takes longer to complete than it usually would.
30) When doing tasks that require thinking, I can concentrate quite well.
31) I have problems thinking clearly.
32) I need to take long breaks between tasks to gain back my mental energy.
35) It takes more effort to do typical activities where I need to think.
39) I can accomplish tasks that require thinking if I put my mind to them.
40) I do not feel engaged in my work.
42) I am more forgetful than usual.
43) I get stuck more often than most people when working through problems that require a lot of thought.
45) I feel like I have a small amount of mental energy that I need to budget across tasks.
47) I feel I am always one step behind.

	53) I find I am less able than usual to start tasks that require thinking. 56) I find it hard to think straight. 60) It is hard for me to answer emails efficiently. 63) I find it hard to follow conversations. 64) I find that I procrastinate more than I used to. 68) When I sit down to do work, I feel like my thoughts are all over the place. 70) It is easy for me to become mentally overwhelmed. 71) I don't have the mental energy to socialize with others. 75) I am making many mistakes. 77) It is hard to remember relevant information that I need to do my work. 81) I can't follow movies with complex plots because it is hard for me to keep track of what is going on. 83) I feel like my brain is not functioning the way it should. 84) The idea of writing a text message to someone on my phone is too exhausting. 86) I have trouble remembering names or passwords for my accounts. 87) My brain feels numb.
Factor 3 – Emotion	2) I feel sad because of mental fatigue. 10) I get mentally fatigued more quickly doing tasks when I am sad. 20) I am not able to do the things that I used to do because I am mentally fatigued. 21) I can be bribed into doing things I don't have the motivation to do. 25) When I am stressed while during work, I get mentally fatigued quickly. 29) When doing activities, I get less mentally fatigued when I am in a good mood. 44) I feel helpless because of mental fatigue. 52) I feel lonely because of mental fatigue. 55) I feel useless because I don't have the mental energy to do things. 58) I get frustrated that I can't do things because I'm mentally fatigued. 59) I am less confident because of mental fatigue. 69) I feel guilty because I cannot do most things that I am supposed to do. 80) I feel anxious because of mental fatigue. 85) It is hard to stay upbeat because I used to do a lot of things and now, I do nothing.
Factor 4 – Decreased Motivation	7) I feel no desire to use my brain.

16) I have lost interest in the work I used to do.
23) I am not motivated to do tasks that require thinking.
46) My motivation is lower than usual.
65) I have lost the feeling of wanting to try at anything.

Appendix C: Appendices for Study 2 Materials
Appendix C1

SONA/Participant Pool Recruitment

Title of Research: The Experience of Mental Fatigue

You are invited to participate in a study investigating the experience of mental fatigue.

If you decide to participate this study will take place online and will involve the completion of eight questionnaires that should take approximately 20-minutes in total. Three of the questionnaires will ask you about your experiences surrounding fatigue and the impact it has on your daily life. You will also be asked to answer some questions about sleep, your overall mood, and whether or not statements about cognition and cognitive tasks are characteristic of you. Finally, the survey portion will end with some basic demographic questions. You will then be directed to the second part of the study which will take place on the online server Pavlovia. You will be instructed to complete two tasks, an Auditory Memory Task (which will take approximately 10 minutes to complete) and a Matrix Reasoning Task (you will have 30 minutes to complete this task however it is likely you will finish much faster than this).

The entire study is expected to take approximately 1 hour to complete. Upon completion, you will receive **1.0 course credit** as compensation.

This study is open to any individual enrolled in the SONA subject pool. All participants will be compensated with credit in accordance with course-specific guidelines. Your participation is voluntary, and all information collected in the study will be kept confidential.

This study will take place **online**. Please note that you must be 18-50 years of age and speak English as a first language to participate in this study.

If you would like more information, please contact Olivia Richards (email: redacted) or the Principle Investigator, Dr. Ingrid Johnsrude (email: redacted).

Version: 2022-12-18

Appendix C2

SONA Letter of Information and Informed Consent

Title of Research: The Experience of Mental Fatigue

Welcome! Please read over the following letter of information and consent before proceeding.

Who do you contact if you have questions?
Should you have questions or concerns related to your involvement in this research, please contact:

Researcher contact information:
Name: Olivia Richards
Role: Graduate student
Department: Psychology
The University of Western Ontario
Email: redacted

Supervisor contact information:
Name: Dr. Ingrid Johnsrude
Role: Faculty member, supervisor
Department: Psychology
The University of Western Ontario
Tel: redacted
Email: redacted

Research Personnel. The researcher running this study is Olivia Richards in the Department of Psychology at the University of Western Ontario. She is working under the supervision of Dr. Ingrid Johnsrude in the Department of Psychology.

Introduction.
You are being invited to participate in this research study about the experience of mental fatigue because you indicated on the Western University Sona systems that you would be interested in participating. Please note that you must be 18-50 years of age and speak English as a first language to participate in this study.

Why is this study being done?
The purpose of this research is to examine the ways in which individuals experience mental fatigue, and how mental fatigue impacts their lives. Taking these perceptions into account can help us determine how mental fatigue manifests in individuals. For example, does motivation effect mental fatigue? Does the amount of effort required for a task impact mental fatigue? These factors likely influence our engagement in and successfully completion of cognitively strenuous tasks. To assess this, we asked you to respond to a series of questions describing

cognitive fatigue.

How long will you be in this study?
It is expected that you will be in the study approximately 60 minutes to complete.

What will happen during this study and what is the study procedure?
If you decide to participate this study will take place online and will involve the completion of eight questionnaires that should take approximately 20-minutes in total. Three of the questionnaires will ask you about your experiences surrounding fatigue and the impact it has on your daily life. You will also be asked to answer some questions about sleep, your overall mood, and whether or not statements about cognition and cognitive tasks are characteristic of you. Finally, the survey portion will with demographic questions on gender, age, ethnic background, whether you have ever been diagnosed with ADHD, dyslexia, epilepsy, or any kind of other psycho educational or neuropsychological issue, what country you reside in, and what your first language is.

You will then be directed to the second part of the study which will take place on the online server Pavlovia. You will be instructed to complete two tasks, an Auditory Memory Task (which will take approximately 10 minutes to complete) and a Matrix Reasoning Task (you will have 30 minutes to complete this task however it is likely you will finish much faster than this).

- In the auditory memory task you will hear a sequence of letters. The letters will be presented one a time and a new sound will play ever 2.5 seconds. Your job will be to listen closely to these sounds for specific kinds of repeats.
- The Matrix Reasoning Task is a pattern completion task. You will be presented with patterns, one pattern at a time. One piece of the pattern will be missing, and your job is to select the best option that completes the pattern.

