Cognitive performance in adulthood: the roles of stress-related exhaustion and depressive symptoms

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Tiivistelmä – Referat – Abstract

Objective: Both stress-related exhaustion and depression have previously been associated with a decline in cognitive performance, but there is a lack of evidence on whether these conditions have different associations with different cognitive domains and whether they have additive effects on cognitive performance. Furthermore, very little is known about the cognitive effects of chronic stress-related exhaustion. Consequently, the aims of this study were to 1) examine the associations between current stress-related exhaustion and cognitive performance, 2) investigate whether different developmental trajectories of stress-related exhaustion are differently associated with cognitive performance, 3) compare the association between stress-related exhaustion and cognitive performance to the relationship between depressive symptoms and cognitive performance, 4) examine if individuals with comorbid stress-related exhaustion and depression have lower cognitive performance than individuals with at most one of these conditions (i.e., whether clinical stress-related exhaustion and clinical depression might have additive effects on cognitive performance).

Methods: The data used in the study was a Finnish population-based sample of six cohorts born between 1962 and 1977 from *the Cardiovascular Risk in Young Finns Study*. Stress-related exhaustion was assessed using the Maastricht Questionnaire, depressive symptoms with the Beck Depression Inventory, and cognitive performance with four subtests of the Cambridge Neuropsychological Test Automated Battery, measuring visuospatial associative learning, reaction time, sustained attention, and executive functions. Cognitive performance and depressive symptoms were assessed in 2012, and stress-related exhaustion in 2001, 2007, and 2012. Participants were 35 to 50 years old in 2012. Linear associations between stress-related exhaustion and cognitive performance (N = 905) and depressive symptoms and cognitive performance (N = 904) were examined by conducting multivariate regression analyses. Age, sex, socioeconomic status, and parents’ socioeconomic status were controlled in the regression models. Additionally, multivariate analyses of variance were performed to investigate the different developmental trajectories of stress-related exhaustion and their relation to cognitive performance (N = 541) and the associations of comorbid stress-related exhaustion and depression with cognitive performance (N = 1273).

Results and conclusion: The main finding was that high stress-related exhaustion is associated with slower reaction times, but not with performance in spatial working memory, visuospatial associative learning, or executive functions. Ongoing, chronic stress-related exhaustion was more strongly associated with slower reaction times than short-term exhaustion experienced years ago. Compared to depressive symptoms, high stress-related exhaustion was associated with slower reaction times also when subclinical cases were included, whereas only clinical levels of depressive symptoms had an association with slower reaction times. There were no differences in cognitive performance between individuals with only stress-related exhaustion or depression and those with comorbid stress-related exhaustion and depression, which supports the notion that these conditions do not have additive effects on cognitive performance. These findings add to the existing evidence of the cognitive effects of stress-related exhaustion in the general population and have several practical implications. Further research is needed on the topic, preferably with longitudinal designs, more comprehensive cognitive measures, and clinical assessment of the psychiatric symptoms.

Avainsanat – Nyckelord – Keywords
stress-related exhaustion, depression, cognitive performance, vital exhaustion, burnout, cognition, depressive symptoms

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Uupumuksen ja masennusoireiden yhteydet kognitiiviseen suoritustasoon aikuisuudessa

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Tiivistelmä – Referat – Abstract

Tavoitteet: Uupumuksen ja masennuksen on aiemmin todettu olevan yhteydessä heikentyneeseen kognitiiviseen suoritustasoon. Toistaiseksi ei kuitenkaan tiedetä, ovatko uupumus ja masennus eri tavalla yhteydessä kognition eri osa-alueisiin tai miten samanaikainen uupumus ja masennus vaikuttavat kognitioon. Lisäksi tarvitaan tutkimustietoa siitä, miten krooninen uupumus on yhteydessä kognitiiviseen suoritustasoon. Näin ollen tämän tutkimuksen tavoitteina on selvittää, 1) onko uupumus yhteydessä kognitiiviseen suoritustasoon, 2) ovatko uupumuksen erilaiset kehityskulut eri tavalla yhteydessä kognitiiviseen suoritustasoon, 3) ovatko uupumuksen ja masennuksen yhteydet kognitiiviseen suoritustasoon keskenään erilaisia ja 4) onko henkilöillä, joilla on samanaikainen uupumus ja masennus, heikompi kognitiivinen suoritustaso kuin niillä, joilla on ainoastaan toinen tai ei kumpaakaan oirekuvaa (eli onko viitteitä siitä, että kliinisellä uupumuksella ja masennuksella olisi yhteisvaikutusta kognitiiviseen suoritustasoon).

Menetelmät: Tutkimuksen aineisto on peräisin suomalaisesta LASERI-seurantatutkimuksesta, jossa on tutkittu kuutta vuosina 1962–1977 syntynyttä ikäkohorttia. Uupumusta mitattiin Maastricht Questionnaire -kyselylomekkeella, masennusoireita Beckin masennuskyselyllä ja kognitiivista suoritustasoa Cambridge Neuropsychological Test Automated Battery -testistöllä (CANTAB). CANTAB:sta käytettiin neljää osatestiä, jotka mittasivat visuospatiaalista assosiatiivista oppimista, reaktioaikaa, tarkkaavuuden ylläpitoa ja toiminnanohjausta. Kognitiota ja masennusoireita tutkittiin vuonna 2012 ja uupumusta vuosina 2001, 2007 ja 2012. Vuonna 2012 tutkittavat olivat 35–50-vuotiaita. Uupumuksen (N = 905) ja masennusoireiden (N = 904) lineaarista yhteyttä kognitiiviseen suoritustasoon tutkittiin monimuuttujaregressioanalyysilla. Ikä, sukupuoli sekä tutkittavan ja tämän vanhempien sosioekonominen status kontrolloitiin regressioanalyyseissa. Uupumuksen eri kehityskulkujen (N = 541) ja samanaikaisen uupumuksen ja masennuksen (N = 1273) yhteyksiä kognitiiviseen suoritustasoon tutkittiin monimuuttujavarianssianalyysilla.

Tulokset ja johtopäätökset: Tutkimuksen päätulos oli, että korkea uupumus oli yhteydessä hitaampiin reaktioaikoihin mutta ei muihin mitattuihin kognition osa-alueisiin. Lisäksi havaittiin, että kroonisella uupumuksella oli vahvempi yhteys hitaampaan reaktioaikasuoritukseen kuin aiemmin koetulla lyhytkestoisella uupumuksella. Korkea uupumus oli lineaarisesti yhteydessä hitaampaan reaktioaikaan, kun taas masennuksen kohdalla ainoastaan kliininen oirekuva oli yhteydessä reaktioaikaan. Kun vertailtiin tutkittavia, joilla oli samanaikainen uupumus ja masennus, ei havaittu eroja niihin, joilla oli ainoastaan toinen oirekuva. Tämä tukee käsitystä siitä, että uupumuksella ja masennuksella ei ole yhteisvaikutuksia kognitiiviseen suoritustasoon. Tutkimuksen tulokset täydentävät olemassa olevaa näyttöä uupumuksen ja masennuksen yhteydestä kognitiiviseen suoritustasoon erityisesti normaaliväestössä, ja niillä on useita käytännön sovelluksia. Aiheesta tarvitaan lisää pitkittäistutkimuksia, joissa arvioidaan sekä psykiatrisia oireita että kognitiivista suoriutumista perusteellisemmin.

Avainsanat – Nyckelord – Keywords

uupumus, masennus, kognitiivinen suoritustaso, burnout, kognitio, masennusoireet

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CONTENTS

1 INTRODUCTION

1.1 Cognitive abilities and cognitive performance

Cognitive abilities refer to the skills involved in all information processing, for instance perception, learning, memory, attention, awareness, reasoning, and language (Harvey, 2019). The term **cognition** is in turn used to describe the sum of all cognitive abilities, in other words “all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used” (Neisser, 1967, p. 4). These different cognitive abilities can be further divided into a set of different but interacting and partially overlapping functions (Harvey, 2019). Cognitive abilities are thought to have high heritability (Briley & Tucker-Drob, 2013; Polderman et al., 2015), although environmental variables also influence their development and determine whether an individual reaches their full potential in cognitive performance (Ijzendoorn, Juffer, & Poelhuis, 2005).

Cognitive performance, in contrast to cognitive abilities, refers to an individual’s test performance in a specific moment in time – that is, other variables besides the actual cognitive abilities also influence the outcome (Evans, 2010). Cognitive performance is usually evaluated with neuropsychological tests that aim to turn the abstract abilities into measurable variables. There can be significant differences between different cognitive tests in an individual’s performance: for example, one can have higher than average scores on tests of memory, but significantly lower scores in measures of visuospatial perception. Contextual factors, such as stress (Quaedflieg & Schwabe, 2018) or sleep deprivation (Pilcher & Huffcutt, 1996), can also influence the performance in a cognitive evaluation. In general, a higher level of cognitive performance is associated with better ability to adapt to changes (Stasielowicz, 2020) and predicts academic success (Lövdén, Fratiglioni, Glymour, Lindenberger, & Tucker-Drob, 2020) and longer life expectancy (Anstey, Luszcz, Giles, & Andrews, 2001). In clinical practice, it is often informative to evaluate cognitive performance: the results can be indicative of a neurogenerative disease or a psychiatric disorder and give insight into the functioning of the patient (Harvey, 2019).

Traditionally, most theories aiming to explain the structure of cognition have focused on the underlying cognitive abilities and not on cognitive performance. There are multiple ways to categorise cognitive abilities into different domains. They can be classified by the general cognitive process involved, e.g., memory, language, or attention (Harvey, 2019). Another way to conceptualise cognitive domains is according to the brain structures they are associated with, such as the frontal lobe, parietal lobe, or the hippocampus (Harvey, 2019; Kranz et al., 2018). Furthermore, the structure of cognitive abilities can also be organised hierarchically, based on the complexity of the cognitive operations (Harvey, 2019). These hierarchical structures are referred to as top-down versus bottom-up processes of cognition (Al-Aidroos, Said, & Turk-Browne, 2012; Harvey, 2019). Bottom-up processes are the least complex and include the basic sensory and perceptual operations, whereas top-down processes are made up of the most complex cognitive operations, such as reasoning, problem-solving, and executive functions (Al-Aidroos et al., 2012; Harvey, 2019).

