Self-reported cognition in Exhaustion Disorder

From brain to experience

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Faculty of Arts and Social Sciences

Psychology

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Self-reported cognition in Exhaustion Disorder:
From brain to experience

Andreas Nelson
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Doctoral Thesis

Till minnet av Svea Mangrell

Hugin och Munin
var morgon flyger
ut över världen vida;
jag för Hugin ängslas,
att han ej hittar tillbaka,
men jag mer för Munin fruktar

Sången om Grimne

Abstract

Exhaustion disorder (ED) is a relatively new diagnosis associated with cognitive symptoms, which are normally assessed using standardized cognitive tests or questionnaires targeting everyday cognitive failures (i.e., subjective cognitive complaints, SCCs). The purpose of this thesis was to add empirical knowledge on the self-reported, first-hand experience of cognitive function in ED. More specifically, it aimed to learn how SCCs relate to test performance, psychological distress and neural activity. Further objectives were to evaluate the types of difficulties being expressed, and what aspects can be considered helpful or hindering with respect to cognitive recovery.

Study 1 found that when compared to healthy controls, ED patients reported substantially higher levels of SCCs, and were more likely to express difficulties in situations without external memory cues. In both groups, the level of SCCs was correlated with psychological distress and not with cognitive test-results. Using functional magnetic resonance imaging, Study 2 investigated the relationship between SCCs, test performance and brain activity. There was no association between SCCs and behavioural results on the in-scanner task, tapping response inhibition. However, a positive correlation was detected between SCCs and relatively more brain activity in a cluster in the right-side occipital lobe during the more difficult task condition. This exploratory finding may indicate compensational neural activity, possibly involving visual processing or the altering between task positive and task negative neural networks. Study 3 analysed interviews with people who had participated in ED-rehabilitation 6-10 years earlier, and displayed a range of individual experiences. Cognitive symptoms had been highly distressing. Lingering problems were also noted in several cognitive areas, but maintenance of attention and executive control may be domain-general areas of importance. Cognitive recovery was seen as closely tied to context, including the overall life situation and general recovery from ED, which varied between individuals. Hence, different restorative or compensatory strategies were considered helpful, as were optimization of the external

environment and a change in approach towards the own self and cognitive performance.

In sum, this thesis studied the subjectively reported cognitive symptoms in ED. It has supported and extended previous findings by showing how substantial cognitive difficulties may be experienced, and that the expression of these problems is intricately linked to different facets and levels of cognition.

Sammanfattning på svenska

Utmattningssyndrom (US) är en relativt ny diagnos som innefattar kognitiva symtom, vilka kan undersökas antingen med standardiserade kognitiva test eller självskattningsformulär som mäter kognitiva misstag och problem i vardagen. Syftet med den här avhandlingen var att öka kunskapen om den upplevda, självrapporterade erfarenheten av kognitivt fungerande. Mer specifikt så har avhandlingen undersökt hur självskattning relaterar till prestation på kognitiva test, psykologiskt mående, och hjärnaktivitet. Den har också granskat vilken typ av kognitiva svårigheter som rapporteras, och vad som har upplevts vara hjälpsamt eller hindrande för återhämtning av kognitiva problem.

Studie 1 jämförde personer som diagnosticerats med US med friska kontrollpersoner och visade att patientgruppen rapporterade betydligt mer kognitiva svårigheter i vardagen, särskilt i situationer utan påminnelser i miljön. I båda grupperna korrelerade självskattning med mående, men inte med kognitiva testresultat. Studie 2 undersökte förhållandet mellan självskattning, testprestation och hjärnaktivitet. Resultaten visade på att SCCs inte var relaterat till testprestation, men däremot med ökad hjärnaktivitet i ett område i den högra occipitalloben. Det är tänkbart att detta resultat återspeglar kompensatorisk hjärnaktivitet, möjligen relaterad till visuella processer eller växlande mellan olika nätverk i hjärnan. Studie 3 analyserade intervjuer 6-10 år efter att personerna genomgått rehabilitering för ED. Resultaten visade på olika individuella erfarenheter. Bland annat framkom att kognitiva symtom inneburit stort lidande. Svårigheter med att bibehålla kognitiv uppmärksamhet och kontroll tycks ha bidragit till kvarvarande problem i olika kognitiva domäner. Kognitiv återhämtning sågs som nära knutet till kontextuella faktorer, exempelvis livssituationen och återhämtning ifrån US i stort. Eftersom deltagarna skilde sig åt i dessa avseenden så beskrevs både restorativa och kompensatoriska strategier ha varit hjälpsamma. Det gjorde också optimering av miljön, såväl som en förändrad syn på den egna personen och på kognitiv prestation.

Sammanfattningsvis har den här avhandlingen undersökt de upplevda, subjektivt rapporterade kognitiva svårigheterna hos personer med US. Den har utökat tidigare kunskap genom att visa hur individer kan uppleva betydande kognitiva problem, och att uttrycken av de problemen bör förstås i ljuset av olika nyanser och aspekter av kognition.

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Study 1

Nelson, A., Gavelin, H.M., Boraxbekk, C-J., Eskilsson, T., Josefsson, M., Slunga Järvholm, L., & Stigsdotter Neely, A. (2022). Subjective cognitive complaints in patients with stress-related Exhaustion disorder: A cross-sectional study. *BMC Psychology, 9*(1), Article 84. https://doi.org/10.1186/s40359-021-00576-9

Study 2

Nelson, A., Gavelin, H.M., Andersson, M., Josefsson, M., Eskilsson, T., Slunga Järvholm, L., Stigsdotter Neely, A., & Boraxbekk, C-J. (2023). Subjective cognitive complaints and its associations to response inhibition and neural activation in patients with stress-related Exhaustion disorder. *Stress 26*(1), Article 2188092. https://doi.org/10.1080/10253890.2023.2188092

Study 3

Nelson, A., Aronsson, I., Tillfors, M., Stigsdotter Neely, A., &, Gavelin, H.M. (in press; accepted for publication 12 March 2025). The experienced route to cognitive health: Cognitive recovery in persons with prior stress-related Exhaustion disorder. *BMC Psychiatry*.

List of abbreviations

5-QEMP	5-item questionnaire on everyday memory problems
ACT	Acceptance and commitment therapy
ANOVA	Analyses of variance
BOLD	Blood-oxygen-level-dependent
BRIEF	Behavior rating of executive functions
CBT	Cognitive behavioural therapy
CET	Cognitive enhancement therapy
CFQ	Cognitive failures questionnaire
CFS	Chronic fatigue syndrome
D-KEFS	Delis-Kaplan executive function system
DMN	Default mode network
DSM	Diagnostic and statistical manual of mental disorders
ED	Exhaustion disorder
EFs	Executive functions
fMRI	Functional magnetic resonance imaging
HADS	Hospital anxiety and depression scale
HPA	Hypothalamic–pituitary–adrenal
ICD	International classification of diseases
KEDS	Karolinska exhaustion disorder scale
MBI	Maslach burnout inventory
MMR	Multi-modal rehabilitation
MRI	Magnetic resonance imaging
PFC	Prefrontal cortex
PRMQ	Prospective and retrospective memory questionnaire
RECO	Rehabilitation for improved cognition
RT	Response time
SASCI-Q	Sahlgrenska self-reported cognitive impairment questionnaire
SCCs	Subjective cognitive complaints
SCD	Subjective cognitive decline

SMBQ	Shirom-Melamed burnout questionnaire
SMCs	Subjective memory complaints
WM	Working memory

General Introduction

Exhaustion disorder (ED) is a hot topic and since 2018, when this project started, things have happened. On a personal note, I've seen both friends and colleagues been diagnosed with stress-related illness, experiencing long sick leaves and substantial cognitive difficulties, to great cost for themselves and their families. During this period, ED has also been frequently discussed in public discourse, both within and outside of academia. For instance: ED has become one of the leading causes of sick-leave absence in Sweden (Försäkringskassan, 2020, 2024); the diagnosis has been criticized for being under-researched, with consequential knowledge gaps regarding fundamental validity of the construct and symptomology, including cognitive difficulties (Lindsäter et al., 2022; Rück et al., 2022); a revision of the criteria has been proposed, emphasizing cognitive symptoms to a greater extent (Åsberg, 2024). Given this backdrop, writing a thesis about the cognitive sequalae of ED has met engaged reactions, not least from persons themselves diagnosed with the condition. Particularly, a repeated response to a result in the first study - revealing a lack of correlation between subjective cognitive complaints and cognitive test performance - has been: "So do you think that I'm/ they're faking it?". Admittedly prematurely, I would like to introduce this thesis by answering this question clearly: No, I really don't. Rather, the results suggest that such pattern is not unique to people with stress-related exhaustion, and that the methods currently used to detect cognitive difficulties in clinical practice are not telling the whole story. Therefore, in order to fully understand this condition that affects so many in our current society, we need to learn more about what kinds of cognitive symptoms are being expressed, how they relate to cognitive performance and neural processes, and what has been experienced as helpful or hindering with respect to cognitive recovery. My hope is that this work may help shed some light on these questions, and to form early pieces to a puzzle that if solved may lead to more effective recovery, treatment and preventive action.

This thesis summary is arranged as follows: the present introductory section presents previous ED research on cognitive functioning. It also provides some historical context for the concepts of exhaustion and cognition. The introduction closes with a resumé and presentation of the thesis' general aims. The second section describes methodological aspects, specifically concerning the included participants and cognitive measures. The third section recapitulates the three empirical studies. The fourth section discusses the findings and suggests directions for clinical practice and future research.