Whether you complete the Auditory Memory Task first or the Matrix Reasoning Task first will be randomized.

What are the risks and harms of participating in this study?
There are no known or anticipated risks or discomforts associated with participating in this study.

What are the benefits of participating in this study?
Fatigue can act as one of the most severe symptoms expressed in neurological and healthy populations (Dobryakova et al., 2013). That said, our understanding of mental fatigue remains relatively minimal, and it appears more research needs to be conducted to expand our knowledge and bridge gaps in the literature (Chaudhuri & Behan, 2004; DeLuca, 2005). You may not directly benefit from this study. However, by participating in this study, you would be helping researchers in their goal of better understanding how to measure mental fatigue and increasing knowledge of the phenomenon of mental fatigue.

Can participants choose to leave the study?
You have the right to end your participation during the study at any time. You can choose not to answer particular questions. If you withdraw from the study, all information you have provided will be immediately destroyed. Due to the anonymous nature of your data, once your responses

have been submitted the researchers will be unable to withdraw your data as all submitted data will not contain identifiers. You can **only withdraw during the study**.

Anonymity/confidentiality.
All responses are anonymous. You should not put any identifying information on the survey. All research data will be stored on the Qualtrics server. Research data will only be accessible by the researchers involved in the project and the research supervisor.

Delegated institutional representatives of Western University and its Non-Medical Research Ethics board may require access to your study-related records to monitor the conduct of the research in accordance with regulatory requirements.

Once the project is completed all data will be collected anonymously and neither the researchers nor anyone else will be able to identify you as a research participant. The data will be stored on a secure server at The University of Western Ontario and will be retained for 7-10 years. Your data will not be distributed to others.

These data may be used for teaching and research publications, presentations, and theses. If the results of the study are published, your name will not be used.

Data Collection.
Your data will be collected online through a third party. Despite these parties taking the steps to secure your data, please note that nothing over the internet is every 100% safe.

- The online forum **Qualtrics** will be used to collect your survey data. For researchers at Canadian institutions, Qualtrics stores their data in Ireland. Their privacy policy can be accessed here.
- The online forum Pavlovia will be used to collect your Auditory Memory Task data and your Matrix Reasoning Task data. The server hardware for Pavlovia is in the United Kingdom. Their privacy policy can be accessed here.

Compensation.
You will be compensated 1.0 course credit for your participation in this study. You will receive your credit through SONA. If you do not complete the entire study, you will still receive this credit. If you need to withdraw from the study **before** completion, contact Olivia Richards (email: redacted) to ensure that you receive your course credit.

What are your rights as a participant?
Your participation in this study is voluntary. You may decide not to be in this study. Even if you consent to participate you have the right to not answer individual questions or to withdraw from the study at any time. If you choose not to participate or to leave the study at any time it will have no effect on you or your compensation. You do not waive any legal right by consenting to this study.

If you have any questions about your rights as a research participant or the conduct of this study, you may contact The Office of Human Research Ethics phone: redacted, email: redacted

This office oversees the ethical conduct of research studies and is not part of the study team. Everything that you discuss will be kept confidential.

This letter is yours to keep for future reference.

Version: 2022-12-18

By indicating that you want to proceed with the study by clicking on the "next" button, you are choosing and consenting to participate this study. If you do not want to proceed with the study please exit the browser now.

Appendix C3

SONA Debriefing

Thank you for participating in this research! Study Title: The Experience of Mental Fatigue What if I have questions later? If you have any remaining concerns, questions, or comments about the experiment, please feel free to contact Olivia Richards at: redacted; or Dr. Ingrid Johnsrude (Faculty Sponsor & Supervisor) at: redacted

Appendix D: Appendices for Supplementary Materials for Chapter 3

Appendix D1

Table 28

Demographics for Study 2 Sample

	Frequency	Percent (%)
Gender		
Female	189	77.8
Male	54	22.2
Ethnicity		
Arab	7	2.9
Black	1	.4
Chinese	30	12.3
Filipino	1	.4
Indigenous	2	.8
Korean	4	1.6
Latin American	1	.4
Mixed Ethnicity	17	7.0
South Asian	33	13.6
Southeast Asian	2	.8
White	138	56.8
Not listed	2	.8
Prefer not to answer	5	2.1
Neuropsychological Diagnosis		
No	206	84.8
Yes	37	15.2
Education Level		
Associate degree (e.g., AA, AS)	2	.8
Bachelor's degree (e.g., BA, BS)	8	3.3
High school degree or equivalent (e.g., GED)	206	84.8
Some college, no degree	26	10.7
Doctorate (e.g., PhD, EdD)	1	.4

Appendix D2

Table 29

Supplementary Information for Study 2

	Frequency	Percent (%)
Headphone Check		
I can't remember if I used headphones	2	0.8
I used headphones the first time but not the second	11	4.5
I used headphones the second time but not the first	1	0.4
No, I did not use headphones	119	49
Yes, I used headphones	106	43.6
Effect of Mental Fatigue (past 4 weeks)		
0 – None	0	0
1	4	1.6
2	12	4.9
3	22	9.1
4	38	15.6
5	39	16
6	54	22.2
7	54	22.2
8	0	0
9	10	4.1
10 – Very Severe	0	0
How Long Mental Fatigue		
Less than 1 week	30	12.3
Two weeks	43	17.7
More than 1 month	44	18.1
Between 2-4 months	55	22.6
More than 6 months	67	27.6

Notes. Although the questionnaire included the question "how long have you experienced mental fatigue" the framing of this question was not deemed appropriate as it assumed the experience of mental fatigue, and so the data were not analysed.

Appendix D3

Table 30

Descriptive Statistics for the 22 EIMFS Items

Item	N	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Std. Error
2) I feel sad because of mental fatigue.	283	4.6	1.6	2.70	-.50	.15	-.75	.29
3) I don't believe I can do well on tasks because I am too mentally fatigued.	282	4.8	1.6	2.40	-.57	.15	-.42	.29
5) It is difficult to make daily decisions, like what to make for dinner.	282	4.3	1.7	2.95	-.14	.145	-1.01	.29
6) When I try to do 'brain problems' I find it difficult to concentrate.	282	4.4	1.6	2.61	-.11	.145	-.99	.29
8) I feel like my ability to learn has decreased.	281	4.3	1.8	3.20	-.21	.145	-1.04	.29
15) I do not have the will to do anything.	281	3.2	1.8	3.06	.49	.145	-.77	.29
16) I have lost interest in the work that I used to do.	282	3.9	1.8	3.20	.03	.145	-1.09	.29
26) Every task takes longer to complete than it usually would.	283	4.6	1.7	2.75	-.34	.145	-.78	.29
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.	285	3.9	1.9	3.42	.05	.144	-1.22	.29
40) I do not feel engaged in my work.	284	4.2	1.6	2.48	-.02	.145	-.85	.29
52) I feel lonely because of mental fatigue.	283	4.1	1.8	3.37	-.17	.145	-1.14	.29
58) I get frustrated that I can't do things because I'm mentally fatigued.	281	4.8	1.8	3.11	-.51	.145	-.77	.29
59) I am less confident because of mental fatigue.	282	4.5	1.9	3.56	-.26	.145	-1.11	.29
65) I have lost the feeling of wanting to try at anything.	284	3.9	1.8	3.22	.08	.145	-1.14	.29