Throughout history, there have been several attempts at specific models seeking to explain the structure of cognitive abilities. **Hierarchical models** are similar to the top-down versus bottom-up perspective: they assume there are different, hierarchically organised factors that constitute cognitive abilities. These theories are based on analysing the interrelationship of scores on cognitive performance tests with the statistical technique of factor analysis. There are two early psychometric theories that most contemporary hierarchical models are based on: **Spearman's g-factor** (Spearman, 1904) and **Thurstone's several independent factors** (Thurstone, 1938). Spearman (1904) suggested there was a single important factor of cognitive abilities that was related to performance on every cognitive test and called this the general factor (g). Additionally, he claimed there was a set of specific factors that were each related to the performance on a single type of ability test (Spearman, 1904). In contrast, Thurstone (1938) claimed to have found seven independent factors of cognitive abilities: verbal comprehension, word fluency, number facility, space, perceptual speed, induction, and memory.

Two later hierarchical models combined these views of cognitive abilities: the theory of fluid and crystallised intelligence also known as **the GF-GC theory** (Horn & Cattell, 1966, 1967) and **the three-stratum theory** (Carroll, 1993). The fluid intelligence of the GF-GC theory consists of the abilities to perceive relationships among stimulus patterns, to comprehend implications, and to draw inferences from relationships (Horn & Cattell, 1966, 1967). In turn, crystallised intelligence entails the set of skills and knowledge acquired throughout the lifespan (Horn & Cattell, 1966, 1967). There are three levels of subfactors in the GF-GC theory: perceptual organisation (processing speed, the ability to visualise information, and the ability to process auditory information), association processing (the ability to acquire and retrieve information from short-term memory and the fluency of information retrieval from long-term memory), and sensory reception (the ability to detect visual and auditory information and hold it in iconic and echoic memory) (Horn & Cattell, 1966, 1967). The theory aims to explain the development of cognitive abilities from childhood to adulthood – the lowest factor levels develop earliest in childhood and the more complex abilities are acquired later in life (Horn & Cattell, 1966, 1967).

In contrast, Carroll's three-stratum theory (1993) conceptualises cognitive abilities as a pyramid. On top, there is the general, heritable intelligence factor (Carroll, 1993). The second layer consists of eight factors: fluid intelligence, crystallised intelligence, general memory and learning, broad visual perception, broad auditory perception, broad retrieval ability, broad cognitive speediness, and processing speed (Carroll, 1993). The bottom consists of numerous specific abilities that are related to one or more of the upper-level factors, such as quantitative reasoning and lexical knowledge (Carroll, 1993). The theory was based on a meta-factor analysis of over 460 cognitive ability datasets, making it the first empirically based framework of cognitive abilities organised into a single taxonomy (McGrew, 2009).

The GF-GC theory and the three-stratum theory have remarkable similarities, and they have later been combined into the umbrella term **the Cattel-Horn-Carroll (CHC) theory** (McGrew, 2009; McGrew, Flanagan, Keith, & Vanderwood, 1997; Sternberg & Kaufman, 1998). The CHC theory organises cognitive abilities on three strata: general ability (g) is on stratum three, 16 broad abilities are on the second stratum, and about 70 narrow abilities are on the first stratum (McGrew, 2009). The CHC theory has been called the most empirically supported model of intelligence (Benson, Hulac, & Kranzler, 2010; Flanagan, Alfonso, & Reynolds, 2013) and used as the theoretical foundation for popular contemporary tests of cognitive performance (Benson et al., 2010; Bowden, 2013; Buczyłowska, Petermann, & Daseking, 2020). Furthermore, the CHC model has been shown to represent cognitive performance measured by multiple neuropsychological tests in both healthy people and a range of clinically relevant populations (Jewsbury, Bowden, & Duff, 2017). However, the model has also recently faced criticism because of insufficient exploration of alternative factor solutions (Canivez & Youngstrom, 2019) and differences between the two original theories it is attempting to combine, i.e., the GF-GC theory and the three-stratum theory (McGill & Dombrowski, 2019).

To conclude, there is no clear scientific consensus on how cognitive abilities are organised. Historically, one problem in the research field has been the discrepancy between theoretical models of cognitive abilities and clinical tools developed to measure cognitive performance (Benson et al., 2010; Bowden, 2013). Keeping in mind the challenges brought to light by researchers (Canivez & Youngstrom, 2019; McGill & Dombrowski, 2019), the CHC model could be considered as one candidate for breaching this gap between theoretical cognitive abilities and practical cognitive performance, because the model has substantial empirical support (Benson et al., 2010; Flanagan et al., 2013) and the factor structure of many current neuropsychological tests can be understood through the model (Benson et al., 2010; Bowden, 2013; Buczyłowska et al., 2020; Jewsbury et al., 2017).

1.2 Stress-related exhaustion

1.2.1 Constructs of stress-related exhaustion

The construct of **vital exhaustion** was originally developed to examine the connection between acute coronary syndrome and symptoms of exhaustion (Appels, 1990; Appels, Höppener, & Mulder, 1987; Appels & Mulder, 1989). It is defined as a state of extreme fatigue, demoralisation, and irritability (Appels et al., 1987; Appels & Mulder, 1989; Vroege, Zuidersma, & De Jonge, 2012). In contrast, the term **burnout** is generally used when discussing prolonged occupational stress and is therefore defined by specifically job-related factors: the three dimensions of burnout are exhaustion, cynicism towards work, and inefficacy on the job (Lee & Ashforth, 1996; Maslach, Schaufeli, & Leiter, 2001). Finally, **exhaustion disorder** is a diagnosis added to the Swedish version of the tenth edition of the International Classification of Diseases (ICD-10; World Health Organization [WHO], 2019) in order to improve the identification of chronic stress in clinical settings (Grossi, Perski, Osika, & Savic, 2015). The diagnostic criteria include psychological and physical exhaustion for at least two weeks as a consequence of clearly identified stressors, a significant lack of energy, problems with memory or concentration, a decreased level of functioning, emotional lability or irritability, sleep disturbances, and somatic symptoms, such as physical fatigue, muscular pain or dizziness (Socialstyrelsen, 2010). Other versions of the ICD-10, including the Finnish version, do not include exhaustion disorder as a separate diagnosis, and neither burnout nor vital exhaustion are classified as disorders: burnout is described as a “state of vital exhaustion” (Z73.0) under the category “problems related to life-management difficulty” (Z73) (Grossi et al., 2015).

In practice, all these paradigms capture virtually the same phenomenon: a psychological exhaustion resulting from prolonged stress. It has been suggested that both burnout and vital exhaustion are syndromes of “tense-tiredness” (Rozanski & Cohen, 2017; Thayer, 1991). According to Thayer (1991), tiredness is a continuum, ranging from calm, restorative tiredness, to tense and maladaptive tiredness. When tense tiredness becomes chronic, it leads to adverse influences on health.

In this study, **stress-related exhaustion** is used as an umbrella term for manifestations of psychological and somatic exhaustion resulting from prolonged stress. It is defined as a state of severe exhaustion as a consequence of experiencing some form of stress, such as work stress, stressful life-events or an otherwise highly distressing environment. Examples of these exhaustive states include vital exhaustion, burnout, and exhaustion disorder. As was described earlier, these concepts overlap widely, and the key difference between them is the purpose for which they have been originally developed and the environment in which they are used.

Stress-related exhaustion can have severe consequences for the well-being of individuals. Vital exhaustion is associated with an increased risk of both somatic illness, such as cardiovascular disorders (Appels & Mulder, 1989; Rozanski & Cohen, 2017), and psychological problems, for instance overcommitment to work (Preckel, Ka, Kudielka, & Fischer, 2005), an increased risk of developing an alcohol use disorder (Just-Østergaard, Mortensen, Tolstrup, & Flensborg-Madsen, 2018), and other psychiatric disorders (Qiu, Gelaye, Fida, & Williams, 2012). Like vital exhaustion, burnout is also extremely harmful to individuals’ health and has been associated with increased all-cause mortality (Ahola, Väänänen, Koskinen, Kouvonen, & Shirom, 2010).

1.2.2 The overlap between stress-related exhaustion and depression

Depression is a psychiatric disorder characterised by lowered mood, reduction of energy, and a lack of interest in previously enjoyable activities, commonly accompanied by disturbances in sleep and appetite (WHO, 2019). Stress-related exhaustion appears to overlap with depression. The concepts of both vital exhaustion and burnout have been widely debated, because they both share symptoms with depression and have been found to partially overlap with it (Bianchi & Brisson, 2019; Bianchi et al., 2021; Frestad & Prescott, 2017; Renzo, Schonfeld, & Laurent, 2017; Schonfeld & Bianchi, 2016). For instance, increased fatigue, irritability, and sleep disturbances are characteristic of both depression and stress-related exhaustion. It has been argued that the feeling of lack of goals in life, general boredom, and dysfunctional cognitions, such as increased need for external recognition and lower self-efficacy, are more central to depression and not stress-related exhaustion, whereas loss of energy is characteristic of specifically stress-related exhaustion (Kopp, Falger, Appels, & Szedmak., 1998).

Regarding the association between burnout and depression, the construct validity of burnout has been questioned because of similarities between the two conditions. There seems to be significant overlap in the symptoms of burnout and depression (Bianchi & Brisson, 2019; Bianchi et al., 2021; Schonfeld & Bianchi, 2016) and the degree to which individuals view their job as the cause for their symptoms (Bianchi & Brisson, 2019). It has even been hypothesised that burnout is a form of depression: the two states consistently overlap across different measures, occupations, and cultures (Bianchi et al., 2021). Particularly the exhaustion factor of burnout is strongly associated with depression (Bianchi et al., 2021), and many burned out individuals also meet the criteria for clinical depression (Schonfeld & Bianchi, 2016).

With regard to the relationship of vital exhaustion and depression, significant correlations between measures of the two conditions have also been found (Kopp et al., 1998; McGowan et al., 2004; Wojciechowski, Strik, Falger, Lousberg, & Honig, 2000) and a one-factor solution for the underlying construct has been suggested (Wojciechowski et al., 2000). In acute myocardial infarction patients, strong correlations have been found for depression and vital exhaustion questionnaires at four different points in time (Wojciechowski et al., 2000) and when controlling for age, sex, and comorbid physical illnesses (McGowan et al., 2004). Additionally, a more specific connection between depression and vital exhaustion has been suggested (Vroege et al., 2012). According to one model (Jonge et al., 2006; Vroege et al., 2012), the symptoms of depression can be divided into two factors: somatic-affective and cognitive-affective, the former meaning symptoms such as fatigue, sleep disturbances, and changes in appetite. It has been proposed that vital exhaustion covers the same underlying construct as the somatic symptoms of depression, and that this accounts for the overlap between the symptoms (Vroege et al., 2012).