Exhaustion disorder

In 2005, the diagnosis ED was included to the Swedish version of the International classification of diseases (ICD-10-SE; Grossi et al., 2015; Socialstyrelsen, 2025). Its development was instigated following a surge in psychiatrically related sick-leave in Sweden during the 1990s, the causes of which a group of researchers and clinical practicians was appointed to assess. The subsequent report, along with clinical observations, suggested that many of the noted cases were characterized by signs of exhaustion, differing from the clinical and demographic picture normally associated with depression (Socialstyrelsen, 2003). In order to facilitate more stringent diagnostics for clinical practice and research, formal criteria were developed, stating psychological exhaustion to be a central part of the clinical picture, and that the symptoms are developed in response to long-term stress, denoting the final stage of such process (Socialstyrelsen, 2003). According to the criteria (Table 1), the core symptom of ED is physical or mental exhaustion developed in response to identifiable stressors, which have been present for at least six months. The criteria also specify a significant reduction in "mental energy", as well as a range of other somatic and mental symptoms (e.g., physical fatigue, disturbed sleep and pain), including persistent complaint of memory or concentration difficulty. Moreover, it is stated that the diagnosis should be differentiated from other conditions that may explain the symptoms, including depression (Socialstyrelsen, 2003, 2025).

The initial report noted that ED was particularly common with regard to ambitious persons in professions characterized by contact with, and responsibility towards, other people (e.g., health care, education, middle management), harmonizing with research on the similar construct of burnout (Socialstyrelsen, 2003). Overall, ED was conceptualised in relation to burnout, which, however, was not considered a suitable metaphor in Swedish, nor a medical term (Socialstyrelsen, 2003). Therefore, the term ED (literally: “Exhaustion syndrome”) was eventually classified in the ICD under the chapter "Adaptation disorders and response to severe stress” (code 43.8). In the international research literature, it is often referred to as “stress-related” or “stress-induced” ED (e.g., Grossi et al., 2015; Wallensten et al., 2019). While the criteria are used in Swedish health care practice exclusively, the reaction it describes has been considered an equivalent to the internationally more applicable concept of clinical burnout, as it too describes the clinical end-stage of a stress- or burnout process (Grossi et al., 2015).

Since its inception, the incidence of ED has increased rapidly and it is today one of the foremost diagnostic reasons behind sick-leave days in Sweden. This has raised concerns that the diagnostic criteria may be too inclusive or vaguely stated (Kalliomäki & Brodda Jansen, 2021). Moreover, the fundamental conceptualization of the construct has been questioned. Perhaps most notably, a 2021 scoping review (Lindsäter et al., 2022) concluded that the scientific knowledge of ED remains limited due to the relative scarcity of research and methodological limitations of the studies conducted to date. Moreover, the authors noted that the limited evidence disallows firm conclusions to be drawn regarding, for instance, cognitive functioning and the link to biological stress-processes; it may also be a considerable overlap with depression or other more established stress-related constructs such as Adjustment disorder (Lindsäter et al., 2022).

A new set of revised ED-criteria was recently suggested, accentuating the magnitude of the difficulties needed in order for a diagnosis to be warranted, and cognitive symptoms even more strongly. Specifically, the new proposal includes cognitive impairment as an obligatory criterium in itself, hence highlighting cognitive difficulties as a central characteristic of the condition (Åsberg, 2024). Although it is currently unclear if these criteria will be officially included in the ICD, they may nevertheless indicate an increased weight given to cognitive dysfunction in ED.

In summary, ED is a novel yet highly prevalent diagnosis unique to Swedish health care. The diagnostic criteria comprise impaired cognitive functioning, which along with other characteristics of the condition needs to be further studied (Lindsäter et al., 2022). Since the diagnosis was introduced, largely on the basis of clinical observations, a growing number of studies have investigated cognitive functioning using either standardized behavioural tests or questionnaires targeting SCCs. As presented in some detail below, this literature has shown relatively heterogeneous results, especially when considering these different methods of measuring cognition. Moreover, ED relates to, but do not entirely equal, other constructs centred around exhaustion, including stress and burnout, and also cognition. Hence, before addressing the cognitive sequela of ED specifically, the following section will outline some of these concepts with the purpose of providing a general historical timeline and picture.

Some historical context

Exhaustion and fatigue

For thousands of years, and for a majority of its population, Europe and the world has seen hardship and poor work- and living conditions (Graeber & Wengrow, 2021; Hofmeester & van der Linden, 2018). Consequently, concepts akin to those of exhaustion or fatigue[1] have been described throughout history, albeit with vocabulary and explanations varying with the zeitgeist, including antiquity's ideas about unbalances in bodily humors; medieval Christianity's notions of "acedia"[2] or "sloth", sinful laziness; the Victorian era's fear of masturbation; to current theories about viral infections, depression, or burnout (Schaffner, 2016). Still, it has been argued that the conception of exhaustion or fatigue is

[1] For the purpose of this introduction, these concepts will be used synonymously.

[2] A condition akin to the antiquity's notion of "melancholia", or depression, but which fell under the moral or religious domain, rather than the medical.

closely tied to modernity. During the 1800s, advances in physics inspired a notion of human-beings as energy consuming devices, often described using the metaphors "the human machine" or "the human motor" (Johannisson, 2006; Rabinbach, 1992). The modern interest in fatigue has thus been dated to the industrial revolution with which subsequent changes in living conditions, increased exposure to certain sensory input, and new occupational and educational behaviour was believed to disrupt the functioning of such apparatus, resulting in energy-depravation (Johannisson, 2006; Leone et al., 2011; Rabinbach, 1992). More specifically, production losses in the factories, ascribed to long work hours and monotonous tasks, as well as ill-health stemming from "brain work" (e.g., educational or academic effort and/ or white-collar labour), sparked an interest in exhaustion or fatigue, which became typical political, cultural and medical tropes during the latter part of the 1800s and early 1900s, associated with a social critique of modern life (Johannisson, 2006; Rabinbach, 1992; Schaffner, 2016). Nevertheless, fatigue was conceptualised as a strictly physiological response, hence combining multiple levels of understanding the challenges posed by industrialized society (Johannisson, 2006). The multifaceted interest in exhaustion and fatigue therefore came to influence sociological and political theorizing (e.g., Marx & Mandel, 1976; Weber, 2002), the scientific study of work conditions, as well as medical practice (Johannisson, 2006; Rabinbach, 1992).

Neurasthenia

During this time period, the fatigue concept was medically described as Neurasthenia, or Nervous exhaustion (Beard, 1869). This diagnosis was first introduced in the United States but soon became a prevalent condition across the western world, including Sweden (Johannisson, 2006). As the name suggests, it was a disease of the nervous system, which was thought to be slowed down or affected by external factors[3], and was,

[3] These included for instance both exposure to viral infections as well as "over-thinking" or "mental strain" (Leone et al., 2011).

unlike other mental disorders, most often considered an "acquired" condition (Kraepelin, 1915). The decreased neural capacity was understood to result in a "disappearance of energy" and "chronic fatigue", taking different expressions depending on the type of strain that a person had experienced and on individual vulnerability (Johannisson, 2006; Kraepelin, 1915). Hence, Neurasthenia was divided into several clinical subtypes (e.g., Crozier, 2009; Lillestøl, 2018), and linked to a range of symptoms, often resembling those associated with current diagnostic constructs such as ED[4] (Kesselring, 2023; Lipsitt, 2019). Although women were thought to be more vulnerable, Neurasthenia was particularly used to understand and treat ill-health in academic or "thinking professions" in which men were overrepresented; it was thereby related to the mental domain, or "an irritability and instability of the functions of the mind" (Dowse, 1880; Johannisson, 2006) [5]. Hence, cognitive symptoms were considered a prominent feature of the disease, including problems with memory and perception, difficulty finding words, as well as distractibility and difficulties concentrating and upholding attention[6] (Dowse, 1880; Johannisson, 2006; Kraepelin, 1915).

The interest in Neurasthenia faded during the 20th century, and since the 1940s, the diagnosis has rarely been used in western medical practice. Yet, it is argued that much of the reasoning behind the concept has subsisted in specific fields. That is, medical disciplines such as

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[4] E.g., cognitive difficulties, insomnia, pain, sensitization to stimuli, anxiety, melancholia (Johannisson, 2006)

[5] In an overview and classification of psychiatric diseases, the German psychiatrist Emil Kraepelin (1915) wrote of the symptoms of Acquired neurasthenia: "*Of the men, naturally those who are more talented, better educated and more active are the individuals who most often suffer from this disease. Indeed, it is a fact worthy of note that great capacity of work is frequently accompanied by greater susceptibility to fatigue. Women, because of their weaker power of resistance and their greater emotional irritability, are more susceptible than men, particularly the overburdened mothers, teachers and nurses. The disease may appear at all ages but is most often met between the ages of twenty-five and forty-five, the period in life in which the greatest mental strain occurs*".

[6] Distractibility was considered a particularly prominent symptom (Johannisson, 2006). Again, in the words of Kraepelin (1915): "*There are as yet no experiments on the effect of the prolonged overexertion of the mind. But we know from long experience, that first of all, the ability to continuously exert the attention fails. The patient is distracted by little things and is inattentive. He is no longer able to think clearly and sharply, and requires much more time for his accustomed work. He is also apt to be forgetful of names and figures, so that the same work has to be done over several times before he is sure of his results*".

neurology, virology, or psychiatry would come to assess exhaustion as a symptom of brain damage or of infectious or psychiatric conditions, respectively (Johannisson, 2006), whereas the effects of social and occupational factors would to a larger extent be studied by work and organisational science and psychology. It has been claimed that this early division of labour was one reason for the parallel development of more current conditions such as chronic fatigue syndrome (CFS)/ myalgic encephalomyelitis, and burnout or ED (Leone et al., 2011).