67) It takes me a long time to decide to do something.	282	4.6	1.6	2.66	-.36	.145	-.66	.29
69) I feel guilty because I cannot do most things that I am supposed to do.	284	4.7	1.9	3.53	-.35	.145	-1.06	.29
72) It is hard for me to see the point in doing chores like the dishes.	284	3.3	1.9	3.41	.50	.145	-.97	.29
76) It is hard to make plans because I can't predict when I will be mentally fatigued.	282	3.8	1.9	3.64	.10	.145	-1.23	.29
80) I feel anxious because of mental fatigue.	282	4.6	1.9	3.76	-.45	.145	-1.03	.29
83) I feel like my brain is not functioning the way it should.	283	4.5	1.9	3.51	-.39	.145	-1.00	.29

Note. Possible range of mean scores are from 1 to 7.

Appendix D4

Table 31

Frequency of Response on EIMFS Likert Scale for the SONA population

Item	Frequency	Percent
2) I feel sad because of mental fatigue.		
1 – Disagree Strongly	7	2.0
2	30	12.3
3	31	12.8
4	23	9.5
5	67	27.6
6	55	22.6
7 – Agree Strongly	29	11.9
3) I don't believe I can do well on tasks because I am too mentally fatigued.		
1 – Disagree Strongly	4	1.6
2	25	10.3
3	29	11.9
4	22	9.1
5	87	35.8
6	43	17.7
7 – Agree Strongly	31	12.8
5) It is difficult to make daily decisions, like what to make for dinner.		
1 – Disagree Strongly	11	4.5
2	35	14.4
3	44	18.1
4	35	14.4
5	54	22.2
6	37	15.2
7 – Agree Strongly	25	10.3
6) When I try to do 'brain problems' I find it difficult to concentrate.		
1 – Disagree Strongly	4	1.6

2	39	16.0
3	44	18.1
4	32	13.2
5	64	26.3
6	38	15.6
7 – Agree Strongly	21	8.6
8) I feel like my ability to learn has decreased.		
1 – Disagree Strongly	16	6.6
2	42	17.3
3	30	12.3
4	33	13.6
5	56	23.0
6	36	14.8
7 – Agree Strongly	28	11.5
9) I feel slowed down in my thinking.		
1 – Disagree Strongly		
2	8	3.3
3	31	12.8
4	32	13.2
5	30	12.3
6	81	33.3
7 – Agree Strongly	36	14.8
15) I do not have the will to do anything.	24	9.9
1 – Disagree Strongly	51	21.0
2	55	22.6
3	40	16.5
4	39	16.0
5	29	11.9
6	18	7.4
7 – Agree Strongly	8	3.3
16) I have lost interest in the work that I used to do.		
1 – Disagree Strongly	25	10.3
2	49	20.2

3	34	14.0
4	32	13.2
5	56	23.0
6	27	11.1
7 – Agree Strongly	18	7.4
26) Every task takes longer to complete than it usually would.		
1 – Disagree Strongly	9	3.7
2	26	1-.7
3	36	14.8
4	34	14.0
5	61	25.1
6	42	17.3
7 – Agree Strongly	33	13.6
33) Even if I am motivated, I put off doing tasks where I need to plan, like making a shopping list.		
1 – Disagree Strongly	23	9.5
2	49	20.2
3	45	18.5
4	23	9.5
5	44	18.1
6	39	16.0
7 – Agree Strongly	20	8.2
40) I do not feel engaged in my work.		
1 – Disagree Strongly	8	3.3
2	38	15.6
3	46	18.9
4	42	17.3
5	60	24.7
6	31	12.8
7 – Agree Strongly	17	7.0
52) I feel lonely because of mental fatigue.		
1 – Disagree Strongly	27	11.1
2	41	16.9

3	28	11.5
4	26	10.7
5	63	25.9
6	37	15.2
7 – Agree Strongly	20	8.2
58) I get frustrated that I can't do things because I'm mentally fatigued.		
1 – Disagree Strongly	12	4.9
2	29	11.9
3	31	12.8
4	17	7.0
5	66	27.2
6	42	17.3
7 – Agree Strongly	43	17.7
59) I am less confident because of mental fatigue.		
1 – Disagree Strongly	19	7.8
2	36	14.8
3	29	11.9
4	31	12.8
5	45	18.5
6	40	16.5
7 – Agree Strongly	41	19.9
65) I have lost the feeling of wanting to try at anything.		
1 – Disagree Strongly	23	9.5
2	54	22.2
3	40	16.5
4	27	11.1
5	47	19.3
6	34	14.0
7 – Agree Strongly	17	7.0
66) I struggle to do tasks that need to be done, like doing the laundry or getting groceries.		
1 – Disagree Strongly	23	9.5
2	49	20.2

3	37	15.2
4	26	10.7
5	48	19.8
6	43	17.7
7 – Agree Strongly	16	6.6
67) It takes me a long time to decide to do something.		
1 – Disagree Strongly	11	4.5
2	24	9.9
3	32	13.2
4	32	13.2
5	75	30.9
6	38	15.6
7 – Agree Strongly	29	11.9
69) I feel guilty because I cannot do most things that I am supposed to do.		
1 – Disagree Strongly	14	5.8
2	37	15.2
3	27	11.1
4	29	11.9
5	53	21.8
6	33	13.6
7 – Agree Strongly	49	20.2
72) It is hard for me to see the point in doing chores like the dishes.		
1 – Disagree Strongly	40	16.5
2	80	32.9
3	28	11.5
4	31	12.8
5	26	10.7
6	23	9.5
7 – Agree Strongly	14	5.8
76) It is hard to make plans because I can’t predict when I will be mentally fatigued.		
1 – Disagree Strongly	32	13.2

2	46	18.9
3	43	17.7
4	23	9.5
5	45	18.5
6	31	12.8
7 – Agree Strongly	20	8.2
80) I feel anxious because of mental fatigue.		
1 – Disagree Strongly	22	9.1
2	33	13.6
3	22	9.1
4	22	9.1
5	48	19.8
6	51	21.0
7 – Agree Strongly	42	17.3
83) I feel like my brain is not functioning the way it should.		
1 – Disagree Strongly	20	8.2
2	35	14.4
3	29	11.9
4	25	10.3
5	53	21.8
6	43	17.7
7 – Agree Strongly	36	14.8