However, some studies suggest that the concepts of vital exhaustion and depression are distinctly different (Kopp et al., 1998; Kudielka, Kanel, Gander, & Fischer, 2004; Van Diest & Appels, 1991). Originally, research found that highly exhausted men had significantly higher scores on self-reported scales of excessive fatigue and loss of vigour, when compared to a non-exhausted control group, whereas depressed mood was uncommon among the subjects (Van Diest & Appels, 1991). This was interpreted as a piece of evidence that vitally exhausted individuals do not necessarily suffer from depression, since depressed mood is a key component in clinical depression. Although, others have criticised this conclusion: it is also possible that these subjects simply did not report depressed mood, because in-depth clinical interviews were not conducted and feelings such as sadness can be first denied, especially in men (Bianchi, Schonfeld, & Laurent, 2017). Nonetheless, it has been argued that even though the symptoms have correlations, they represent separate factors in a factor analysis (Kudielka et al., 2004). Vital exhaustion has been suggested to be a broader concept than depression, since there are significantly more subjects who are exhausted but not depressed than those who are depressed but not exhausted (Kopp et al., 1998). Vital exhaustion and depression also have partially different but overlapping associations with health outcomes (Igna, Julkunen, & Vanhanen, 2011; Kopp et al., 1998). Both conditions are associated with cardiovascular disorders (Igna et al., 2011; McGowan et al., 2004), but it has been suggested that vital exhaustion is more strongly linked to cardiovascular disorders than depression is (Balog et al., 2017; Kopp et al., 1998). In contrast, depression seems to be connected to more psychiatric and substance abuse problems than vital exhaustion (Kopp et al., 1998).

All in all, these different constructs of stress-related exhaustion have some overlap with depression, but the question of whether these concepts are separate from each other remains unresolved. Moreover, more research is needed on whether stress-related exhaustion and depression are differently associated with other outcomes, such as cognitive performance. Nevertheless, it is important to take into consideration depressive symptoms when studying stress-related exhaustion – the two states share many symptoms and comparing their associations with third variables can give valuable insight into differentiating between them.

1.3 Stress-related exhaustion and cognitive performance

These different constructs of stress-related exhaustion seem to be associated with impaired cognition. Many studies have focused specifically on work-related exhaustion and investigated the concept of burnout or some key aspect of the condition, such as emotional exhaustion. However, as stress-related exhaustion is defined as a broader concept in this study, evidence is presented from studies examining some form of stress-related exhaustion and cognitive performance. Most current studies have been conducted on clinical populations, who either have a diagnosis of exhaustion disorder or are seeking treatment because of stress-related exhaustion.

Research on the relationship between stress-related exhaustion and cognitive performance remains inconclusive: many studies have found associations between exhaustion and lower performance in specific cognitive domains (Beck, Gerber, Brand, Pühse, & Holsboer-Trachsler, 2013; Dam et al., 2011, 2012; Diestel, Cosmar, & Schmidt, 2013; Ellbin et al., 2018; Feuerhahn, Stamov-Roßnagel, Wolfram, Bellingrath, & Kudielka, 2013; Horvat & Tement, 2020; Jonsdottir et al., 2017, 2013; Krabbe et al., 2017b; May, Bauer, & Fincham, 2015; Öhman, Nordin, Bergdahl, Birgander, & Stigsdotter Neely, 2014; Sandström, Nyström Rhodin, Lundberg, Olsson, & Nyberg, 2005), while some studies have found no clear association (Castaneda et al., 2011; Österberg, Karlson, & Hansen, 2009; Wekenborg et al., 2018). There is also some indication that impaired cognition is only characteristic of the most severe cases of stress-related exhaustion and not subclinical exhaustion or burnout (Oosterholt, Maes, Linden, Verbraak, & Kompier, 2014, 2016; Sokka et al., 2017).

Increasing evidence suggests that stress-related exhaustion is particularly associated with lower performance in specific cognitive domains, and not all aspects of cognition are affected equally. Stress-related exhaustion seems to be especially associated with a decline in executive functions (Beck et al., 2013; Dam et al., 2011; Diestel et al., 2013; Ellbin et al., 2018; Feuerhahn et al., 2013; Jonsdottir et al., 2013; May et al., 2015; Öhman et al., 2014; Van Der Linden, Keijsers, Eling, & Van Schaijk, 2005), attention (Ellbin et al., 2018; Jonsdottir et al., 2017; Krabbe et al., 2017b; Sandström et al., 2005; Sokka et al., 2017; Van Der Linden et al., 2005; Vitaliano, Echeverria, Shelkey, Zhang, & Scanlan, 2007), reaction time (Dam et al., 2011; Ellbin et al., 2018; Golonka, Mojsa-Kaja, Gawlowska, & Popiel, 2017; Krabbe et al., 2017b; Oosterholt et al., 2014; Österberg et al., 2009; Österberg, Karlson, Malmberg, & Hansen, 2012; Österberg, Skogsliden, & Karlson, 2014; Sandström et al., 2005), and learning and memory (Feuerhahn et al., 2013; Jonsdottir et al., 2017, 2013; Malmberg et al., 2020a; Öhman et al., 2014; Sandström et al., 2005). In their review of 15 research articles, Deligkaris and colleagues conclude that burnout is associated with a decline in executive functions, attention and memory (Deligkaris, Panagopoulou, Montgomery, & Masoura, 2014). It has also been suggested that overall, stress-related exhaustion is connected to lower performance in visual cognition but not in verbal cognition (Sandström et al., 2005).

Executive functions have been studied quite a lot in association with stress-related exhaustion, since executive control affects the performance of most complex cognitive tasks and is thus essential in many demanding professions. There is conflicting evidence about response inhibition (i.e. inhibition of irrelevant information and inhibition of proponent answers): some studies have found no decline in the ability in exhausted (Horvat & Tement, 2020; Jonsdottir et al., 2013) or burned out individuals (Wekenborg et al., 2018), while others have observed lower scores in inhibition tasks in emotionally exhausted (Diestel et al., 2013) and in burned out individuals (May et al., 2015; Van Der Linden et al., 2005). Monitoring and updating working memory representations is one facet of executive function that has been shown to be impaired in stress-related exhaustion (Diestel et al., 2013; Jonsdottir et al., 2013; Oosterholt, Van der Linden, Maes, Verbraak, & Kompier, 2012). Regarding shifting (i.e. shifting between tasks, operations, or mental sets), there are conflicting results: set-shifting has been impaired in some studies (Beck et al., 2013), while in others there has not been a perceivable difference to healthy individuals (Oosterholt et al., 2014, 2012). One explanation for the somewhat inconsistent results regarding executive functions might be the differences in task difficulty: the performance of individuals with high exhaustion only differs from that of healthy controls when the task places high demands on executive control (Diestel et al., 2013; Van Der Linden et al., 2005). All in all, possible decline in executive functions should be considered when interpreting results from studies on exhaustion and cognition.

Stress-related exhaustion is also associated with difficulties in **attention**. Exhausted and burned out individuals have been found to perform poorly on tasks measuring selective and sustained attention (Horvat & Tement, 2020; Van Der Linden et al., 2005). Severe burnout has also been associated with problems in shifting of attention (Sokka et al., 2017), and stress-related exhaustion has been associated with problems in divided attention (Öhman et al., 2014). Both visual and verbal attention seem to be impaired in patients with chronic burnout (Sandström et al., 2005). In general, complex attention (i.e. sustained, divided, and selective attention) seems to be more impaired than simple attention (Krabbe et al., 2017b). Moreover, there is evidence of attention being impaired even after recovering from burnout (Österberg et al., 2014).

Processing speed and reaction time seem to be consistently impaired in stress-related exhaustion. Especially in clinical burnout and exhaustion patients, reaction speed is significantly slower than in healthy controls (Ellbin et al., 2018; Jonsdottir et al., 2013; Oosterholt et al., 2014, 2012; Österberg et al., 2009, 2012, 2014). Processing speed has also been found to be slower (Öhman et al., 2014). Furthermore, processing speed does not seem to fully recover when the symptoms of stress-related exhaustion are alleviated (Jonsdottir et al., 2017). In one study, exhausted individuals actually answered faster than the control group in the beginning of the cognitive task, but they also made more mistakes and experienced more exhaustion after the test (Krabbe et al., 2017b). There is also some evidence of altered neural activity in patients with stress-related exhaustion during processing speed tasks (Skau et al., 2020).

Furthermore, **memory and learning** seem to be affected by stress-related exhaustion. In prospective studies, high emotional exhaustion has been shown to predict a lower level of general learning and memory performance (Feuerhahn et al., 2013). In particular, verbal working memory seems to be impaired in highly exhausted individuals (Ellbin et al., 2018; Jonsdottir et al., 2017, 2013; Malmberg et al., 2020a). There is also tentative evidence about a performance decline in episodic memory (Jonsdottir et al., 2013), spatial memory (Österberg et al., 2012; Sandström et al., 2005) and prospective memory (Öhman et al., 2014). All in all, there is slightly more evidence on the association between stress-related exhaustion and impaired verbal memory performance (Ellbin et al., 2018; Jonsdottir et al., 2017, 2013; Malmberg et al., 2020b; Öhman et al., 2014) than visual memory performance (Österberg et al., 2012; Sandström et al., 2005).

Interestingly, a rather consistent finding has been that while people with high levels of stress-related exhaustion report significant cognitive problems in their everyday life (Horvat & Tement, 2020; Oosterholt et al., 2014; Van Der Linden et al., 2005; Wekenborg et al., 2018), these subjectively reported problems are not always associated with the level of impairment measured by standardised neurocognitive measures (Horvat & Tement, 2020; Oosterholt et al., 2014; Österberg et al., 2009, 2012; Wekenborg et al., 2018). One possible explanation for this discrepancy is that exhausted individuals tend to exert more effort during cognitive tasks, evaluate the tasks as more demanding and experience more fatigue during and after testing than healthy control subjects (Dam et al., 2011; Krabbe et al., 2017b; Oosterholt et al., 2014). Following the cognitive-energetic framework (Hockey, 1997), it has been hypothesised that these chronically stressed individuals might be able to maintain an apparently high level of cognitive performance even with diminished mental resources, but that this comes at a greater subjective cost, i.e., increased effort and fatigue (Horvat & Tement, 2020; Oosterholt et al., 2014).