In sum, the concept of exhaustion and fatigue was to a large extent born as a product of the social changes concurrent with the industrial revolution and modernity. In medical practice during 1800s and early 1900s, the diagnosis Neurasthenia described physiological effects of societal and occupational demands, with symptoms, including cognitive dysfunction, similar to the clinical picture described in modern constructs, such as ED. Although Neurasthenia is not commonly used in western, medical practice today[7], its overall conceptualization of exhaustion is believed to still influence current-day thinking.

Stress

During the early 1900s, observations were made of a “fight-flight-response”, marked by a general heightening of arousal (i.e., increased respiratory frequence, blood pressure and heart rate) associated with increases in activity of the autonomic nervous system and hormonal secretion, particularly adrenalin (Cannon, 1929). On the neural level, these processes are to a large extent controlled by the so-called Hypothalamic–pituitary–adrenal (HPA) axis, denoting the structures of a major neuroendocrine system regulating fundamental bodily processes (e.g., digestion, immune reactions and general activity and alertness), involved in upholding a state of homeostasis (Cannon, 1929; Chrousos &

7 The diagnosis is still used in Asia and included in the current version of the Chinese classification of mental disorders (Chen, 2002; Wang, 2022). Some researchers have also suggested a revival of the concept in a western context (Harvey et al., 2009; Molina et al., 2012). As outlined below, it is sometimes used in order to formally diagnose a concept of clinical burnout (van Dam, 2021).

Gold, 1992). In the 1930s, these concepts were further built on by the Canadian biochemist and medical scientist Hans Selye, often credited with introducing the stress concept in medical literature, and much of the terminology still used in stress research today. This included, for instance, the differentiation between stress (a biochemical response) and stressor (a cause of the stress-response; Selye, 1936). Moreover, a predictable pattern, the General adaption syndrome, was noted, in which the organism responds to stress in three steps: an alarm stage (i.e., the fight-flight response); a resistance stage in which the body seeks to adapt to the stressor and reach equilibrium; and lastly, if the previous stage would endure for too long, a stage of exhaustion caused by a shortage of "mental energy" (Schaffner, 2016; Selye, 1936). In other words, stress was conceived as a general reaction to any kind of internal or external demand, which in the long run may lead to depleted resources and deteriorating health effects (Schaffner, 2016).

Importantly, in this view, stress is not considered an inherently negative phenomenon but rather an adaptive way for an organism to manage difficult situations. Therefore, a distinction is commonly made between acute and prolonged stress reactions, with the latter increasing the probability of worse health outcomes over time (Zhu et al., 2014). Such notion has been empirically supported by studies showing links between persistent stress and cardiovascular disease (Steptoe & Kivimäki, 2012) and a range of other somatic (Chrousos & Gold, 1992), psychiatric, and cognitive problems (Duric et al., 2016; Herman et al., 2016).

While this biologically oriented model of stress is still conceptually relevant, subsequent theorization and empirical findings has developed it further. For example, current stress-research tend to focus on a concept of allostasis, involving the physiological processes by which the body *predicts* its future state, thereby counteracting possible imbalances (Guidi et al., 2021). Relatedly, in alignment with the generally increased accent on cognition in psychological research during the later parts of the 20th century (Robinson, 2018), later models have underlined the impact of cognitive appraisal (i.e., judgements made by an individual on whether an event is dangerous or threatening, and if sufficient resources are available), seeing it as crucial for the stress response to occur in the first place (Lazarus, 1984).

The literature on stress has also highlighted the significance of social aspects and gender. For instance, it has been shown that women and men tend to be dissimilarly affected by stress, both psychologically and physiologically, not least in regards to the balancing of work- and family life (Frankenhaeuser, 1996). More broadly, since at least the 1950s, the social aspects of stress have been underscored, not least in Sweden where much research has been conducted on how the "psycho-social" environment and alienated modern life may trigger stress-related illness (Levi, 1981; Schaffner, 2016). The relation between individual stress and work-related factors has been particularly discussed, with influential models demonstrating the importance of balancing either individual effort and the perceived reward (Siegrist, 1996), or work-related demands, control and support (Bakker & de Vries, 2021; Bakker & Demerouti, 2007; Karasek & Theorell, 1990). Notably, work conditions have also been shown to influence the experience and report of cognitive dysfunction in the general work-force (Stenfors et al., 2013).

In summary, a biological concept of stress was introduced during the 1900s, describing a general physiological response to threating external events. While stress is conceived to be an adaptive response, prolonged stress-reactions have been associated with exhaustion and a range of detrimental health outcomes, including cognitive difficulties (Herman et al., 2016). Current stress-models emphasizes that stress responses are not triggered equally between individuals but instead sees a complex system comprising physiological as well as interacting social and psychological/cognitive phenomena (Juster et al., 2011).

Burnout

Burnout is said to be one of the most widely discussed mental health issues today (e.g., Heinemann & Heinemann, 2017). The academic discussion of the concept originated with observations of a response to difficult work-conditions, marked by a number of physical and behavioural signs of exhaustion, including motivation loss and difficulties concentrating (Fernandes Fontes, 2020; Freudenberger, 1974). More specifically, these observations were of “Staff burnout”, explicitly signifying the experience of a worker in response to excessive “unattainable” job demands (Freudenberger, 1974). The burnout concept was hence developed within the field of work and organizational psychology and is not synonymous with the aforementioned stress-response, although it may be influenced by it (Schaufeli et al., 2009; Shirom & Melamed, 2006). Instead, burnout is usually seen as a process specifically applicable to the relation between a worker and the work-environment, emphasizing factors such as productivity demands and social support, rather than aspects of individual psychology or biology (Freudenberger, 1974; Schaufeli et al., 2009).

The most commonly used burnout model was introduced in the 1970s, and was initially based on interviews conducted with nurses and other human care professions (Maslach & Jackson, 1981; Schaufeli et al., 2009). They revealed that several workers referred to themselves as being burnt out, reporting of emotional exhaustion, in-turn leading to a negative view on their clients and worsened job performance (Maslach & Jackson, 1981; Maslach et al., 2001; Schaufeli et al., 2009). These observations led to predictions of a number of symptoms, resulting in the development of a questionnaire, the Maslach burnout inventory (MBI), seeing burnout in three dimensions: exhaustion, cynicism or depersonalization, and professional inefficiency (Maslach & Jackson, 1981; Schaufeli et al., 2009). This conceptualization is still influential on how burnout is identified across a number of occupational groups (Schaufeli et al., 2009; Tavella et al., 2021), and is currently included in the ICD as a factor “influencing health status or contact with health services”. Importantly, however, the ICD explicitly states that burnout is not to be understood as a medical condition (i.e., a disorder), and that it should refer to phenomena in the occupational context and not in other areas of life (World Health Organization, 2010, 2019).

Other notions of burnout have been suggested, with a number of studies arguing that it is best understood as a unidimensional construct, fundamentally reflecting exhaustion (e.g., Kristensen et al., 2005; Shirom

& Melamed, 2006). While it has been reasoned that this approach risk making the burnout-term outmoded (Kristensen et al., 2005; Schaufeli et al., 2009; Tavella et al., 2021), it has also been proposed that a core symptom of exhaustion may still be expressed by subfactors indicating specific features. One such model is reflected in an alternative instrument, the Shirom-Melamed burnout questionnaire[8] (SMBQ), understanding burnout using the sub-dimensions emotional weariness/ physical fatigue, tension, listlessness, and cognitive weariness (Shirom & Melamed, 2006). The latter dimension indicates an experience of cognitive dysfunction, which is not included in the MBI-based conceptualisation, but increasingly highlighted in other models as an important feature of burnout (Schaufeli et al., 2009; Shirom & Melamed, 2006). For instance, a range of studies by Tavella and colleagues have suggested that burnout should be understood as a one factor concept, where this factor reflects a combination of exhaustion and cognitive dysfunction (Tavella et al., 2020; Tavella et al., 2021; Gabriela Tavella & Gordon Parker, 2020; G. Tavella & G. Parker, 2020).

Although widespread, burnout is a contested concept, not least given that the field lacks consensus on a coherent definition (Heinemann & Heinemann, 2017). As a point in fact, a 2018 review identified "at least 142 unique definitions for meeting overall burnout or burnout subscale criteria" (Rotenstein et al., 2018). This confusion may be partly due to the creators of the MBI not seeing it as a tool for categorization or diagnosis, but rather as a reflection of a dimensional phenomenon less suited for clinical cut-off-points or strict criteria (Maslach & Leiter, 2016). However, such view has met criticism. For instance, MBI-scores may correlate and overlap with depressive symptoms, and it has been proposed that conceptually, burnout should be viewed as depression caused by occupational factors (Bianchi et al., 2015). Still, as not all dimensions of burnout may be shared with depression, a distinction between the concepts has also been supported (Koutsimani et al., 2019).

[8] In some versions named the Shirom-Melamed burnout measure (Almén & Jansson, 2021)

Clinical burnout

Despite the societal and individual costs of burnout being considerable (Nekoei et al., 2024), the view of it being strictly work-related, and the confusion regarding definitions, has made the concept difficult to approach from the clinical, health care perspective (Grossi et al., 2015; van Dam, 2021). Specifically, it has been noted that while some persons who experience burnout may need to seek health care, there is currently no international consensus on how to best classify these problems diagnostically (Bianchi et al., 2015; Tavella et al., 2020). Therefore, a range of diagnoses have been employed to describe burnout in research and clinical practice, including, for instance, Work-related neurasthenia, Undifferentiated somatoform disorder, Severe stress and adjustment disorder, and Major depression (Grossi et al., 2015; van Dam, 2021). Addressing this problem, a concept of clinical burnout is a suggested way to signify burnout-related problems in the health care setting (van Dam, 2021). Notably, clinical burnout is currently not included in the Diagnostic and statistical manual of mental disorders (DSM; American Psychiatric Association, 2013), nor in the ICD (World Health Organization, 2019). The term has been used, however, in research as a collective term describing the burnout phenomenon in a clinical context (e.g., Perski et al., 2017).