Appendix D5

Table 32

Study 2 CFA Four-Factor Model Item Loadings

Factor	Item	Estimate	SE	Z	P	Standard. Estimate
Factor 1 – Emotional Consequences	80	1.56	0.11	14.68	< .001	**0.80**
	58	1.54	0.10	16.16	< .001	**0.85**
	59	1.63	0.10	16.16	< .001	**0.85**
	52	1.37	0.10	13.28	< .001	**0.74**
	76	1.19	0.11	10.76	< .001	**0.64**
	2	1.00	0.10	10.07	< .001	**0.60**
	83	1.57	0.10	15.62	< .001	**0.83**
Factor 2 – Daily Life Impact	66	1.28	0.11	11.88	< .001	**0.70**
	72	0.94	0.12	8.20	< .001	**0.52**
	33	0.89	0.12	7.60	< .001	**0.49**
	67	1.15	0.10	11.87	< .001	**0.70**
	5	0.85	0.11	7.88	< .001	**0.50**
	69	1.49	0.11	14.18	< .001	**0.79**
Factor 3 – Cognitive Difficulties	9	1.37	0.09	16.13	< .001	**0.86**
	8	1.53	0.10	15.81	< .001	**0.85**
	6	1.04	0.10	10.91	< .001	**0.65**
	3	0.97	0.09	10.42	< .001	**0.63**
	26	1.14	0.10	11.51	< .001	**0.68**
Factor 4 – Motivation & Engagement	15	1.27	0.10	13.10	< .001	**0.74**
	16	1.53	0.10	16.16	< .001	**0.86**
	40	1.20	0.09	13.55	< .001	**0.76**
	65	1.48	0.10	15.27	< .001	**0.82**

Note. 'Maximum likelihood' estimation method was used. Factor loadings (i.e., stand. Estimates) greater than 0.40 are bolded.

Appendix D6

Table 33

Study 2 CFA Four-Factor Model Item Loadings after Modification

Factor	Item	Estimate	SE	Z	P	Standard. Estimate
1 – Emotional Consequences	80	1.55	0.11	14.62	< .001	0.79
	58	1.53	0.10	16.04	< .001	0.85
	59	1.62	0.10	16.05	< .001	0.85
	52	1.37	0.10	13.25	< .001	0.74
	76	1.17	0.11	10.57	< .001	0.63
	2	1.00	0.10	10.03	< .001	0.60
	83	1.58	0.10	15.76	< .001	0.83
	69	1.43	0.10	13.59		0.76
Factor 2 – Daily Life Impact	66	1.39	0.11	12.83	< .001	0.76
	72	1.02	0.12	8.72	< .001	0.56
	33	0.97	0.12	8.10	< .001	0.53
	67	1.14	0.10	11.41	< .001	0.70
	5	0.90	0.11	8.15	< .001	0.53
Factor 3 – Cognitive Difficulties	9	1.38	0.09	16.17	< .001	0.86
	8	1.53	0.10	15.81	< .001	0.85
	6	1.04	0.10	10.91	< .001	0.65
	3	0.97	0.09	10.43	< .001	0.63
	26	1.14	0.10	11.49	< .001	0.68
Factor 4 – Motivation & Engagement	15	1.27	0.10	13.19	< .001	0.75
	16	1.53	0.09	16.23	< .001	0.86
	40	1.19	0.09	13.47	< .001	0.76
	65	1.48	0.10	15.21	< .001	0.82

Note. The modification refers to moving item 69 from Factor 2 to Factor 1.

Appendix D7

Table 34

Factor Covariances Final Four-Factor CFA Model for Study 2

		Estimate	SE	Z	p	Stand. Estimate
Factor 1 – Emotional Consequences	Factor 1	1.00				
	Factor 2	0.79	0.04	20.8	<.001	0.79
	Factor 3	0.85	0.03	31.5	<.001	0.85
	Factor 4	0.86	0.03	34.2	<.001	0.86
Factor 2 – Daily Life Impact	Factor 2	1.00				
	Factor 3	0.77	0.04	18.3	<.001	0.77
	Factor 4	0.82	0.04	21.6	<.001	0.82
Factor 3 – Cognitive Difficulties	Factor 3	1.00				
	Factor 4	0.85	0.03	29.6	<.001	0.85
Factor 4 – Motivation & Engagement	Factor 4	1.00				

Appendix E: Appendices for Supplementary Results for Chapter 4

Appendix E1: Simple Linear Regression Tables Study 1

Table 35

Model Summary for Study 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.327	.106	.105	1.46606	.107	43.494	1	363	<.001	1.972

Table 36

Collinearity Diagnostics for Study 1

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Need for Cognition
1	1	1.963	1.000	.02	.02
	2	.037	7.294	.98	.98

Table 37

ANOVA for Study 1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	93.482	1	93.482	43.494	<.001
	Residual	780.204	363	2.149		
	Total	873.686	364			

Appendix E2: Simple Linear Regression Tables Study 2

Table 38

Model Summary for Study 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.246	.061	.057	1.20166	.061	15.427	1	239	<.001	1.879

Table 39

Collinearity Diagnostics for Study 2

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Need for Cognition
1	1	1.985	1.000	.01	.01
	2	.015	11.701	.99	.99

Table 40

ANOVA for Study 2

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.277	1	22.277	15.427	<.001
	Residual	345.110	239	1.444		
	Total	367.387	240			