1.4 Limitations in current research literature

While there is increasing evidence of the cognitive impairments associated with stress-related exhaustion, there are still considerable limitations in the research literature. First, most of the studies are conducted on clinical populations who have sought treatment for stress-related exhaustion (e.g. Jonsdottir et al., 2013; Oosterholt et al., 2014, 2016; Van Der Linden et al., 2005). This causes challenges with the generalisability of the results, as they cannot be directly generalised into non-clinical populations. Furthermore, the approach of comparing small samples of clinical populations to healthy control groups inadvertently causes a false dichotomy of “exhausted” and “healthy” individuals, even though it is more probable that the phenomenon of stress-related exhaustion exists on a continuum, like depression (Tebeka, Geoffroy, Dubertret, & Le Strat, 2021). Thus, it would improve the ecological validity of the research to conduct studies in population-based samples using a continuum-based viewpoint to stress-related exhaustion. There are only a few studies about the association between stress-related exhaustion and cognitive performance with non-clinical samples (Horvat & Tement, 2020; McInerney, Rowan, & Lawlor, 2014) and only one with a population-based sample (Castaneda et al., 2011). Thus, further research is needed.

Second, current research is strongly focused on the concept of burnout and work-related stress (Beck et al., 2013; Österberg et al., 2014). Less is known about non-occupational stress-related exhaustion, for example exhaustion caused by stressful life experiences. There is a risk of obtaining an overly narrow view of the effects of stress-related exhaustion, if only occupational stress and the employed population are considered.

Third, there is a lack of research on the effects of long-term stress-related exhaustion on cognitive performance, for instance exhaustion lasting more than five years. While there are studies examining whether cognitive performance improves after recovering from stress-related exhaustion, the results remain inconsistent (Beck et al., 2013; Dam et al., 2012; Jonsdottir et al., 2017; Oosterholt et al., 2016; Österberg et al., 2012, 2014; Van Der Linden et al., 2005). A number of studies suggest that some cognitive symptoms remain after treatment (Dam et al., 2012; Jonsdottir et al., 2017; Oosterholt et al., 2016; Österberg et al., 2014; Van Der Linden et al., 2005), while other studies have found normative (Beck et al., 2013) or at least improved (Österberg et al., 2012) cognitive performance after the symptoms of stress-related exhaustion have diminished. It seems likely that cognitive performance somewhat improves alongside the symptoms of stress-related exhaustion, but it may take time for cognition to reach premorbid levels (Dam et al., 2012; Van Der Linden et al., 2005). Moreover, there are currently no studies examining chronic stress-related exhaustion (i.e., exhaustion lasting multiple consecutive years) – therefore it is still unclear what effects such a long-lasting state of exhaustion may have on cognitive performance.

Fourth, there are currently no studies directly comparing the associations between stress-related exhaustion and cognitive performance to those between depression and cognitive performance. Furthermore, very little is known about whether comorbid stress-related exhaustion and depression have additive effects on cognitive performance. Like stress-related exhaustion, depression has also been associated with cognitive impairments (Gotlib & Joormann, 2010; McDermott & Ebmeier, 2009; Rock, Roiser, Riedel, & Blackwell, 2014; Snyder, 2013). Compared to the specific impairments associated with stress-related exhaustion, the cognitive decline in depression is more general and can be perceived in most cognitive domains (Parkinson et al, 2020). Depression has been found to be associated particularly with problems in executive functions, attention and memory (Rock, Roiser, Riedel, & Blackwell, 2014). Moreover, in studies of stress-related exhaustion and cognition, there have been inconsistent results when controlling for symptoms of depression. Some studies have found the association between cognitive performance and exhaustion is significant only when depression is controlled (Horvat & Tement, 2020), whereas others have specifically excluded subjects with comorbid depression and have hypothesised that this may have caused the absence of cognitive impairments in the participants (Oosterholt et al., 2014). Nevertheless, symptoms of depression should always be considered when studying the relationship between stress-related exhaustion and cognitive performance. Since the two states have been found to overlap, and both seem to be connected to cognitive impairment, comparing the two could give important insight into differential diagnostics and treatment.

1.5 Research questions and hypotheses

In this study, a prospective population-based sample of Finnish adults was used to examine the associations between stress-related exhaustion (conceptualised as vital exhaustion), depressive symptoms, and cognitive performance. The main cognitive domains assessed were visuospatial associative learning, reaction time, sustained attention, and executive functions (specifically spatial working memory, problem solving, and conducting a self-organised search strategy). Considering the previous research literature and its limitations described earlier, the research questions and hypotheses of the current study were:

Research question 1: Is stress-related exhaustion associated with cognitive performance, and if so, is the association specific to certain cognitive subdomains or rather general, relating to all measured cognitive domains?

Hypothesis 1: High stress-related exhaustion is associated with lower cognitive performance, and this association is specific to performance in reaction time, sustained attention, and executive functions. Stress-related exhaustion is not assumed to be associated with the performance in visuospatial associative learning, because there is comparably less previous evidence on specifically visual memory performance in stress-related exhaustion.

Research question 2: Are different developmental trajectories of stress-related exhaustion differently associated with cognitive performance?

Hypothesis 2: Consistently high stress-related exhaustion over time has a stronger association with lower cognitive performance than consistently low exhaustion or short-term exhaustion.

Research question 3: Are stress-related exhaustion and depressive symptoms differently associated with cognitive performance?

Hypothesis 3: Stress-related exhaustion is specifically associated with poorer performance in reaction time, sustained attention, and executive functions, whereas depressive symptoms are associated with lower performance in all cognitive subdomains.

Research question 4: Do individuals with comorbid stress-related exhaustion and depression have lower cognitive performance than individuals who have at most one of them?

No hypothesis is set for this research question because there is currently not enough evidence on the subject.

2. METHODS

2.1 Participants

The participants were from the longitudinal Young Finns Study. The original sample was randomly selected from the areas close to six Finnish universities with medical schools using the population register of the Finnish Social Insurance Institution. In 1980, the original sample included 3596 participants from six cohorts born in 1962, 1965, 1968, 1971, 1974, and 1977. The baseline measurement was in 1980, and since then, nine follow-up measurements have been conducted between 1983 and 2017. In this study, the 2012 measurements were used, when participants were between the ages of 35 and 50.

The Young Finns Study was carried out in accordance with the Declaration of Helsinki. Moreover, the study design was approved by ethical committees in all the Finnish universities with medical schools. The nature of the procedures was fully explained to the participants, and all the participants or their guardians (for participants younger than 18 years) provided written informed consent prior to participation. The design and methods of the Young Finns Study are described in detail elsewhere (Raitakari et al., 2008).

For this study, cognitive performance was assessed in 2012; vital exhaustion in 2001, 2007 and 2012; depressive symptoms in 2012; parents' socioeconomic factors in 1980; and participants' socioeconomic factors in 2011. Participants were included in the cross-sectional analyses (analysing the associations between current stress-related exhaustion and cognitive performance, N = 905; and between current depressive symptoms and cognitive performance, N = 904) if they had valid data on all the socioeconomic factors, all cognitive performance variables, and over 50 % data on the items of the vital exhaustion questionnaire or the depression questionnaire in 2012. For the analysis of different trajectories of vital exhaustion (i.e., the development of stress-related exhaustion over time and its relationship with cognitive performance), participants were included if they had over 50 % valid data on vital exhaustion in 2001, 2007, and 2012, as well as all data on cognitive performance (N = 541). Finally, for the investigation of comorbid clinical vital exhaustion and depression, participants who had over 50 % data on both vital exhaustion and depressive symptoms in 2012 and all data on cognitive performance were included in the analysis (N = 1273).

2.2 Measures

Vital exhaustion was assessed using the Maastricht Questionnaire (MQ) (Appels, Falger, & Schouten, 1993; Appels et al., 1987; Vroege et al., 2012). The MQ is a 21-item questionnaire assessing the symptoms of vital exhaustion, such as fatigue, irritability, and demoralisation. The questionnaire was originally developed to identify future cases of coronary heart disease (Appels et al., 1987). The MQ has good predictive validity: high scores are associated with multiple markers and outcomes of chronic stress, such as altered cortisol levels and higher levels of self-reported stress and major life events (Nicolson & Van Diest, 2000), reduced habituation to repeated acute psychosocial stress (Kudielka et al., 2006), altered cardiac reactivity to task-induced stress (Keltikangas-Järvinen & Heponiemi, 2004), and cardiovascular disorders (Appels et al., 1993). Each statement (e.g. “Do you sometimes feel that your body is like a battery that is losing its power?” and “Does it take more time to grasp a difficult problem than it did a year ago?”) is answered using a 3-point scale (0 = No, 1 = I do not know, 2 = Yes). For statistical analyses, a sum variable of all the items in the MQ was calculated separately for 2001, 2007, and 2012. Participants were included if they had answered over 50 % of the items. Missing values below 50 % were replaced with the participant’s mean score of the other items. The sum scores ranged from 0 to 42 (Cronbach’s $\alpha = 0.89$ in 2001, $\alpha = 0.90$ in 2007, and $\alpha = 0.90$ in 2012, signifying excellent internal reliability). The scores of the MQ in 2001, 2007, and 2012 had strong positive intercorrelations ($r = .52 – .66$), meaning that vital exhaustion was relatively stable over the follow-up. To reduce skewness, a logarithmic transformation was performed on all three sum variables of vital exhaustion.

Depressive symptoms were assessed with the Beck Depression Inventory (BDI). The BDI is widely used to assess the presence and severity of depressive symptoms in both clinical and research settings (Beck, Steer, & Garbin, 1988; Erford, Johnson, & Bardoshi, 2016; Reynolds & Gould, 1981). The questionnaire includes 21 items, and participants were instructed to rate the statements on a scale from 0 to 3, a score of 0 representing the absence of a symptom and scores from 1 to 3 representing increasing levels of symptom severity (Cronbach's $\alpha = 0.92$ in 2012, demonstrating excellent internal reliability). The items include statements depicting varying levels of depressive symptoms (e. g. "I feel the future is hopeless and that things cannot improve" and "I would kill myself if I had the chance"). A sum of all the items was counted. Participants were included if they had valid data on over 50 % of the items, and missing values below that were replaced with the participant's mean score. The total score ranged from 0 to 63, and the sum variable was logarithmically transformed to reduce skewness.