Clinical burnout is in several ways distinguished from burnout in the traditional occupational sense (van Dam, 2021). For instance, it is conceived to describe an end stage of the process where symptoms cause severely impaired daily functioning. As these problems may necessitate professional treatment, clinical burnout call for more categorical assessment, as opposed to the questionnaire-based, multidimensional approach (Grossi et al., 2015; van Dam, 2021). Moreover, clinical burnout is less concerned with the nature of specific causes (i.e., work-related aspects) and instead focusses more on the biological impact on the individual (i.e., the effects of stress). Hence, it is understood as a bio-psycho-social response to long-term strain in either one's personal or professional life (van Dam, 2021).

In sum, burnout is a heterogenous concept which normally describes an occupational phenomenon and not a medical condition. Clinical burnout is a proposed way of labelling the end-stage of the burnout process in a healthcare setting, focussing more broadly on the effects of long-term stress on an individual.

Overall, this overview has shown how expressions similar to fatigue and exhaustion have been present throughout history, in its modern form understood as a physical reaction to societal or environmental changes. A challenge for researchers and clinical practice is that the phenomenon is studied from different academic and medical perspectives, overlapping only in part, adding to conceptual and diagnostic confusion. Still, cognitive difficulties may be seen as an integral part of several of the current day concepts, including ED.

Cognition

The concept of cognition is similar to that of exhaustion in it being old but also closely tied to modernity and the modern era's inclination towards quantification and precise measurement. Specifically, cognitive science was established during the mid 1900s in a process often referred to as the "cognitive revolution" within psychological science (Greenwood, 1999). This entailed a new view of human behaviour, inspired by advances in neurology and also the advent of computer science and theories of artificial intelligence (Greenwood, 1999; van Rooij et al., 2024). Thus, the subfield Cognitive psychology, a term popularized in the 1960s, was founded around the computer as a metaphor, focussing on empirical studies of "input", "storage", "processing" and "output" of information (Lezak, 2004; Neisser, 1967). Thereby, cognitive psychology became based on the concept of information processing. The field developed schematic models of how human behaviour can be understood as a product of the workings and interaction of specific, quantifiable, information processing modules or functions, such as perception, attention, or memory (Neisser, 1976; Scheerer, 1988). Hence, the claim of cognitive psychology was, and still is, that it is possible to measure mental operations objectively (Neisser, 1967). This approach contested the behaviourist view that had been dominant in academic psychology up to that point, and also earlier attempts of capturing “inner phenomena” by elaborate ways of introspection (Greenwood, 1999). Instead, cognitive psychology was mainly developed using laboratory-based tests and paradigms, operationalizing cognitive processes as accuracy scores or response times (RT) on standardized tasks designed to measure specific functions (Greenwood, 1999; Vestergren, 2011). This methodology has allowed research on fluctuations in cognitive functioning as well as on more stable traits, perhaps most prominently the concept of general intelligence (Horn, 1972), and also the conceptualization of specific cognitive domains (Harvey, 2019).

Cognitive test-performance has been proven successful in predicting behavioural outcome, even complex processes such as academic achievement (Costa et al., 2012; Deary et al., 2007; Neisser, 1976; Plomin & von Stumm, 2018), and the functional level of cognitive processes is considered meaningful in its own right (Page, 2006). Nonetheless, cognitive phenomena are normally believed to reflect physiological events in the brain (Bassett & Gazzaniga, 2011 , but see also Chalmers, 2017), and their conception has been developed in synchrony with advances in biology and neuroscience (Price, 2018). For instance, intelligence is reported to have a strong genetic component (Plomin & von Stumm, 2018), and cognitive testing has been used to map out the functions associated with specific brain regions and networks[9] (Price, 2018). Cognitive models have thereby informed medicine, particularly neurology, where they are routinely used to understand the impact of brain damage or degeneration (Parsons, 2001), and also psychiatry, in which sub-optimal cognitive functioning has been associated with several diagnoses, including stress-related conditions (Abramovitch et al., 2021; Girotti et al., 2024).

Cognitive domains

[9] This intersection between anatomy and behaviour is the explicit study matter of the discipline of Neuropsychology.

The precise conceptualization of cognitive domains varies, but often involves a hierarchal organization in which narrower, relatively less complex functions constitutes, or are governed by, broader, higher-level abilities (Harvey, 2019; McGrew, 2009). This intricacy is reflected in the neural correlates to cognitive functions which are similarly comprised of overlapping networks, where more complex processes are relatively widely distributed over multiple, interacting brain structures (Bassett & Gazzaniga, 2011). The following is a description of some of the broader domains relevant to this thesis, including very brief summaries of some of the neural aspects related to their functioning.

Long-term and episodic memory

Long-term memory comprises a range of more specific abilities, including implicit memory (i.e., information that is influencing behaviour unconsciously) and declarative memory (i.e., encoding, storage, and retrieval of conscious information). The latter is further subdivided into semantic memory, denoting processing of factual knowledge (i.e., the concept of breakfast) and episodic memory, concerning events that are fixed in space and time (e.g., what one had for breakfast this morning; Tulving, 1983; Tulving, 2002). Episodic memory is often further split into yet more specific processes. For instance, a distinction is made between prospective and retrospective memory, describing events that have happened (e.g., yesterday's breakfast) and events that are intended to happen (i.e., remembering to have breakfast tomorrow), respectively (Henry, 2021; Meacham & Colombo, 1980). Measurement of episodic memory traditionally involves tasks where a person is presented with information (such as words or digits) to be recalled after a delay. During such procedure, certain aspects relevant to memory functioning may be manipulated, showing, for example, the impact of distractions or external memory cues (Cheke & Clayton, 2013; Tulving, 1972).

On the neural level, the forming and retrieval of episodic memories are highly associated with the medial temporal lobes, comprising the hippocampus, acting in conjunction with other areas, such as the prefrontal cortex (PFC) and parietal lobes, (e.g., Moscovitch et al., 2016; Rolls & Treves, 2024). As elaborated on below, the neural correlates to episodic memory constitute larger-scale networks as well as more process-specific neural activity in a wide range of structures, contingent on the precise task and information involved (Moscovitch et al., 2016).

Working memory

Working memory (WM) has been defined in several different ways, but broadly refers to a process (or processes) in which a limited amount of information is made temporarily accessible. It is hence an imperative feature of many other cognitive tasks and processes (Adams et al., 2018; Cowan, 2017). The delineation of the concept is not always obvious and WM is in some models seen as an integral part of Executive functions (EFs) (Diamond, 2013), and in others, more as a product of interactions between several components and processes, including aspects of long-term memory, attention and perception (e.g., Baddeley, 2017; Cowan, 1988; Cowan et al., 2018; Eriksson et al., 2015). Hence, WM is associated with most areas of the brain, again depending on the specific task or information being processed (Eriksson et al., 2015). Still, models of WM emphasizes that the capacity to temporarily store and manipulate information is restricted. Therefore, in order to test these limits, WM tasks commonly involve instructions to hold information active in short-term memory (e.g., repeating sequences of digits) while also manipulating them in some manner (e.g., repeating the sequence in reverse order), and then to immediately reproduce them (Wechsler, 1981).

A concept related to the limited nature of WM is cognitive load. Specifically, intrinsic cognitive load refers to complexity of a cognitive task to be learnt or performed (e.g., the quantity of digits to be memorized, or if they are to be presented backwards). Germane cognitive load signifies the impact on WM of the act of learning itself (e.g., the procedure with which one learns to perform the task). External cognitive load refers to demands on WM that is not contributing to the goals of the task at hand

(i.e., distracting external events, or complex instructions; Hawthorne et al., 2019; Sweller, 2010; Sweller et al., 1998)

Executive functions

The term EFs describes a collection of top-down control[10] processes necessary for goal-directed behaviour, particularly in novel tasks where automated responses and processes are less helpful (Diamond, 2013). EFs orchestrates behaviour and are important for a wide range of more specific functions, and may therefore be considered domain general (Friedman & Miyake, 2017; Harvey, 2019). An influential model by Miyake et al (2000) sees EFs as largely (but not exclusively) comprised of three processes: *Updating*, often measured using tasks where a person is asked to continuously report on the information held (and updated) in WM (e.g., the n-back task, described below); *Inhibition* of well learnt responses, commonly tested by comparing responses to congruent and incongruent stimuli, where the degree of congruence between stimuli operationalizes the need for inhibitory control (e.g., the Flanker task); *Shifting*, i.e., the ability to flexibly switch between tasks or rules, often tested by comparing the performance on tasks with different sets of instructions (e.g., the Trail Making Test). Notably, these processes are seen as distinct but also overlapping, often working in tandem across multiple tasks (Friedman & Miyake, 2017).