Appendix E3

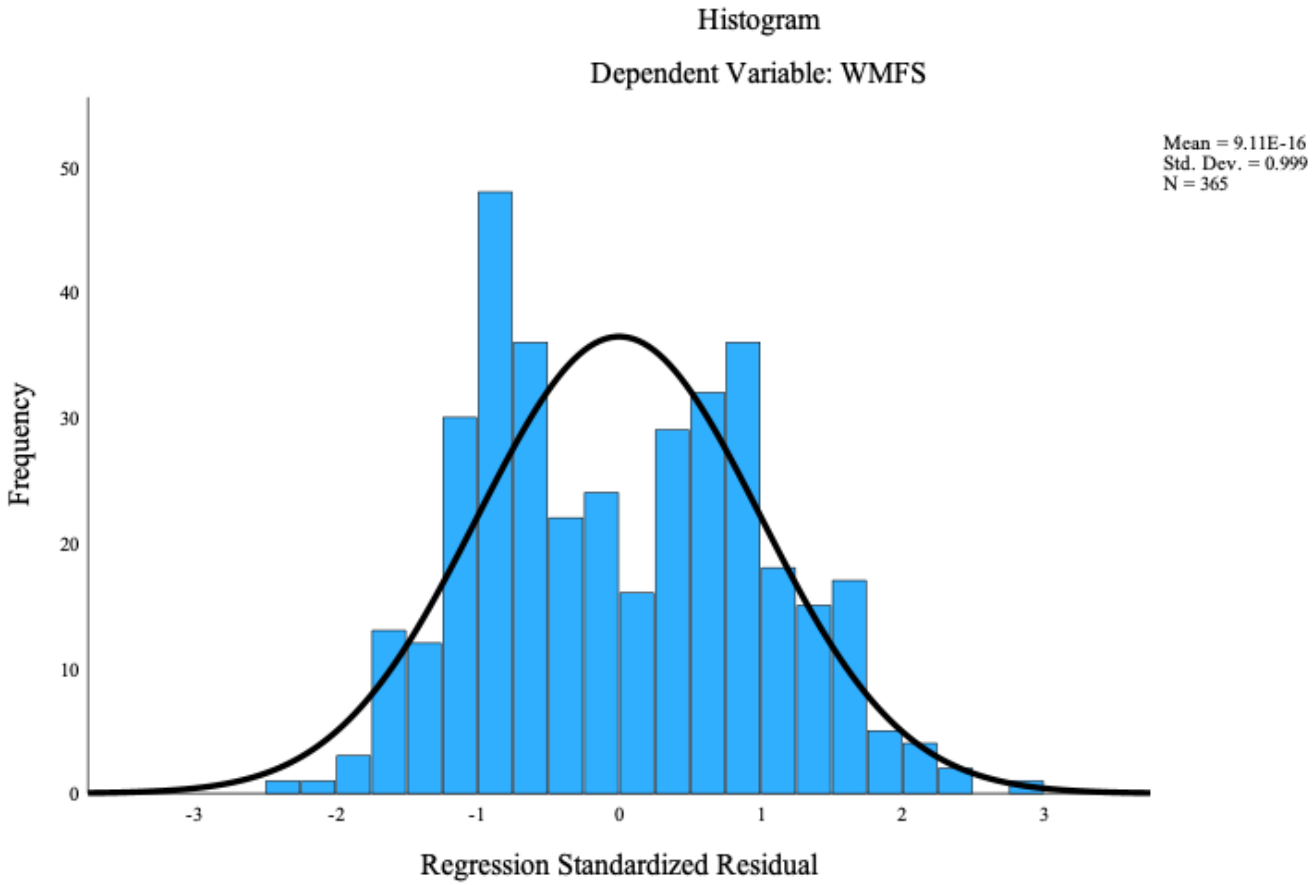

Figure 1. The assumption of normality holds for Study 1 as the regression residuals are roughly normally distributed.

Appendix E4

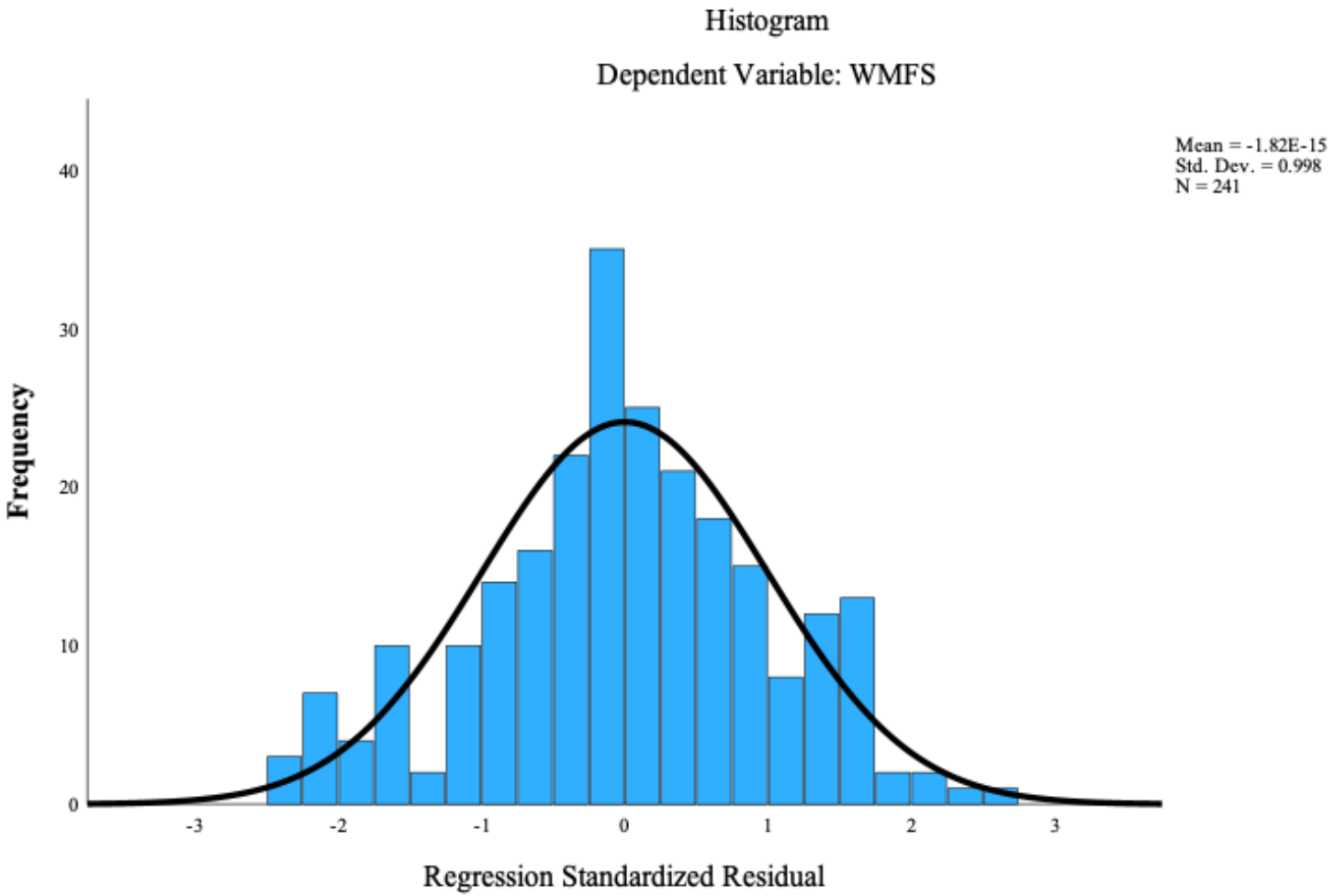

Figure 2. The assumption of normality holds for Study 2 as the regression residuals are roughly normally distributed.