Cognitive performance was assessed in 2011 using the Cambridge Neuropsychological Test Automated Battery (CANTAB). The CANTAB is a computerised, primarily non-linguistic test battery that consists of 24 individual tests assessing a wide range of cognitive domains. The test battery has been shown to be sensitive to normative ageing (Abbott et al., 2019), Alzheimer's disease (Junkkila, Oja, Laine, & Karrasch, 2012) and cognitive impairment in different psychiatric disorders such as first-episode psychosis (Haring, Mõttus, Koch, Trei, & Maron, 2015) and bipolar disorder (Sonkurt, Altınöz, Çimen, Köşger, & Öztürk, 2021). In this study, four tests were used: the Paired Associates Learning test (PAL), the Reaction Time test (RTI), the Rapid Visual Information Processing test (RVP), and the Spatial Working Memory test (SWM). The chosen tests measured several cognitive domains that were considered relevant for studying stress-related exhaustion and depression: the PAL test was used to assess visuospatial associative learning, visual memory, and episodic memory (Torgersen, Helland, Flaatten, & Wester, 2010); the RTI test to assess reaction time, i.e., speed of response and movement (Gonçalves, Pinho, & Simões, 2018); the RVP to assess sustained attention, visual processing, and recognition (Gonçalves et al., 2018); and the SWM to assess executive functions, particularly the ability to retain spatial information and to manipulate items stored in the working memory, problem solving, and the ability to conduct a self-organised search strategy (Kim, An, Kwon, & Shin, 2014). These four tests have been shown to have adequate to good concurrent validity with pen-and-paper cognitive tests measuring similar cognitive domains (Gonçalves et al., 2018) and adequate to high test-retest reliability (Gonçalves, Pinho, & Simões, 2016).

An overall score for each subtest was calculated based on several variables derived from the test (e.g., number of correct responses and errors). The individual variables' distributions were analysed, and only the variables that discriminated the subjects were included in the overall scores. Normally distributed variables were categorised according to quartiles, and heavily skewed variables were sorted into four groups to resemble quartile-based categorisation. Next, the quartiles and categories were given values from 1 to 4, and all the variables within each subtest were added up to form a sum score for each subtest. Distribution analyses were performed for the sum variables, and these scores were then normalised with the rank order normalisation procedure. Thus, the final variables were normally distributed with a mean of 0 and standard deviation of 1 and treated as continuous variables in this study. For a more detailed description of the CANTAB tests and variables used in the study, see Rovio et al (2016).

Socioeconomic factors of the participants and their parents included education level and annual income. Both the participants' and their parents' educational levels were classified into three categories (1 = comprehensive school, i.e., the first 9 years of school; 2 = high school or occupational school; 3 = academic, i.e., university or college) and treated as categorical variables. The parental annual income variable was assessed in 1980 and consisted of eight categories (1 = less than 15 000 Finnish mark; 8 = more than 100 000 Finnish mark). Participants' annual income was assessed with a 13-point scale, where a score of 1 represented an income of less than 5000 € per year and 13 more than 60,000 € per year. Both income variables were treated as continuous variables. All socioeconomic factors were added to the models as separate variables.

2.3 Statistical analyses

Statistical analyses were conducted using the version 27 of IBM Statistics SPSS. First, attrition analyses were performed using the χ^2 test for categorical variables and the independent samples t-test for continuous variables. Then, correlations between all variables were examined. The data were then analysed using multivariate linear regression analysis and multivariate analysis of variance (MANOVA), because these analyses take into account moderate correlations between the dependent variables and decrease the possibility of incorrectly rejecting the null hypothesis. The four subtests of CANTAB were used as outcome variables simultaneously. Outliers were examined graphically to ensure there were no data units outside the range of measurement. Additionally, the variables were examined graphically to ensure that they fulfilled the assumptions of multivariate regression analysis and MANOVA.

Two sets of multivariate regression analyses were conducted. First, it was examined whether vital exhaustion was cross-sectionally associated with cognitive performance in 2012. That is, the continuous score of vital exhaustion in 2012 was set as an independent variable to the model. To investigate whether depressive symptoms were cross-sectionally associated with cognitive performance, a similar analysis was done with the continuous score of current depressive symptoms as the predictor. These analyses were done separately because of high correlations and multicollinearity between the scores of the MQ and the BDI (Vroege et al., 2012). Both analyses were adjusted for the participants' age, sex, and participants socioeconomic factors in adulthood (income and educational level in 2011) as well as parents' socioeconomic factors (parents' income and educational level in 1980). In these two analyses, the control variables and the variables of interest were added to the regression models simultaneously. Thus, the total coefficients of determination (R^2) were calculated. In order to correct for multiple comparisons, a Bonferroni correction was used and p values < .0125 were considered as statistically significant.

To examine how chronic vital exhaustion was associated with cognitive performance, the development of vital exhaustion over the follow-up was analysed. First, the vital exhaustion variables from 2001, 2007, and 2012 were categorised into three classes according to percentiles: low vital exhaustion (the lowest 25 percent of the MQ scores), high vital exhaustion (the highest 25 percent), and moderate vital exhaustion (the middle 50 percent). Second, the participants were sorted into four groups depending on how their exhaustion scores changed during the study: *consistently high exhaustion* (i.e. participants with high vital exhaustion in 2001, 2007, and 2012), *increasing exhaustion* (participants with either low exhaustion in 2001 and moderate to high vital exhaustion in 2007 and 2012 or moderate vital exhaustion in 2001, moderate to high exhaustion in 2007 and high exhaustion in 2012), *decreasing exhaustion* (participants who had high exhaustion in 2001 but moderate to low exhaustion in 2007 and 2012, and participants with moderate exhaustion in 2001, low to moderate exhaustion in 2007 and low exhaustion in 2012) and *consistently low exhaustion* (low exhaustion in 2001, 2007, and 2012). These four groups were used as a grouping variable in the MANOVA to investigate the differences in the CANTAB test scores. To correct for multiple comparisons, a Bonferroni correction was used for the *p* values of the subsequent one-way analysis of variance and post-hoc tests.

To address the final research question and investigate whether comorbid depressive symptoms and vital exhaustion may have additive effects on cognitive performance, previously used clinical cut-off points of 14 for the MQ (Vroege et al., 2012) and 10 for the BDI (Beck et al., 1988) were used to categorise the participants into four groups: *depression without exhaustion* (i.e. participants who had clinically significant depressive symptoms but no significant vital exhaustion), *exhaustion without depression* (participants with clinically significant vital exhaustion but no significant depressive symptoms), *neither* (participants who had no significant depressive symptoms nor vital exhaustion) and *both* (participants with clinically significant depressive symptoms and vital exhaustion). The cognitive performance of these four groups was then compared using MANOVA. To correct for multiple comparisons, a Bonferroni correction was used for the *p* values similarly to the MANOVA described previously.

3. RESULTS

3.1 Sample characteristics

Table 1 summarises background variables for the total sample. Participants' age varied from 35 to 50, and 57.97 % were female. Most of the participants had either a high school (51.66 %) or academic (45.53 %) education, compared to only 2.81 % in the comprehensive school category. The most common developmental trajectories of exhaustion were decreasing exhaustion (34.75 %) and increasing exhaustion (31.98 %), whereas fewer participants remained at the consistently low (17.38 %) or consistently high (15.90 %) levels of exhaustion. Most participants did not have clinical levels of stress-related exhaustion or depression (78.78 %), and it was more common to have comorbid exhaustion and depression (14.53 %) than to only have exhaustion (6.91 %) or depression (3.77 %).

Attrition analyses were performed by comparing the participants included in the study to those who were excluded because of missing data. The attrition analyses were performed with regard to all the study variables. There was no attrition bias in age, depressive symptoms, stress-related exhaustion, or participants' income. However, the study sample included more females (58.01 % vs. 47.07 %, χ^2 (1) = 39.36, p < .001) and more academically educated participants (51.61 % vs. 20.19 %, χ^2 (2) = 308.58, p < .001) than the excluded group. Furthermore, participants with highly educated parents were also slightly over-represented in the study sample (26.42 % vs. 24.18 %, χ^2 (2) = 2.86, p < .001).

Table 1. *Descriptive statistics of the sample.*

		Frequency (%)	Mean (SD)	Measurement range
Sex				
	Female	738 (57.97 %)		
	Male	535 (42.03 %)		
Age			42.91 (5.07)	35-50
Participants' educational level				
	Comprehensive school	27 (2.81 %)		
	High school	497 (51.66 %)		
	Academic	438 (45.53 %)		
Participants' annual income			7.37 (3.04)	1-13
Parents' educational level				
	Under 9 years	416 (33.23 %)		
	9–12 years	505 (40.34 %)		
	Over 12 years	331 (26.44 %)		
Parents' annual income			4.89 (1.95)	1-8
Exhaustion in 2001			8.89 (7.73)	0-42
Exhaustion in 2007			8.67 (8.27)	0-42
Exhaustion in 2012			8.65 (8.34)	0-42
	Non-exhausted	1000 (78.55 %)		
	Exhausted	273 (21.45 %)		
Developmental trajectories of exhaustion				
	Consistently high	86 (15.90 %)		
	Consistently low	94 (17.38 %)		
	Decreasing	188 (34.75 %)		
	Increasing	173 (31.98 %)		
Depression in 2012 (BDI)			5.00 (6.51)	0-63
	Non-depressed	1040 (81.70 %)		
	Depressed	233 (18.30 %)		
Exhaustion and depression in 2012				
	Exhaustion without depression	88 (6.91 %)		
	Depression without exhaustion	48 (3.77 %)		
	Neither	952 (78.78 %)		
	Both	185 (14.53 %)		

N = 1273. All participants in at least one analysis are included.

Table 2. *Correlations between all variables.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. PAL											
2. RTI	.11**										
3. RVP	.26**	.18**									
4. SWM	.22**	.13**	.26**								
5. Sex	-.03	.12**	.06*	.11**							
6. Age	-.24**	-.15**	-.10**	-.21**	.02						
7. Parental income	.10**	.02	.17**	.03	.01	-.03					
8. Parental education	.22**	.07*	.19**	.08**	.03	-.29**	.48**				
9. Education	.16**	.12**	.27**	.09**	-.08**	-.17**	.23**	.29**			
10. Income	.12**	.08**	.24**	.06*	.28**	.04	.17**	.14**	.32**		
11. MQ	-.01	-.11**	-.06*	-.04	-.10**	.01	-.09**	-.02	-.05	-.19**	
12. BDI	-.04	-.10**	-.07**	-.05	-.11**	.00	-.07*	-.03	-.07*	-.19**	.78**

** Correlation is significant at the 0.01 level (2-tailed, uncorrected). * Correlation is significant at the 0.05 level (2-tailed, uncorrected).

PAL = the Paired Associates Learning test, RTI = the Reaction Time test, RVP = the Rapid Visual Information Processing test, SWM = the Spatial Working Memory test, MQ = the Maastricht Questionnaire score in 2012, BDI = the Beck Depression Inventory score in 2012.