The overlapping character of EFs is reflected on the neural level, where they too are associated with task-specific processes and activation, as well as more generally with a large-scale fronto-parietal network[11], reliably activated across different cognitively demanding tasks (van Oort et al., 2017). There is a lack of consensus regarding the exact nomenclature and conceptualization of this circuit[12], referred to as, for instance, the central executive network, the domain general network or the lateral

[10] This thesis uses the terms cognitive control and executive control synonymously.
[11] It is normally considered to consist of: the dorsolateral PFC the posterior parietal cortex, the frontal eye fields, and sometimes the supplementary motor cortex and fronto-insular operculum. For a review on the interplay of large-scale networks, see van Oort et al., 2017.
[12]And indeed of other large-scale networks, and neural nomenclature in general (e.g., Uddin et al., 2019).

fronto-parietal network (Dixon et al., 2018; Uddin et al., 2019)[13]. Nevertheless, it is shown to be anti-correlated with another large-scale network, the Default mode network (DMN), comprising several medially located structures in the brain[14] that are reliably activated during rest conditions, i.e., when the demands of executive functioning is low (Menon, 2023). In other words, when activity increases in the executive network, it decreases in the DMN, and vice versa (Fox et al., 2005; Persson et al., 2007; van Oort et al., 2017). Notably, the dynamic interplay and capacity to switch smoothly between these task-positive and task-negative circuits have been associated with executive task performance, as well as with stress (Menon, 2023; van Oort et al., 2017).

Attention

Attention is a multifaceted concept, broadly denoting the act of focusing on something. It relates to the fact that there is a limit to the amount of information that is possible to process consciously, and is thus closely interrelated with, and overlapping, the domains of WM and EFs (Oberauer, 2019). Specifically, clinical models of attention often involves, for instance the subcategories selective and alternating attention, which are conceptually similar to the aforementioned executive functions of inhibition and switching (Wickens, 2021), and also sustained attention (or vigilance), describing the ability to maintain behaviour and to focus continuously over time (Klösch et al., 2022; van Schie et al., 2021). Hence, similar to EFs and WM, attentional processes are considered integral to, or necessary for, functioning in several other domains (Harvey, 2019).

Functional brain imaging has revealed that attention on particularly external stimuli is generally associated with task-positive networks. It is also linked to a so-called salience network which enables focus to alter

[13] The network is sometimes seen as related to, or inclusive of, the Dorsal attention network (DAN; Hammer et al., 2024; Littow et al., 2015)

[14] Most commonly the medial PFC, the posterior cingulate cortex, the precuneus and the inferior parietal lobule. The DMN is normally studied using resting-state functional imaging, i.e. as the neural response to not performing any task in particular; it is, interestingly, also associated with self-referential processes (van Oort et al., 2017)

between inner and outer phenomena of interest, and is hence involved in the switching between task-positive and task-negative circuits (Hammer et al., 2024; van Oort et al., 2017). Interestingly, sub-optimal performance on tasks tapping EF or attention has been associated with a lack of suppression of the DMN, which may be subjectively experienced as lapses of attention or thoughts unrelated to the task (Hammer et al., 2024; Weissman et al., 2006; Zuberer et al., 2021).

Perceptual speed

Perceptual speed (sometimes referred to as processing speed) may be defined as the ability to process information rapidly. It is often measured using tests where a person is instructed to manually code or copy information using pen and paper (e.g., see the description of the coding task below). Hence, perceptual speed tasks are considered highly dependent on, and related to, for instance, WM, visual discrimination and attention, as well as motor functioning (Ebaid et al., 2017). It is associated with several structures in the brain, including fronto-parietal regions (Gajardo-Vidal et al., 2024). As tests of cognitive abilities often involves time limits or operationalize ability in terms of time, processing speed is relevant to cognitive performance in a number of specific domains. Clinically, lowered processing speed has been associated with both normal and pathological processes in aging as well with a number of psychiatric conditions and traits (Abramovitch et al., 2021; Adrover-Roig et al., 2023; Nuño et al., 2021).

In summary, cognitive psychology is largely centred around the idea of objectively measured information processing. Some cognitive domains of interest to the current thesis are episodic memory, WM, EFs, attention and processing speed. These areas are overlapping but still describe distinct aspects of cognition. This complexity is echoed at the neural level where functions and paradigms are associated with activity specific to certain paradigms and information, but also with more general patterns. Regarding the latter, the interplay of task-negative and task-positive networks is associated with top-down executive or attentional control.

The cognitive sequela of Exhaustion disorder

Test performance

Cross-sectional findings

A growing body of research has shown patients with ED to perform worse in cognitive tests compared to healthy controls (e.g., Ellbin et al., 2018; Franke Föyen et al., 2023; Jonsdottir et al., 2013; Krabbe et al., 2017; Olsson et al., 2010; Sandström et al., 2012; Savic et al., 2017; Skau et al., 2021; Öhman et al., 2007; Österberg et al., 2009). However, the specific domains in which difficulties are implicated have varied between studies (Deligkaris et al., 2014; Gavelin et al., 2021; Lindsäter et al., 2022). This may be exemplified with the case of WM, for which some studies have found relatively worse performance by ED patients (Jonsdottir et al., 2013; Savic et al., 2017) whereas others (Oosterholt et al., 2014; Öhman et al., 2007) have not.

Synthesizing cross-sectional findings on test performance in burnout (including studies on ED), a 2014 review concluded that overall, it was associated with impairment in three major cognitive domains: EFs, attention, and memory, with the executive component of WM being particularly affected (Deligkaris et al.). While most of the included studies indicated impaired cognitive performance in people with burnout, the results were in part contradictory, with one individual study (Castaneda et al., 2011) showing stronger WM performance in the burnout sample, compared to controls. The authors theorized that the variability in results may be due to heterogeneity in the investigated population (the review included studies on burnout as well as clinical burnout) and recommended future research to specifically investigate different aspects of WM.

A more recent review and meta-analysis on clinical burnout (in which the majority of the included studies assessed ED patients; Gavelin et al., 2021) disclosed that in comparison with healthy control participants, patients performed worse in some, but not all, domains. Specifically, the analysis revealed significant group differences, with small to moderate effect sizes, in tasks tapping episodic memory, WM, EFs, attention, processing speed, and fluency. It did not show any significant differences in crystallized (i.e., semantic) abilities or visuo-spatial functions. Overall, the findings suggest that the cognitive impairment in ED may be particularly related to attention and EFs. Such notion was further supported by more fine-grained analysis where group differences were not seen in tests of solely short-term memory, but instead in WM tasks. Similarly, in episodic memory, larger differences were revealed in the more executively demanding prospective memory tasks, relative to tests tapping retrospective memory.

Findings from longitudinal and follow-up studies

Some studies have followed up tested cognition in ED over time. Österberg et al. (2012) reported that after 1.5 years, ED patients had improved their cognitive performance but still performed worse than healthy controls on tests measuring sustained attention and visuo-constructive ability. However, the patient group performed equally well or better as controls with respect to episodic memory. Contrastingly, a 3-year follow up study by Jonsdottir et al (2017) showed worse performance than healthy controls in tasks measuring attention, WM and name-finding, but not in measures of EFs (inhibition and switching). No significant longitudinal within-group change was noted, with the sole exception of the name-finding task in which the patients had improved significantly. Also worth mentioning is a Danish prospective study, not explicitly studying people diagnosed with ED, but instead patients referred to a Danish clinic for occupational medicine due to work-related stress (Eskildsen et al., 2016). A follow-up after 1 year revealed that patients still performed worse than healthy controls in tasks measuring prospective memory, processing speed, attention and immediate memory, with small to moderate between group effect sizes. The patients did not perform worse in tasks tapping working-, visual-, or general memory. Moreover, relative to controls, they had improved their test performance significantly in about half of the administered tests, specifically those measuring prospective memory and processing speed. At a subsequent 4-year follow up study (Dalgaard et al., 2021), when a majority of the patients reported that they were partly or fully recovered, between-group differences were largely unsignificant. It was hence concluded that over the whole four-year period, the patients had improved their performance in relation to controls, and that the bulk of improvement had happened during the first year.

To summarize the literature on cognitive test performance in ED, amalgamated evidence from cross-sectional research (see Gavelin et al., 2021 for an overview) indicates that ED-patients perform worse than healthy controls in primarily executively oriented tasks, with small to moderate between-group effects. Few prospective studies have been conducted to date, with the current evidence pointing to difficulties being potentially long-lasting, despite recovery in other aspects of ED. Overall, however, the literature on cognitive test-performance in ED is still limited and show marked heterogeneity with regard to both findings and the methods used (Lindsäter et al., 2022), which may hamper comparability between studies and clinical groups. On this note, it should be seen that few studies have compared test performance between ED and other populations directly[15], and that similar cognitive deficits have been observed across several psychiatric conditions (Abramovitch et al., 2021). It is therefore still uncertain to which extent any cognitive profile specific to ED may be discerned.

Biological and neurostructural findings

Comparably few studies have investigated the neural substrates of ED, and the aforementioned scoping review (Lindsäter et al., 2022) further pointed out that many are methodologically limited, hampering the

[15] A notable exception is the study by Franke-Föyen et al, 2023, comparing cognitive test performance of patients with ED to a group diagnosed with Adjustment disorder. No significant differences were found between the groups.

prospect of drawing firm conclusions. Some research has included measures relating to the HPA-axis and hormonal properties (e.g., Jönsson et al., 2015; Lennartsson, Sjörs, et al., 2015; Olsson et al., 2010; Sjörs & Jonsdottir, 2015; Sjörs et al., 2012). These studies have reported partly differing results; some have found of alterations in the ED population (Lennartsson, Sjörs, & Jonsdottir, 2015), or in certain stages of ED (e.g., Jönsson et al., 2015), whereas others have not detected any deviations (e.g., Rotvig et al., 2024). However, it has been appraised that, collectively, this bulk of research has not provided evidence of any clear overall differences between ED patients and controls with respect to HPA-axis measures or growth factors (Lindsäter et al., 2022).