Appendix E5

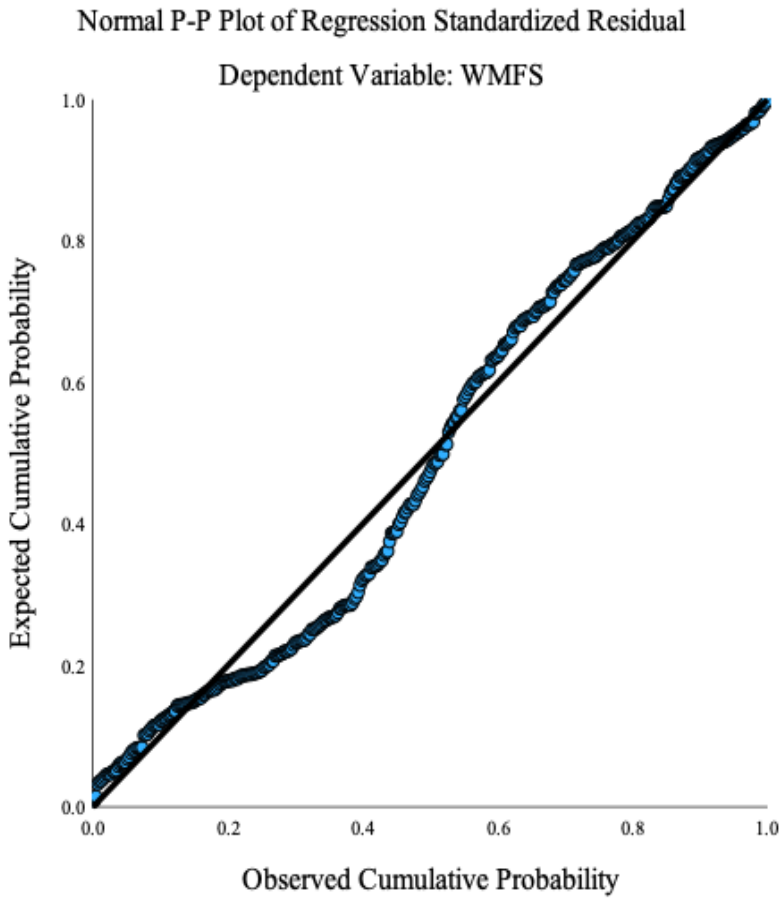

Figure 3. Normal P-P plot with diagonal reference line for Study 1. The linearity of the pattern is evidence that the measurements are normally distributed. The linearity assumption also holds.

Appendix E6

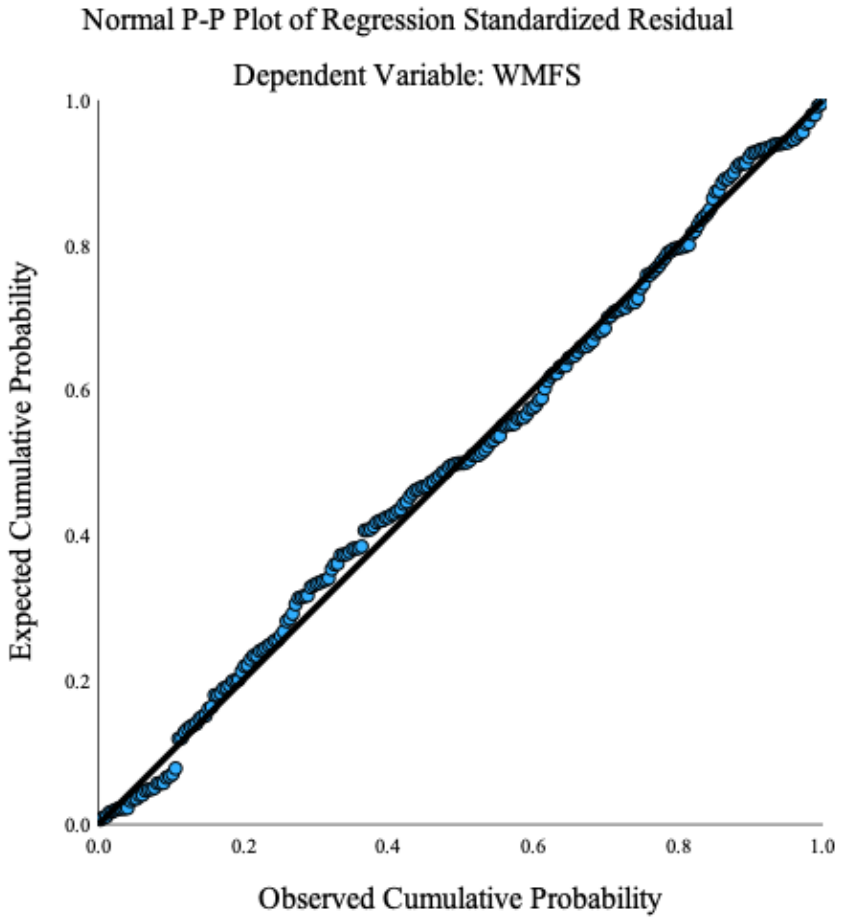

Figure 4. Normal P-P plot with diagonal reference line for Study 2. The linearity of the pattern is evidence that the measurements are normally distributed. The linearity assumption also holds.