Correlations between all the variables used in the study are depicted in Table 2. There were comparatively weak positive correlations (r = .11–.26, p < .01) between all the CANTAB subtests. High scores on the MQ were strongly correlated with higher scores on the BDI (r = .78, p < .01). Participants' income and educational level as well as parental education level had weak positive correlations with all the cognition variables (r = .06–.27, p < .01), meaning that high educational and income levels were associated with higher scores on the CANTAB tests.

3.2 The associations between current stress-related exhaustion and cognitive performance

To examine the associations between current stress-related exhaustion and cognitive performance, vital exhaustion (measured by the MQ score) was used in a multivariate regression analysis to predict the scores of all the CANTAB subtests. Initially, interaction between sex and stress-related exhaustion was investigated. There was no statistically significant interaction, so women and men were included in the same analysis.

Table 3 summarises the results of the multivariate regression analysis. After the Bonferroni correction, high stress-related exhaustion was associated with lower scores on the Reaction Time test. There were no associations between stress related exhaustion and the Paired Associated Learning score, the Rapid Visual Information Processing score, or the Spatial Working Memory score. The regression models explained 5–12 % of the variance in the CANTAB tests.

Table 3. *The results of multivariate regression analysis: associations between current vital exhaustion and the CANTAB tests, when predicting cognitive performance with current vital exhaustion.*

	B	95 % CI	*p* (uncorrected)	Model R^2
PAL	0.12	-0.03; 0.26	.11	.09
RTI	-0.21	-0.37; -0.06	<.01	.05
RVP	0.03	-0.12; 0.18	.72	.12
SWM	-0.05	-0.20; 0.10	.51	.07

N = 905

After the Bonferroni correction for multiple testing, p values less than .0125 were considered significant.

Age, sex, education, income, parental education, and parental income were controlled in the model.

3.3 The associations between current depressive symptoms and cognitive performance

The associations between current depressive symptoms and cognitive performance were also investigated using a multivariate regression analysis, where the BDI was used to predict all the CANTAB test scores. There was no interaction between depressive symptoms and sex, so women and men were included in the same analysis.

The overall results are displayed in Table 4. After the Bonferroni correction, there were no significant associations between depressive symptoms and the Reaction Time score, Paired Associated Learning score, the Rapid Visual Information Processing score, or the Spatial Working Memory score. There was a weak trend between high stress-related exhaustion and lower scores on the RTI test, but the association did not survive the Bonferroni correction for multiple testing. The regression models explained 5–12 % of the variance on the CANTAB tests.

Table 4. *The results of multivariate regression analysis: associations between current depressive symptoms and the CANTAB tests, when predicting cognitive performance with depressive symptoms.*

	B	95 % CI	p (uncorrected)	Model R^2
PAL	0.02	-0.11; 0.16	.72	.08
RTI	-0.18	-0.33; -0.03	.02	.05
RVP	-0.01	-0.16; 0.13	.84	.12
SWM	-0.08	-0.22; 0.06	.27	.07

N = 904

After the Bonferroni correction for multiple testing, *p* values less than .0125 were considered significant.

Age, sex, education, income, parental education, and parental income were controlled in the model.

3.4 The associations between different developmental trajectories of exhaustion and cognitive performance

A multivariate analysis of variance was performed to investigate the differences between all four exhaustion groups (*consistently high exhaustion, consistently low exhaustion, increasing exhaustion,* and *decreasing exhaustion*) in all the CANTAB subtests. In the MANOVA, exhaustion had a main effect on the performance in the CANTAB tests [Wilks' λ =.95, $F(12, 1413) = 2.13$, $p = .01$]. To investigate the different tests of CANTAB further, multiple one-way analyses of variance were performed for each subtest. There were differences between the different exhaustion groups in in the RTI test ($F(3) = 4.68$, Bonferroni corrected $p = .012$), but none of the other associations with the CANTAB subtests remained significant after the Bonferroni correction. Finally, pairwise comparisons were performed for the RTI test. The findings are illustrated in Figure 1. The *consistently high exhaustion* group had significantly lower scores on the RTI test compared to the *decreasing exhaustion* group (Bonferroni corrected $p < .01$), whereas the other group differences were statistically insignificant. As can be seen from Figure 1, however, there appeared to be trend-level differences so that the *consistently high exhaustion* group also seemed to have slightly lower performance in the RTI test than *the consistently low exhaustion* group and *the increasing exhaustion* group, but these differences did not reach statistical significance.

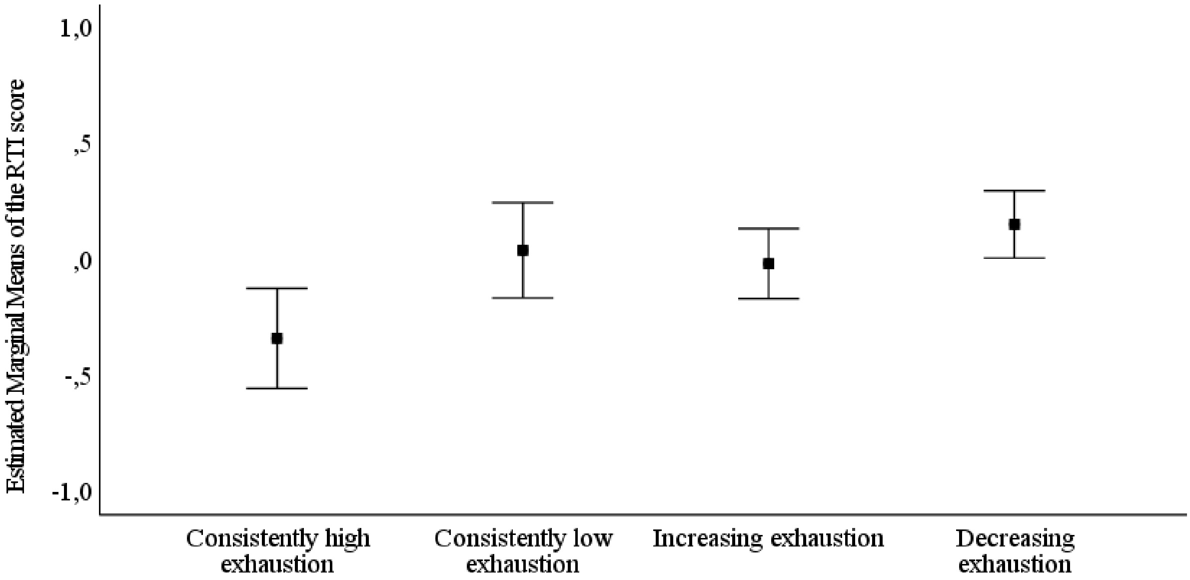

Figure 1. *Estimated marginal means with 95 % confidence intervals of the RTI scores: comparisons between the different trajectories of stress-related exhaustion in 2001, 2007, and 2012.*

3.5 The additive effects of comorbid stress-related exhaustion and depression on cognitive performance

The four combination groups of vital exhaustion and depression (*depression without exhaustion, exhaustion without depression, both,* and *neither*) were compared using a MANOVA, where all four CANTAB subtests were set as dependent variables. In the MANOVA, there were differences between the four groups in cognitive performance [Wilks' $\lambda = .97$, $F(12, 3350) = 2.78$, $p < .001$]. In the separate one-way analyses of variance, there were differences between the groups in the RTI test [$F(3) = 8.01$, Bonferroni corrected $p <.001$] but not in the other CANTAB subtests. In the subsequent pairwise comparisons, the *neither* group had higher scores in the RTI than all three other groups (Bonferroni corrected $p = .02$ when compared to the *depression without exhaustion* group; $p < .01$ compared to the *exhaustion without depression* group; and $p = .04$ compared to the *both* group). There were no significant differences between these three groups. These findings are displayed in Figure 2.

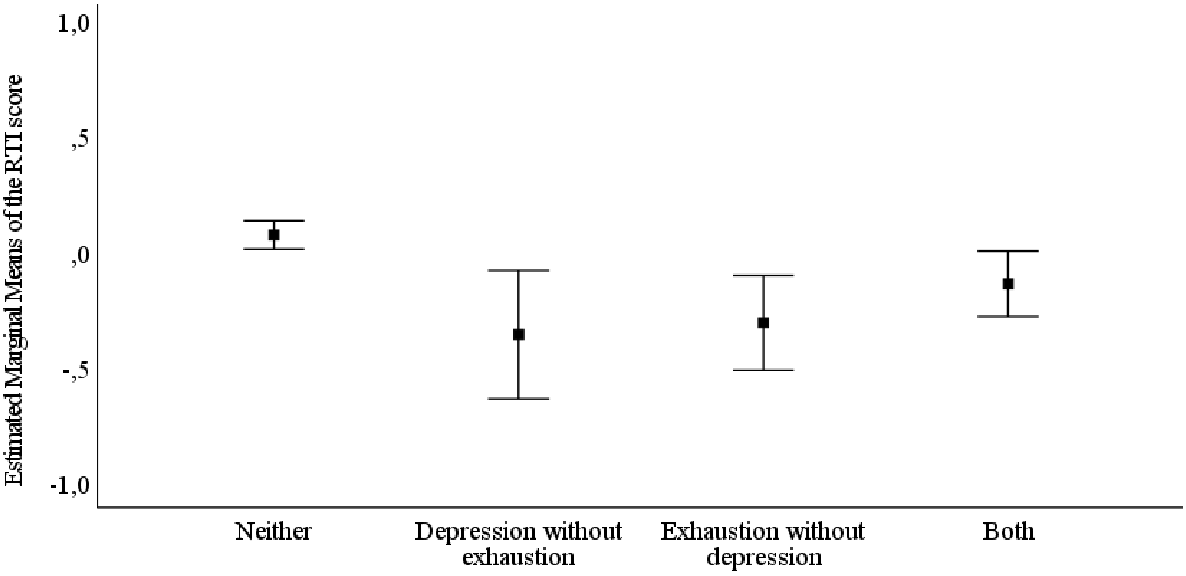

Figure 2. *Estimated marginal means with 95 % confidence intervals of the RTI scores: comparisons between the different depression and exhaustion groups.*

4. DISCUSSION

The goals of this study were to examine i) whether high stress-related exhaustion is associated with lower cognitive performance and whether these associations are specific to certain cognitive subdomains or more general relating to all cognitive subdomains; ii) whether different trajectories of stress-related exhaustion over time are differently associated with cognitive performance; iii) whether depressive symptoms and stress-related exhaustion are differently associated with cognitive performance; and iiii) whether individuals with comorbid stress-related exhaustion and depression have lower cognitive performance than individuals with at most one of them (i.e., whether comorbid stress-related exhaustion and depression might have additive effects on cognitive performance). Contrary to the hypothesis, the only associations found between stress-related exhaustion and cognitive performance were in reaction time, i.e., speed of response and movement. Thus, the association between high stress-related exhaustion and lower cognitive performance was related to a narrower cognitive subdomain than was expected. Furthermore, chronic stress-related exhaustion had a stronger association with cognitive performance than other trajectories of exhaustion. This association was observed only in the reaction time task, which was in line with the other results. Moreover, depressive symptoms had no significant linear associations with cognitive performance, which was different from the hypothesis. However, in the comparisons between the depression and exhaustion groups, depressed individuals had poorer performance in reaction time than non-depressed participants, indicating a possible cut-off effect of clinical depression. Finally, the results tentatively suggested that comorbid clinical depression and stress-related exhaustion may not have additive effects on cognitive performance in any cognitive subdomain.