As for structural neuroimaging, it has similarly been argued that relatively little is known about the neural correlates of the cognitive symptoms noted in the ED population (Arthur Cully & Björnsdotter, 2023). Still, some research has highlighted neural abnormalities in primarily prefrontal areas and/ or the striatum, theorized to reflect the experienced cognitive difficulties. For instance, one study compared ED patients with healthy controls, seeing smaller volumes of the caudate nuclei and larger volumes of the right-side amygdala in the patient group (Savic et al., 2017). The patients also showed less cortical thickness in the right PFC and left superior temporal gyrus. These findings partially echoed previous research on Swedish patients with "long-term occupational stress", who relative to controls displayed smaller volumes of the dorsolateral PFC, anterior cingulate cortex, as well as of the caudate and putamen (Blix et al., 2013). However, the picture is complicated by other studies presenting somewhat contrasting results. Notably, in a larger sample of ED patients, higher stress-levels were associated with more lateral PFC thickness which, in-turn, was not associated with self-reported cognitive symptoms (Arthur Cully & Björnsdotter, 2023). Furthermore, another study disclosed that ED patients with higher levels of mental fatigue had smaller volumes of the caudate and putamen, but did not see any link between fatigue and PFC volume (Gavelin et al., 2020).

Overall, the neural properties associated with ED is still uncertain. Structural alterations have been noted in prefrontal or striatal areas, but the findings are inconclusive and point towards both larger and smaller volumes of prefrontal structures, possibly suggesting intricate interactions with stress, fatigue and cognition. As elaborated on below in relation to a "high-effort approach", this complexity is further accentuated by functional neuroimaging showing either increased or decreased neural activity during cognitive tasks (Gavelin et al., 2017; Sandström et al., 2012; Skau et al., 2021).

Subjective cognitive complaints

While standardized tests are often considered the gold-standard of cognitive assessment within the cognitive psychology tradition, they have also been questioned, in part for lacking ecological validity, i.e., not accurately reflecting phenomena experienced in everyday life (Neisser, 1976; Pinto et al., 2023). This notion has led to the development of alternative test procedures more resemblant of circumstances and challenges outside of the laboratory, and also of a number of questionnaires sharing a common aim to capture subjective experiences of cognitive functioning as they appear in naturalistic, everyday environments (e.g., Burgess et al., 2006; Herrmann, 1982; Neisser, 1976; Steiner & Frey, 2021). The latter measures are often referred to as subjective cognitive complaints (SCCs; Carrigan & Barkus, 2016; Herrmann, 1982), or, when memory functioning is the sole focus: Subjective memory complaints (SMCs)[16]. Notably, there is a marked heterogeneity in how these constructs are conceptualized in research and it has been pointed out that a clear definition is still lacking (see

[16] Unless there is a specific point in specifying memory, this thesis will generally keep to the wider term (SCCs) to describe both. It is also noteworthy that the concept of SMCs has been used to describe a specific tradition of subjective memory measurement, primarily associated with clinical assessment and diagnostics of age-related decline. Such "Memory complaints paradigm" has been contrasted from other traditions, specifically an "Everyday memory paradigm" more concerned with the question of ecological validity and cognitive failures; as well as from a "Meta-memory paradigm", focussing on laboratory-based measures of metacognitive knowledge, monitoring and self-referent beliefs about memory (Vestergren, 2011). Notably, however, while interesting, this distinction is not common practice and the use of SCCs as a general descriptor, such as in the current thesis, is recurring in much of the literature (e.g., Carrigan and Barkus, 2016).

Vestergren, 2011 for an in-depth discussion). This also holds true for the ED literature specifically, where individual studies have studied, for instance, "cognitive failures", "self-reported cognitive difficulties", and "subjective measure of cognitive status" (see Table 2 for an overview of studies on clinical burnout that have included SCCs). Moreover, studies in the ED field have employed different questionnaires to capture SCCs, with outcome measures most often being the summed scores of these instruments, but in some cases (Ellbin et al., 2018; Jonsdottir et al., 2013), single questions. While acknowledging this variability, the term SCCs will be used throughout this thesis as a collective descriptor of questionnaires that in slightly different ways aim to measure the subjective[17] experience of cognitive functioning in everyday life.

Level of SCCs

As seen in Table 2, cross-sectional studies have reliably shown that compared to healthy controls, patients with ED report significantly higher levels of SCCs (Dalgaard et al., 2021; Ellbin et al., 2018; Eskildsen et al., 2015; Eskildsen et al., 2017; Jonsdottir et al., 2013; Oosterholt et al., 2012;

[17] For a comprehensive overview regarding subjectivity and objectivity in the specific case of cognitive measurement, please, again, see Vestergren, 2011. Briefly summarized, it may be noted that although the mention of objective and subjective measurement is common in the psychological literature, definitions of these concepts tend to be sparse, and there is currently no general consensus regarding the philosophical distinction of this dichotomy (Vestergren, 2011). In part, this seems to relate to differences in the level of understanding the phenomenon in question. For instance, objectivity or subjectivity is sometimes seen in relation to the variable that is being measured, such as when assessing the usefulness of latent variables, or discussing whether a certain measure target "inner phenomena" or something in the "external world" (Annett, 2002; Vestergren, 2011). However, subjectivity may also denote attributes of specific cognitive instruments, for example if the scoring of an instrument is reliable and independent of who is measuring, or if the purpose of the assessment is sufficiently "hidden" (Vestergren, 2011).

In this thesis, the terms subjective and objective are not used as value judgements. Instead, subjective is used: (1) as in the descriptor of cognitive complaints (i.e., the term used to describe the category of questionnaires now under discussion); similarly, a phrase such as "objective cognitive measurement" may refer to cognitive tests); (2) as in *"Relating to the thinking subject, proceeding from or taking place within the individual consciousness or perception; belonging to the conscious life; frequently opposed to objective*" (Oxford University Press, 2024). An example of the latter is when referring to a subjective experience of cognitive functioning. Which one of these meanings that are applicable should be clear given the context.

Oosterholt et al., 2016; van Der Linden et al., 2005; Öhman et al., 2007; Österberg et al., 2009; Österberg et al., 2012; Österberg et al., 2014)[18].

Some research has followed up these observations over time. Studies comparing groups of patients with healthy controls cross-sectionally have reported that patients performed significantly worse after 1 (Eskildsen et al., 2016), 1.5 (Oosterholt et al., 2016), 2 (Österberg et al., 2014), 4 (Dalgaard et al., 2021) and 7-10 years (Ellbin, Jonsdottir, et al., 2021). As for longitudinal research, a 2012 study by Österberg et al., revealed that the patients in their cohort reported significantly less SCCs at a 1.5-year follow-up. The authors noted that this improvement was seen in tandem with a reduction in self-rated depressive symptoms. Similarly, Eskildsen et al. (2017) measured SCCs in ED patients repeatedly during a 12-month period and noticed a significant improvement, which was bidirectionally related to sleep quality and stress.

Type of SCCs

Questionnaires on SCCs normally comprise questions that target different or multiple cognitive functions or domains. Hence, the method of using summed (total) scores of these instruments provides relatively sparse information about which specific types of cognitive difficulties are experienced. However, some indication is given by studies that have investigated subscales of questionnaires.

Ellbin et al. (2021) compared ED patients, recovered ED patients and healthy controls cross-sectionally, 7-12 years after seeking health care. To this end, the study employed an instrument developed for distinguishing patients with subjective cognitive impairment from healthy controls (Eckerström et al., 2013). Notably, the authors compounded items into composite measures reflecting the following cognitive themes: "Difficulties related to communicating with others", "Feeling cognitively insecure and making mistakes", "Getting comments from others about my functioning", "Difficulties with learning and memory", "Using memory

[18] Notably, the studies by Österberg et al (2009, 2012, 2014) included patients diagnosed within the F43 category of the ICD, with symptoms of burnout. At baseline, 89% met criteria for ED.

aid", and "Difficulties related to general/executive cognitive function". The results showed that in all of these measures, both the recovered and non-recovered group of ED patients expressed considerably more cognitive problems relative to healthy controls. Recovered ED patients reported substantially less cognitive difficulties than persons still fulfilling the general ED criteria. Moreover, for all domains, the ED patients, and to a lesser degree also recovered ED patients, reported relatively high levels of problems. All comparisons were statistically significant, perhaps indicating that the subjectively experienced cognitive deficit associated with ED is broad in nature, impacting several domains. However, as the study did not statistically compare the domains to each other, it is uncertain if any specific cognitive profile may be distinguished.

Moreover, a 2023 study (Renaud & Lacroix) specifically assessed various aspects of EFs using the Behavior rating of executive functions (Roth et al., 2022). Notably, the study did not comprise participants diagnosed with ED, but instead a relatively small sample of patients who had received health care, been granted sick leave for burnout, and scored above a clinical cutoff on the Karolinska exhaustion disorder scale (KEDS; Besèr et al., 2014). Comparing the results to standardized norms, the authors found that patients reported significantly higher levels in several executive measures, including inhibition, shifting, emotional control, initiation, WM, planning/ organizing, monitoring, as well as in indexes summing metacognition and a global executive composite. For all these measures, effect sizes were large, with the most substantial being displayed for the broader indexes, as well as for initiation and WM. The results thus pointed towards relatively general executive impairment, but that initiation and WM may be most strongly affected. However, the small number of (non-ED) participants and the use of norms instead of matched control participants make the validity and transferability to the ED population hard to evaluate, as do the fact that the study did not statistically compare the different domains beyond the immediate effect sizes.

On this note, an earlier study by Österberg et al. (2009) investigated SCCs using the Euroquest-9 (Chouanière et al., 1997), comprising items specifying difficulty with either memory or attention/ concentration.

Patients reported higher levels than controls on the summed total score of all items, as well as the two subscales, indicating an association between stress-related exhaustion and more cognitive problems. Furthermore, an interaction analysis revealed that relative to controls, the patients reported more problems with respect to attention and concentration problems compared to memory difficulties, perhaps suggesting that the former is particularly salient in ED.