Appendix E7

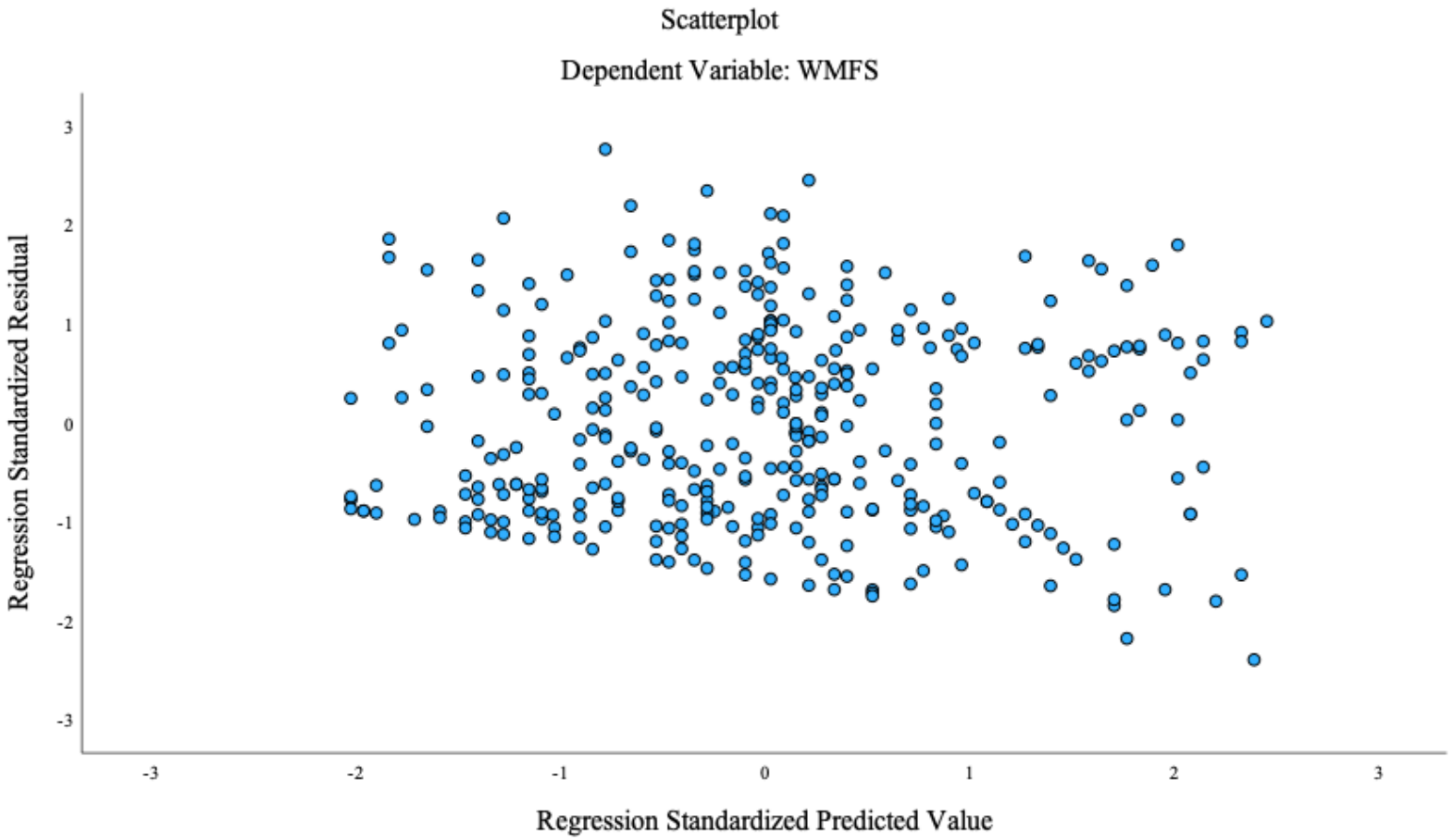

Figure 5. The scatterplot for Study 1 shows that the assumption of homoscedasticity is met, as the residual plot does not show strong curvilinearity.

Appendix E8

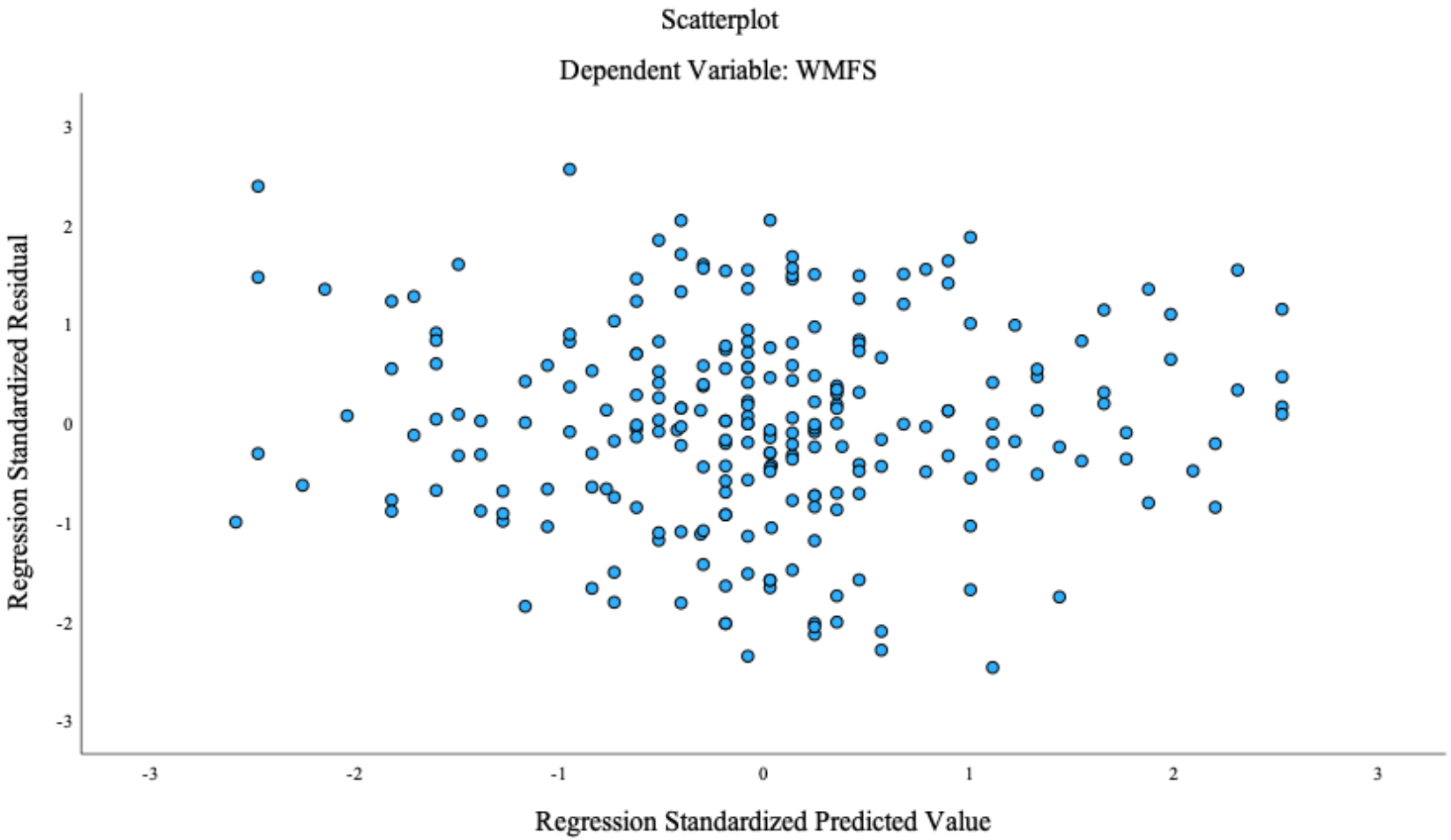

Figure 6. The scatterplot for Study 2 shows that the assumption of homoscedasticity is met, as the residual plot does not show strong curvilinearity.