4.1 The associations between cognitive performance and current symptoms of stress-related exhaustion or depression

The main result of the cross-sectional analyses was that current stress-related exhaustion was associated with poorer performance on tasks that require speed of response and movement. This is in line with previous research (Ellbin et al., 2018; Jonsdottir et al., 2013; Oosterholt et al., 2014, 2012; Österberg et al., 2009, 2012, 2014).

However, other cognitive subdomains that have previously been associated with stress-related exhaustion such as sustained attention (Ellbin et al., 2018; Jonsdottir et al., 2017; Krabbe et al., 2017b; Sandström et al., 2005; Sokka et al., 2017; Van Der Linden et al., 2005; Vitaliano et al., 2007) and executive functions (Beck et al., 2013; Dam et al., 2011; Diestel et al., 2013; Ellbin et al., 2018; Feuerhahn et al., 2013; Jonsdottir et al., 2013; May et al., 2015; Öhman et al., 2014; Van Der Linden et al., 2005), did not have any associations with stress-related exhaustion in this study. This is partly in line with one earlier study that found no associations between stress-related exhaustion and cognitive performance in a population-based sample (Castaneda et al., 2011). Therefore, the incongruity of these results compared to many earlier studies could be explained by the non-clinical sample. There are also previous findings of only reaction time being impaired in clinical stress-related exhaustion, while other cognitive domains, such as sustained attention or episodic memory, remain at normative levels (Österberg et al., 2009). However, it has been called into question whether the burnout patients may have initially had higher levels of cognitive performance than the controls, since their cognitive performance improved in a follow-up measurement (Österberg et al., 2012). Thus, the lack of a baseline measurement could be another explanation for the differences in the current results compared to earlier studies.

Moreover, stress-related exhaustion was not associated with the performance in visuospatial associative learning, which was in line with the hypothesis. In some previous studies, episodic memory (Jonsdottir et al., 2013) and spatial memory (Österberg et al., 2012; Sandström et al., 2005) have been impaired in stress-related exhaustion, but no previous studies have examined specifically the relationship between stress-related exhaustion and visuospatial associative learning. Furthermore, most previous studies have used verbal memory tasks to investigate memory performance (Ellbin et al., 2018; Jonsdottir et al., 2017, 2013; Malmberg et al., 2020b; Öhman et al., 2014), so these findings provide new information on visual memory and learning performance in stress-related exhaustion.

Regarding the linear associations between depressive symptoms and cognitive performance, somewhat unexpected results were found. There were no associations between depressive symptoms and performance in any cognitive subdomains measured: reaction time, visuospatial associative learning, sustained attention, or executive functions. This contrasts with earlier studies where depression has been shown to be associated with a general decline in cognitive performance (Parkinson, Rehman, Rathbone, & Upadhye, 2020) and poorer performance on the same CANTAB tests used in this study (Rock et al., 2014). Although, there was a weak, not quite significant trend between high levels of depressive symptoms and slower performance in the reaction time task; a cognitive domain that has been impaired in depression in previous studies (Azorin, Benhaïm, Hasbroucq, & Possamaï, 1995).

Compared to the lack of linear relationships between depressive symptoms and cognitive performance, there was a clearer association between clinically significant depression and slower reaction times in the depression and exhaustion group comparisons. One explanation could be that only clinical depression has been associated with slower reaction times (Azorin et al., 1995), and this is captured better by comparing depressed individuals to non-depressed counterparts. In line with this idea, the incongruence between these results and some previous studies could be explained by the population-based sample. Most participants had quite low levels of depressive symptoms, which is typical for a non-clinical sample, since the prevalence of clinical depression is about 10 % (Bretschneider, Kuhnert, & Hapke, 2017; Lindeman et al., 2000). Earlier studies using population-based samples have found that while severe depression is associated with a decline in cognitive performance, lower levels of depressive symptoms may not be (Airaksinen, Larsson, Lundberg, & Forsell, 2004). Thus, the findings of this study support the idea of studying subclinical depressive symptoms and clinical depression separately, because depressive symptoms appear to be associated with lower levels of cognitive performance only when subclinical cases of depression are not included in the investigation, at least in the cognitive domains measured in this study.

Furthermore, previous population-based studies have found a relationship between depression and cognitive decline in older adults (Pantzar et al., 2014; Pantzar et al., 2017), but not in young adults (Castaneda et al., 2008). Therefore, it is possible that even though depression was not linearly associated with cognitive performance in the age group studied here, the effects of depression might become visible later in life.

4.2 The development of stress-related exhaustion over time and cognitive performance

As expected, different trajectories of stress-related exhaustion over time were differently associated with cognitive performance, specifically performance in reaction time. Interestingly, the statistically significant difference was between chronic stress-related exhaustion and decreasing stress-related exhaustion. Still, some trend-level differences were also observed: the group with consistently high exhaustion appeared to have slightly lower performance in the reaction time task than the groups with increasing or consistently low exhaustion, too, although these differences did not reach statistical significance. Thus, the main finding is that the group with consistently high exhaustion performed poorer in the reaction time task than the other groups. In other words, chronic stress-related exhaustion was more strongly associated with lower cognitive performance than short-term exhaustion, which was congruent with the hypothesis. These findings are partly in contrast with previous evidence supporting long-lasting cognitive impairments even after recovery from stress-related exhaustion (Dam et al., 2012; Jonsdottir et al., 2017; Oosterholt et al., 2016; Österberg et al., 2014), but consistent with other studies that have found improvement in cognitive performance when the symptoms of exhaustion have ameliorated (Beck et al., 2013; Österberg et al., 2012). However, the follow-ups in all these studies have been considerably shorter than in this study, lasting from twelve weeks up to three years. The findings of this study support the notion that cognitive performance may recover several years after stress-related exhaustion, but more research is needed to confirm exactly how long this recovery takes. It must also be noted that no direct causal inferences can be made about the recovery of cognition without a baseline measurement. Additionally, the sizes of the groups with consistently high and consistently low exhaustion were comparably small, so these results should be interpreted with caution – more research on the topic is needed with larger and more balanced samples. Nevertheless, these results provide important new information on the effects of chronic stress-related exhaustion lasting several years and tentative evidence on cognitive recovery after exhaustion.

4.3 The cognitive effects of comorbid clinical stress-related exhaustion and depression

There have previously been no studies directly investigating how comorbid stress-related exhaustion and depression affect cognitive performance. When comparing the groups formed according to the clinical cut-off points in depression and vital exhaustion scores (*exhaustion without depression*, *depression without exhaustion*, *both*, and *neither*), it was found that the group that suffered from neither condition performed significantly better than all other groups on the reaction time task. There were no associations between any other cognitive subdomain and group membership: for example, participants who had either clinical depression or stress-related exhaustion did not differ from each other in cognitive performance. This finding suggests that comorbid stress-related exhaustion and depression do not have additive effects on cognitive performance, but rather that they have very similar associations with poorer performance in specifically reaction time. This is in contrast with previous findings about depression and comorbid disorders: it has been found that comorbid psychiatric disorders have a significant additive effect on cognitive impairment in depression (Baune, Mcafoose, Leach, Quirk, & Mitchell, 2009). It is conceivable that stress-related exhaustion and depression share some key aspect that specifically impacts the speed of response and movement, as there is also significant overlap between their symptoms (Bianchi & Brisson, 2019; Bianchi et al., 2021, 2017; Frestad & Prescott, 2017; Schonfeld & Bianchi, 2016). For instance, this could be the somatic factor of depression that has been shown to be similar to the concept of vital exhaustion (Vroege et al., 2012). Finally, it must be noted that the *depression without exhaustion* and the *exhaustion without depression* groups were relatively small. This supports the idea that these conditions partly overlap but also adds a degree of uncertainty to the conclusions of this study. Therefore, more research is needed with larger subgroups.

4.4 Strengths, limitations, and future research

This study has several strengths. First, the original sample was population-based, which improves the generalisability of the results. Second, most previous studies on the subject have been conducted on clinical burnout patients (Jonsdottir et al., 2013; Oosterholt et al., 2014, 2016; Van Der Linden et al., 2005). Therefore, this study considered the whole spectrum of exhaustion symptoms, and the results provide important insight into how stress-related exhaustion affects the general population. Third, this study had longitudinal data on stress-related exhaustion. There are very few studies on the associations between chronic stress-related exhaustion and cognitive performance, so this study extends our understanding of the cognitive effects of long-term stress-related exhaustion. Fourth, age, sex, and socioeconomic status were controlled in the study: thus, the results cannot be explained by age differences or the effects of poverty. Fifth, this was the first study to investigate the association between specifically vital exhaustion and cognitive performance: most studies examining the relationship between stress-related exhaustion cognitive performance have used the concept of burnout. The results can broaden our understanding of disorders related to vital exhaustion, such as cardiovascular disorders. Sixth, all the main measures (the CANTAB, the BDI, and the MQ) in the study are widely used and their validity and reliability are well-researched (Appels et al., 1987; Erford et al., 2016; Gonçalves et al., 2016, 2018; Kudielka et al., 2006; Nicolson & Van Diest, 2000; Reynolds & Gould, 1981). Seventh, the use of an objective measure of cognitive abilities reduced common method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), meaning that the associations observed in the study cannot be solely explained by similar methods used to measure all the variables of interest. Eighth, using multivariate analysis of variance and regression allowed for moderate correlations between the dependent variables, which reduced the possibility of perceiving false associations.