Qualitative research

As total scores of questionnaires may be ill-suited to capture fine nuances of everyday cognitive functioning, it should be seen that some research has investigated the first-hand experience of general ED symptomology using qualitative methods. Two recent studies are particularly noteworthy.

Using thematic analysis, a 2021 study by Ellbin, Jonsdottir & Bååthe noted that patients priorly diagnosed with ED experienced remaining cognitive symptoms a decade after the onset of the disorder, including difficulties with memory, concentration, and hyper-sensitivity towards external stimuli. While this may support a notion that cognitive impairment in ED affect multiple domains, the authors specifically underlined that some participants experienced difficulties maintaining concentration over time and with multitasking, as well hypersensitivity to stimuli.

A 2023 survey-based study by Lindsäter and colleagues aimed to investigate central clinical attributes of ED by qualitative content analysis of open-ended questions, including "which aspect of ED" that is "most difficult to endure". The results generated a number of classifications, one being cognitive symptoms. This category was, in-turn, comprised of 14 sub-categories displaying a heterogeneous set of difficulties, including those relating to broader domains such as memory, attention and EFs, as well as more narrow abilities, such as multitasking and sense of direction. General descriptions of "cognitive functioning", and of "memory", "attention" or "brain fog" were more frequently reported than other often narrower concepts, such as multitasking, but also to EFs. While the results do not provide evidence on whether any set of cognitive difficulties are experienced as more difficult than the others in ED, they nevertheless suggest that the problems are described in a broad manner.

Overall, the results of these studies indicate a heterogeneous clinical picture in ED, perhaps related to comorbidity or overlap with other diagnoses. As discussed by the authors of the latter study, the fine-grained information provided by the qualitative methodology highlights important symptoms that may not be covered by the diagnostic criteria. To speculate, this likely also holds true for the specific case of experienced cognitive symptoms and questionnaires targeting everyday difficulties. Considering just one example, the said area of multitasking is not explicitly included in neither the CFQ nor the cognitive weariness scale of the SMBQ. This demonstrates how fine-grained aspects of cognitive functioning may not be captured by traditional, quantitative measures, possibly due to real-life cognitive tasks being complex and dependant on the interaction of multiple specific processes (Snyder et al., 2021).

In summary, previous studies on clinical burnout or ED have consistently shown that compared to healthy controls, patients report high levels of SCCs. Research regarding the cognitive course and if ED is associated with any domain-specific cognitive profile is markedly sparser. The available evidence points towards a relatively long-lasting experience of cognitive impairment. It also indicates that stress-related exhaustion may affect cognition broadly, but perhaps most obviously with respect to attention or executive functioning, as opposed to memory, a notion that needs to be further investigated. Studies using qualitative methods have similarly shown that, as a group, ED patients describe cognitive dysfunction in relatively heterogeneous or broad terms, but also specific difficulties that may go unnoticed in quantitative measures of SCCs.

The association between subjective cognitive complaints and test performance

The pattern of suboptimal cognitive performance seen in both questionnaires and tests has been interpreted as indicative of an association between the subjective and objective cognitive measures (Oosterholt et al., 2012; Öhman et al., 2007). However, other research has yielded dissimilar results or interpretations. For instance, studies comparing ED patients with healthy controls have observed larger group differences in SCCs than in test performance (e.g., Eskildsen et al., 2015; Österberg et al., 2009). Moreover, within the clinical group, the course of cognitive recovery may be different for SCCs than for tests, with SCCs remaining longer than tested deficits (Oosterholt et al., 2016; Österberg et al., 2014). Furthermore, the studies that have explicitly analysed the relationship between SCCs and test performance in clinical burnout have found low or no correlations (Ellbin et al., 2018; Franke Föyen et al., 2023; Jonsdottir et al., 2013; Österberg et al., 2009; Österberg et al., 2012). This disconnect may be attributed to different phenomena. For instance, it has been revealed that SCCs correlate positively with depression levels, leading to the interpretation that they are a "poor indicator of actual cognitive functioning" and may instead reflect depressed mood and "enhanced self-monitoring" in ED patients (Österberg et al., 2014). Drawing from findings from research on other clinical conditions, such as fibromyalgia, functional neurological disorders and CFS, (Teodoro et al., 2018; Walitt et al., 2016), it has also been discussed if the discrepancy may be at least partly due to the result of "an attentional bias, exacerbated by catastrophic interpretations of cognitive failures and unrealistic self-expectations, and not of objective cognitive impairment" (Franke Föyen et al., 2023).

On this point, it should be seen that outside the specific study of ED, a vast literature on the relationship between SCCs and test performance has presented similarly different results and interpretations (Burmester et al., 2016; Vestergren, 2011). However, across several reviews and populations, including healthy participants (Carrigan & Barkus, 2016), there is weak evidence for any considerable or consistent association between SCCs and test performance (e.g., Burmester et al., 2016; Herrmann, 1982; Perez Garcia et al., 1998; Reid & MacLullich, 2006). Instead, stronger associations have often been detected between SCCs and various psychological symptoms or phenomena, perhaps most notably depression (Burmester et al., 2016; Torenvliet et al., 2024), or personality traits, including neuroticism (Kliegel et al., 2005) and perfectionism (Teodoro et al., 2018). As in the specific case of ED, such results have been attributed in widely different ways, including that cognitive tests may lack in ecological validity (e.g., Bennett-Levy & Powell, 1980) or reliability, hampering the comparability between the two kinds of measurement (Dang et al., 2020). Other proposals are that SCCs could indicate either very small effects that go unnoticed in cognitive tests (Burmester et al., 2016), or inherently different aspects of cognition. Regarding the latter, it has been theorized that standardized cognitive tests aim to measure optimal performance in structured conditions where the goals of assessment are unambiguous, which is not the case for questionnaires measuring SCCs, in which an individual's goals, standards, beliefs and reflection are integral parts of the measurement (Toplak et al., 2013)[19]. In other words, the two types of measurement are hence active at different levels of analysis and may be viewed as complementary rather than interchangeable (Isquith et al., 2013; Snyder et al., 2021; Toplak et al., 2013).

In research on aging populations, the field with which SCCs are perhaps most clearly associated, a particular interest has been given their possible prospective implications, particularly whether they are a valid indicator of later pathological degeneration. Similar to the results in other fields, studies have found low or modest cross-sectional correlation between SCCs and test performance in elderly people (Burmester et al., 2016), and often stronger associations between SCCs and psychological phenomena such as depression (Edmonds et al., 2014) or personality (Terracciano et al., 2014). SCCs has thus been considered a reflection of

[19] For example, a common instruction in cognitive tests is to complete a task as fast and/ or as accurate as possible, whereas questionnaires may ask if appointments have been forgotten "often" or "very often" (Broadbent et al., 1982). Thus, the latter not only involves recalling memory failures, but also a decision of what is meant by "often", thereby including assessment of one's own standards.

the “worried well”, i.e., concerns over normal cognitive difficulties experienced in older-age, rather than of pathological neural decline (Edmonds et al., 2014; Sutherland et al., 2022). However, research has also shown that the correlation with test-performance may be stronger when assessing longitudinal change (Zimprich & Kurtz, 2015), and that SCCs may be a risk-factor for later development of (testable) cognitive and neural degeneration (Mitchell et al., 2014). Specifically, it is proposed that in a test situation, the deficits indicated by SCCs may be compensated for by exertion of more executive control (Burmester et al., 2016). On this note, a concept of Subjective cognitive decline (SCD) has been suggested as a pre-clinical stage that precedes both Alzheimer’s disease and its precursor Minor cognitive impairment. SCD is characterized by “self-experienced decline in cognitive capacity” together with normal performance on standardized tasks (Jessen et al., 2014), possibly reflecting early cognitive or neural decline so subtle that it is not yet affecting test performance (Studart & Nitrini, 2016). While the practical use of SCD in healthcare has been disputed (Howard, 2020), its study is interesting for the purpose of the current thesis as it has exhibited potential neural correlates to SCCs and effort-related compensational processes (for a comprehensive review, see Viviano & Damoiseaux, 2020), further described in the next section.

In sum, ED research has revealed low correlation between SCCs and test performance. Such findings have frequently been seen in other fields with different explanations, including characteristics of clinical populations and more methodological or conceptual aspects. The link between SCCs and test performance may be stronger over time, and possibly associated with neural and compensational processes.

A high-effort approach

Several studies have found that patients with ED or clinical burnout report disproportionally high levels of fatigue and effort during and after cognitive testing (Gavelin et al., 2023; Krabbe et al., 2017; Oosterholt et al., 2014; Skau et al., 2021), with higher levels of fatigue being associated with impaired task performance (van Dam et al., 2011). A recent study moreover reported that compared to controls, patients with ED display partly different autonomic activity during prolonged test procedures, and not as much improvement in performance from repeated testing, (Gavelin et al., 2023). On the neural level, it has also been shown that a relationship between smaller volumes of the striatum and better WM performance was mediated by mental fatigue (Gavelin et al., 2020). These results imply a set of intricate interactions where effort and fatigue levels may in some, but not all, cases indicate compensation for neural deficiencies.

Functional neuroimaging

The complexity proposed in relation to a high-effort approach is further underpinned by functional imaging studies having shown different neural activation patterns in patients with ED, compared to healthy controls, despite test performance being similar between the groups. Specifically, a functional magnetic resonance imaging (fMRI) study revealed that patients performed as accurately as controls on the n-back task, tapping the executive function of WM updating. However, the patients showed longer RT and decreased activity in areas of the PFC, interpreted as suboptimal WM processing at the neural level (Sandström et al., 2012).