Olivia Hayley Richards | Curriculum Vitae

EDUCATION

M.Sc. Clinical Science & Psychopathology – *University of Western Ontario* **Anticipated August 2023**

- Thesis – Development of the Western Mental Fatigue Scale
- Supervisor: Dr. Ingrid Johnsrude

M.A. Psychology – *Carleton University* **2018 – 2020**

- Specialized in social psychology
- Thesis – Exploring the Missing Element of Racism: The Unintentional Factor
- Supervisor: Dr. Kim Matheson

B.A. Psychology – *Carleton University* **2014 – 2018**

- Concentration in personality psychology
- Honours thesis: The Impact of Nature on Interpersonal Conflict Resolution
- Supervisor: Dr. John Zelenski

ACADEMIC WORK EXPERIENCE

Psychometrist – *St. Joseph's Hospital, Parkwood Institute, London ON* **Present**

- Worked under the supervision of Dr. Serena Wong
- Was assigned to the Treatment & Rehab Program
- Role included administering and scoring neuropsychological, psychological, personality, and academic tests for patients with various neurological disease, psychological health issues, or learning disabilities.

Research Assistant – *Saint Paul University* **2020 – 2021**

- Worked under the supervision of Dr. Stephanie Wiebe
- Role included running intake screening assessments using the Beck Depression Inventory-II and the Beck Anxiety Inventory. This was done to determine eligibility for a randomized control trial of Individual Emotion-Focused Therapy for depression and anxiety through various through inclusion/exclusion criteria
- Responsibilities also included running a post-treatment exit assessment using the Anxiety and Related Disorders Interview Schedule for the DSM-5.

Research Assistant – Social Diversity Lab, *Carleton University* **2018 – 2020**

- Faculty Member: Dr. Kim Matheson
- Research coordinator on the Youth Social Action Project
- Role included examining whether participation in social action research has a significant impact on facilitating resiliency, feelings of well-being, empowerment, and cultural connectedness in First Nations and ethnic minority youth in Thunder Bay, Canada.
- Taught youth arts-based research methods to help facilitate self-advocacy
- Worked on research projects regarding various forms of prejudice and racism

Research Assistant – Psychology of Solitude Lab, *Carleton University* **2017 – 2019**

- Faculty Member: Dr. Robert Coplan
- Tasked with data collection from human subjects (running quantitative interviews regarding the conceptualization of solitude in youth), qualitative coding for study on coach perception of solitude in youth sports

Research Assistant – Forensic Psychology Lab, *Carleton University* **2017 – 2018**

- Faculty Member: Dr. Joanna Puzzulo

- Worked on research centered on issues with eyewitness testimony and factors that influence juror decision making; conducted with lineups
- SPSS data entry; student data collection, including surveys and qualitative questions

Teaching Assistant – *The University of Western Ontario* **2021 – 2023**

- PSYC 3184 (Research in the Psychology of Language): Tasks included marking/providing feedback for weekly lab reports, a midterm, & final term paper
- PSYC 1003B (Psychology as a Social Science): Tasks included running weekly tutorials, marking discussion participation, & marking thought papers.

Teaching Assistant – *Carleton University* **2018 – 2020**

- Worked as a teaching assistant for the following courses: PSYC 1001 (Introduction to Psychology), PSYC 2500D (Developmental Psychology), PSYC 2307 (Neuropsychology), PSYC 3402 (Criminal Behaviour), PSYC 3505 (Exceptional Children)
- Tasks included proctoring and marking midterms and final exams; hosting TA hours which allowed students to review/discuss various class materials; marking and providing critical feedback on self-reflection assignments and essays

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RESEARCH WORK EXPERIENCE

Junior Data Analyst, *Government of Canada Gatineau, QC* **2021**

- Governance Branch: Public Health Agency Canada
- Worked on research papers for publication
    - A paper regarding the relationship between sleep, concussions, and physical activity in the Canadian population
    - A systematic review on COVID-19 and unintentional injuries in Canada
    - A descriptive paper on concussions in Canada

Junior Policy Analyst, *Government of Canada, Gatineau, QC* **2020**

- Governance Branch: Women and Gender Equality
- Supported the National Action Plan on Gender Equality
    - Worked on the Gender-based Violence Task Team by aiding in policy coordination. Duties included working on funding modality scans, reporting on GBV strategies and priorities across the federal and provinces and territories.
- Supported Governance and Horizontal Policy Coordination
    - Assisted in Materials for Minister's Advisory Council by preparing meeting logistics such as: agendas, records of discussion, and background material
- Was tasked with being the lead on the gender-based violence COVID-19 scan
    - Reported weekly on any new announcements released by the federal provinces and territories regarding the implementation of strategies to tackle gender-based violence during the COVID-19 pandemic

Research Analyst, *Government of Canada, Gatineau, QC* **2019 – 2020**

- Research, Results, & Delivery Branch: Women and Gender Equality
- Worked on brief summary reports of stats Canada and research articles that were newly published, critiquing research proposals through a gender equality lens, reporting various statistics from stats Canada, creating tables on specific statistics, etc.
- Was the lead writer on a literature review surrounding gender norms within Canada and the implementation of various interventions used to combat them

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UNIVERSITY INVOLVEMENT

Western Undergraduate Psychology Journal
Present
Graduate Reviewer

- Reviewed and made recommendations for submitted manuscripts
- Provided feedback for authors on how to improve their submissions

CONFERENCES

SPSP – Society for Personality and Social Psychology Conference, *New Orleans LA* **2020**

- Presented an academic research poster on my M.A. thesis work

CPA – Canadian Psychological Association Conference, *Conducted virtually online* **2020**

- Presented an academic research poster on my M.A. thesis work

AWARDS

- Western Graduate Research Scholarship, $12,460.86 **2022 – 2023**
- Western Graduate Research Scholarship, $12,460.40 **2021 – 2022**
- Scholarship Departmental, $4000 **2019 – 2020**
- TA Excellence Recognition **2020**
- Scholarship Departmental 3, $2000 **2018 – 2020**
- Research Assistant, $6000 **2018 – 2020**
- P.D. McCormack Fund Masters, $4000 **2018 – 2019**
- Domestic Entrance Masters, $2000 **2018 – 2019**
- Dean's List **2014 – 2018**
- The Engelsman-Gold Family Scholarship, $2000 **2017 – 2018**
- Harry. S Southam Scholarship, $2000 **2016 – 2017**
- C.J. Mackenzie Scholarship, $2000 **2015 – 2016**
- Entrance Scholarship Award, $2000 **2014 – 2015**