Some limitations must also be considered. Although the CANTAB included tests that assessed cognitive subdomains usually associated with stress-related exhaustion, there were some disadvantages to using the test battery. For example, the cognitive tests used in this study took a relatively short time to perform. Thus, it was not possible to observe whether the participants' performance would have deteriorated over time because of fatigue or difficulties in concentration – which has been the case in some previous studies (Krabbe et al., 2017a). Furthermore, the tests used in this study did not include a highly demanding measure of executive functions, although the SWM test requires a self-organised search-strategy and problem solving. It has been established that participants with high stress-related exhaustion perform poorly compared to controls especially in tasks that place particularly high demands on executive control (Diestel et al., 2013; Van Der Linden et al., 2005). Thus, it is possible that all the associations between high stress-related exhaustion and poor performance in executive functions might not have been perceived in this study. Finally, the CANTAB is heavily focused on non-verbal measures of cognitive performance; therefore, this study did not provide information on the associations between stress-related exhaustion and verbal cognitive performance. Nevertheless, according to some previous studies, stress-related exhaustion may not affect verbal cognitive performance as much as visual performance (Sandström et al., 2005). Considering these possible limitations, future research should incorporate a more comprehensive assessment of cognitive functions, including more demanding measures of executive functions and verbal cognition.

Additionally, the results might have been influenced by the measures used to assess the symptoms of stress-related exhaustion and depression. Self-report questionnaires always involve a degree of subjective interpretation. For example, it is possible that participants under-reported psychiatric symptoms because of the stigmatisation of mental health problems (Picco, Pang, Wen, Jeyagurunathan, & Satghare, 2016). In future research, it would be important to include a more comprehensive clinical assessment and information about the psychiatric diagnoses of the participants. This would help to distinguish between different degrees of stress-related exhaustion and depression, provide information on the causes of the symptoms (for instance whether the experienced stress-related exhaustion is connected to the working environment, stressful life-events, or a symptom of another psychiatric or somatic illness), and give insight into the day-to-day functioning of the exhausted or depressed participants. Additionally, a more thorough clinical assessment would allow for comparisons between the participants' subjective evaluations of cognitive problems and their objective cognitive test performance, which previous evidence shows are not always correlated (Horvat & Tement, 2020; Oosterholt et al., 2014; Österberg et al., 2009, 2012; Wekenborg et al., 2018). Furthermore, including information about diagnoses would eliminate the possibility of confounding psychiatric and substance abuse disorders that may influence both stress-related exhaustion (Ahola et al., 2006; Qiu et al., 2012) and cognitive performance (Baune et al., 2009; Latvala et al., 2009).

Regarding the different trajectories of stress-related exhaustion, the follow-up points of the symptoms were six years apart, so it is not possible to account for the variation of symptoms between these measurements. Although the vital exhaustion scores from 2001, 2007, and 2012 had strong correlations with each other, there were still distinctly different developmental trajectories of stress-related exhaustion over time. Furthermore, about a third of the participants remained at the highest or lowest exhaustion levels in all measurement points, indicating that in most participants, exhaustion changed over time, but that there was a subgroup of participants who may have been clinically exhausted over the whole follow-up. This was in line with previous findings suggesting that about a third of the patients treated for stress-related exhaustion still have clinically significant levels of exhaustion after seven years (Glise, Wiegner, & Jonsdottir, 2020). More research is needed to recognise the factors that contribute to stress-related exhaustion becoming chronic. In general, stress-related exhaustion can be associated with both contextual factors, such as unfavourable psychosocial working environments (Hadžibajramović, Ahlborg, & Grimby-Ekman, 2019), and individual attributes, for instance personality traits (Zellars, Hochwater, Perrewé, Hoffman, & Ford, 2004). Additionally, it has been found that in chronic burnout, stress-related exhaustion and environmental job stressors can turn into a vicious cycle, where elevated symptoms of burnout increase perceptions of job stressors, which in turn exacerbate the burnout symptoms (Guthier, Dormann, & Voelkle, 2020). In future research, it would be important to identify the specific factors that make individuals vulnerable to the development and maintenance of chronic stress-related exhaustion and consequently cognitive decline. Moreover, future studies should investigate whether chronic stress-related exhaustion lasting several years is caused by adverse environments, personality traits, or the bidirectional relationship between these two. To achieve this, future research should address personality traits and changes in the participants' life circumstances and include more frequent follow-up measurements of the psychiatric symptoms.

Moreover, cognitive performance was only measured at one point in time, allowing only cross-sectional analyses but not analyses of causal relationships. However, previous studies have indicated that it is unlikely that lower premorbid cognitive performance functions as a vulnerability for developing stress-related exhaustion (Feuerhahn et al., 2013; Jonsdottir et al., 2017; Österberg et al., 2012). Thus, it seems unlikely that the findings of this study could be exclusively explained by lower premorbid cognitive performance leading to more stress-related exhaustion. To gain a deeper understanding of chronic stress-related exhaustion and its effects on cognitive performance, future research should include prospective assessments of cognitive performance. Moreover, more research is needed on how ageing affects the relationship of stress-related exhaustion and cognitive performance. There is tentative evidence on executive functions changing during middle adulthood: cognitive performance in working memory, inhibitory control, and planning abilities seems to decline beginning as early as 30–40 years old (Ferguson, Brunsdon, & Bradford, 2021). Thus, examining the relationship between stress-related exhaustion and executive functions in a longitudinal study would provide important information on whether prolonged stress impacts the process of cognitive ageing.

Finally, the sample used in the study was slightly skewed towards women. However, since there was no interaction between sex and stress-related exhaustion nor depressive symptoms in association with cognitive performance, it is unlikely that the findings of this study would be explained by the attrition bias. In earlier studies, it has been found that stress-related exhaustion is slightly more common in women than men (Innstrand, Langballe, Falkum, & Aasland, 2011; Redondo-Flórez, Tornero-Aguilera, Ramos-Campo, & Clemente-Suárez, 2020). However, there are gender differences in different aspects of stress-related exhaustion: women seem to be higher in emotional exhaustion, whereas men have higher levels of depersonalisation (Innstrand et al., 2011; Purvanova & Muros, 2010). Regarding depression, there is also a gender difference, particularly in reporting somatic symptoms: women consistently report more somatic symptoms than men (Chaudhry, Arshad, Javed, & Asif, 2010; Silverstein, 1999; Wenzel, Steer, & Beck, 2005). Further research should be conducted to explore whether these different factors of stress-related exhaustion and depression are differently associated with cognitive performance and whether the gender differences in experiencing these specific symptoms are significant with regard to cognitive performance.

4.5 Practical implications

These findings have several clinical and societal implications. Since symptoms of stress-related exhaustion and depression were not associated with poorer performance on all cognitive measures, the results suggest that even clinically significant exhaustion and depression may not necessarily affect one’s performance level, for example, in professions demanding high performance in working memory or sustained attention. It appears that only reaction times may be slower in individuals with clinical and subclinical stress-related exhaustion and clinical levels of depression, but changes in reaction time may not be easily detected in all professions. Therefore, signs of stress-related exhaustion should not be ignored based on an individual’s attentiveness or good memory performance at work or other contexts. It has also been found in previous studies that exhaustion does not predict always predict job performance (Feuerhahn et al., 2013). According to the current findings, even highly exhausted or depressed people may perform at a seemingly normal level, yet if their psychiatric symptoms are ignored in healthcare, they could be in risk of more serious health complications such as suicide (Edwards & Wilkerson, 2020).

Furthermore, these results give insight into differentiating between stress-related exhaustion and depression. The findings of this study give tentative support to the idea that stress-related exhaustion and clinical depression have quite similar effects on cognition, namely reaction speed. Moreover, the two conditions do not seem to have additive effects on cognitive performance: depressed, exhausted, and comorbidly depressed and exhausted individuals have similar cognitive impairments. Some earlier studies have hypothesised that the cognitive effects of stress-related exhaustion may be caused by depressive symptoms (Oosterholt et al., 2014) and found that comorbid psychiatric disorders in depression have additive effects on cognition (Baune et al., 2009). In contrast, these results suggest that exhaustion has an independent association with cognitive performance and that comorbid depression does not enhance this association. In clinical practice, it should be considered that the two conditions may overlap and that cognitive evaluations are not a sufficient tool for distinguishing between them. Thus, there should be careful psychological assessment involved in the diagnostic process, and contextual factors, such as work stress and previous depressive episodes, should be taken into account.

Moreover, the finding that speed of response and movement are slower in highly exhausted individuals should be taken into consideration in professions that require fast reactions, such as emergency service workers and professional drivers. These professions should be considered a high-risk population for the cognitive effects of stress-related exhaustion for multiple reasons. First, these occupations have built-in elements of vulnerability: working irregular hours and night shifts (Cheng & Cheng, 2017; Peterson et al., 2019) and exposure to potentially traumatic events (Adriaenssens, De Gucht, & Maes, 2015; Kim et al., 2019) are associated with developing stress-related exhaustion. Second, shift-work itself may enhance cognitive impairment in these professions: for example, sleep disturbances caused by shift-work have adverse effects on reaction time performance in firefighters (Stout, Beidel, Brush, & Bowers, 2020), and multiple consecutive shifts reduce vigilance-based reaction times in hospital nurses (Thompson, 2019). Third, slower reaction times could cause potentially dangerous situations in these professions. For instance, fatigue while driving has been found to be associated with traffic accidents (Zhang, Yau, Zhang, & Li, 2016). To conclude, employers and health-care professionals should take into account the cognitive effects of stress-related exhaustion particularly in these professions, and neuropsychological assessment should be easily accessible to determine whether employees are capable of performing the job.

Finally, these findings support the importance of early interventions for stress-related exhaustion, which has also been a consistent conclusion in earlier studies (Maslach & Leiter, 2008; Ojala, Nygård, Huhtala, Bohle, & Nikkari, 2019; Wegner, Berger, Poschadel, Manuwald, & Baur, 2011). It is crucial to treat symptoms of exhaustion before they become chronic, because chronic stress-related exhaustion appears to be associated with more cognitive decline than short-term exhaustion. Therefore, offering well-timed interventions could prevent the symptoms of exhaustion from having long-time effects on cognitive performance.

4.6 Conclusion

In conclusion, the results of this study provide valuable information on the associations between stress-related exhaustion and cognitive performance in the general population. The main finding was that high stress-related exhaustion is associated with slower reaction times, but not with visuospatial associative learning, sustained attention, or executive functions. Also, ongoing, chronic stress-related exhaustion is more strongly associated with slower reaction times than short-term exhaustion experienced years ago, tentatively suggesting that the slowed performance in reaction time may subside after recovery from stress-related exhaustion. Compared to depressive symptoms, high stress-related exhaustion is associated with slower reaction times on subclinical and clinical levels, whereas only clinical levels of depressive symptoms had an association with slower reaction time. Comorbid stress-related exhaustion and depression did not have additive effects on cognitive performance. These findings advance the understanding of the adverse effects of prolonged stress and shed light on the importance of identifying harmful stress-related exhaustion in early stages.

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