Similarly, a study using functional Near infrared spectroscopy reported that ED patients displayed less activation than healthy controls in areas of the motor cortex and PFC during another executive task, tapping response inhibition (Skau et al., 2021). When comparing differences between congruently and incongruently presented stimuli, the difference in neural activation was negatively correlated with level of perceived fatigue. In other words, higher level of exhaustion was associated with less activation of these regions during the executively more demanding task conditions. The patients again executed the task as correctly as controls and showed longer RT, which may suggest that accuracy was maintained at the cost of a slower performance. Notably, the study also disclosed stronger neural activation in patients compared to controls in the motor cortex and PFC during two perceptual speed tests in which the groups performed equally well. The authors theorized that the differences in activation may be task specific as the inhibition task was substantially longer and more strenuous than the perceptual speed tests, possibly affecting patients and healthy controls asymmetrically. That is, the ED group may have managed to compensate for cognitive deficits by recruiting additional resources in the shorter perceptual speed task, characterized by less intrinsic cognitive load, but not in the lengthier, more challenging inhibition task.

Moreover, an fMRI study found a positive correlation between burnout levels in ED patients and increased activation in areas of the PFC, parietal cortex and striatum, during the n-back task (Gavelin et al., 2017). In this study (which included the same subjects as in Study 2), burnout levels were not correlated with test performance, suggesting that hyper-recruitment of these regions is a possible neural correlate to a compensational effort put in by ED patients during WM updating. Here, research on aging populations should again be noted as it has revealed that SCCs and SCD are linked to altered neural functioning, both during resting-state (e.g., Hafkemeijer et al., 2013; Kawagoe et al., 2019; Wang et al., 2013) and task (see Sun et al., 2015 for a review), indicating that SCCs may reflect neural changes that occur before being detectable in traditional cognitive testing (Erk et al., 2011; Kawagoe et al., 2019; Rivas-Fernández et al., 2024; Rodda et al., 2011; Rodda et al., 2009). If this would hold true for also people with ED, SCCs may reflect slight neural deficits that are manageable under only certain conditions, possibly aggravating the core symptom of exhaustion.

Overall, the results of previous cognitive and neuroimaging studies indicate a multifaceted picture where people with ED may employ a high-effort compensational approach towards cognitive challenges. However, the success of such compensational effort and the neural processes involved may be influenced by multiple factors, including which specific cognitive functions are being targeted; task difficulty; burnout levels; and the use of strategies, such as lowering response speed to maintain test accuracy (see for instance Bartfai et al., 2021). This complexity adds to the challenge of understanding the SCCs experienced by ED patients and how they relate to objectively measured cognition and neural activity, not least considering that the direct relationship between SCCs and compensational neural activity is yet to be explored in this clinical group.

Rehabilitation of cognitive difficulties

Several forms of treatment for ED have been proposed and although individual trials have shown promising results, there is currently "limited evidence for any one intervention" (see Lindsäter et al., 2022 for a review). Nevertheless, for the purpose of this thesis, some should be specifically mentioned. Firstly, multi-modal rehabilitation (MMR) is recommended by the Swedish board of health and welfare, and commonly administered in ED care (Lindsäter et al., 2022). The term refers to programmes where several interventions are being administered by a multidisciplinary team, consisting of, for instance, psychologists, physiotherapists and physicians (e.g., Clason van de Leur et al., 2020). Hence, MMR may include several different types of interventions, such as relaxation techniques; physical therapy or exercise; vocational support; and psychotherapy, often using concepts and procedures from cognitive behavioural therapy (CBT), or Acceptance and commitment therapy[20] (ACT; Clason van de Leur et al., 2020; Wallensten et al., 2019).

The latter is, along with other similar types of interventions, sometimes conceptualized as being "process-based", indicating an emphasis placed on functioning, context and processes, rather than on the specific content or symptoms associated with a diagnosis, as in more traditional forms of CBT (Hayes et al., 2022). A recently proposed "contextual behaviour model" of ED (Clason van de Leur, 2024) posits that stress and ED may be understood as a contextual phenomenon, where persistent external demands interact with, for instance, contact with individual values, avoidance and controlling behaviour, as well as with fluctuations in memory and concentration (van der Leur et al., 2024). ACT, facilitating acceptance and psychological flexibility, may hence be

[20] Notably, CBT and/ or ACT have not been administered within MMR exclusively but also as more self-contained treatments for ED in their own right (e.g., Finnes et al., 2019; Lindsäter et al., 2018)

helpful in ED, where symptoms may be associated with psychological inflexibility, perfectionism and pathological worry (Clason van der Leur, 2024; Clason van der Leur et al., 2024).

On this point, while not commonly used in the ED-context, metacognitive therapy is also noteworthy. Metacognition broadly describes "thinking about thinking" or, more formally, "an individual's knowledge and cognition about the own cognitive phenomena" (Flavell, 1979). Specifically, metacognitive processes are subdivided into multiple interacting levels, ranging from automatic, low-cost functioning, to more consciously controlled cognitive monitoring and regulation, as well as to stored self-knowledge and broader self-beliefs (Wells & Matthews, 1996). The latter is theorized to guide metacognitive action and to select regulatory strategies, which may be dysfunctional in a longer perspective. Specifically, similar to the contextual behaviour model, threat monitoring, inflexible self-focussed attention and perseverative thought (e.g., worrying), are seen as problematic processes that may contribute to several psychiatric problems, including anxiety (Gkika et al., 2018), depression (Capobianco et al., 2020), and burnout (Evli & Şimşek, 2021; Sapancı, 2023). Moreover, a metacognitive concept of Detached mindfulness is akin to acceptance in denoting a state of inner awareness, marked by an absence of effortful self-processing, which is proposed to enhance flexibility of metacognitive regulation (Wells, 2005). In short, stemming from partly different theoretical traditions, process-based interventions often aims to increase the flexibility in a which a person may approach their problems, including cognitive phenomena.

Few ED studies have investigated interventions that explicitly or primarily targets cognitive functioning. One exception is the Rehabilitation for improved cognition (RECO) trial (Gavelin et al., 2018), to which the participants of this thesis was recruited. RECO has investigated the effects of cognitive and aerobic training as add-on interventions to MMR. Briefly summarized, the results displayed how computerized cognitive training of multiple cognitive functions gave a small but lasting effect on a global cognitive score. This effect was seen immediately after 12 weeks of training and again after 1 year (Gavelin et al., 2018). As for physical exercise, some immediate training gains were noted regarding episodic memory. However, this effect did not remain at the 1 year-follow up (Eskilsson et al., 2017; Gavelin et al., 2018).

In summary, relatively few ED studies have investigated which interventions are helpful with respect to cognition. Process-based therapeutic models may provide theoretical clues about the mechanisms involved. The available research to date suggests promising effects from computerized cognitive training. However, in order to develop effective treatment, more research is needed on the time course of cognitive symptoms, and potential facilitators or hinders towards everyday cognitive functioning, as they are experienced by patients with stress-related exhaustion.

Summary of the introduction

Previous research on the cognitive sequela of ED has revealed that, at the group level, people diagnosed with the condition report relatively high levels of SCCs, indicating substantial cognitive impairment that may persist years after treatment (Dalgaard et al., 2021; Ellbin, Jonsdottir, et al., 2021; Eskildsen et al., 2015; Eskildsen et al., 2017). This notion seems to be supported by studies showing that ED patients perform worse in cognitive tests tapping a number of cognitive domains, including EFs, and also by imaging studies revealing altered structural and functional properties in primarily fronto-striatal brain areas. Yet, there are gaps in our understanding of the cognitive sequela to ED, not least concerning the subjective experience and report. Although high levels of SCCs have been reliably found in this group, their specific implications and associations with other phenomena is less certain. For instance, the relation between SCCs and cognitive test performance may be weak, which calls for further investigation. Moreover, the summed scores of questionnaires used to operationalize SCCs in many studies say relatively little about individual differences in how the cognitive performance or course is experienced, or which types of cognitive difficulty are being reported. Furthermore, evidence is sparse on how SCCs relates to psychological distress and brain activity. The latter is of interest not least considering the suggested high-effort approach towards cognitive testing in this group, and possible compensational processes which could be detected at the neural level rather than appearing in test performance. There is also insufficient evidence for what interventions or approaches that are helpful with respect to cognitive recovery in ED. Hence, more research is needed on what people diagnosed with ED themselves experience as helpful or hindering in this regard.

Aims

The overarching purpose of this thesis was to gain more empirical knowledge about the subjective experience of cognitive functioning, as it is reported by people diagnosed with ED. Specifically, the thesis aimed to assess the type and magnitude of SCCs and to explore how the latter relates to test performance, psychological distress and neural activity in this clinical group. A further objective was to evaluate the experience of cognitive functioning, how it may have changed during the recovery process, and what has been perceived as helpful or hindering with respect to cognitive recovery.

Study 1 therefore investigated: 1. the magnitude of SCCs reported by patients diagnosed with ED, in comparison with healthy control participants; 2. if patients with ED differed from healthy controls in type of SCCs; 3. if SCCs were associated with cognitive test performance and psychological distress in a group of patients with ED and in a healthy control group, respectively.

Using fMRI, study 2 explored SCCs in relation to neural alterations and performance on the Flanker task. It specifically investigated if SCCs and burnout levels were associated with: 1. behavioural performance, measured as accuracy and RT inhibition costs; 2. the functional brain response during task performance.

Study 3 analysed interview data in order to explore how cognitive functioning and recovery were experienced 6-10 years after participating in a rehabilitation programme. The research questions were: 1. What were the experiences of current cognitive functioning, at the time of the interview? 2. What were the experiences of change in cognitive functioning over time, during the recovery process? 3. What were experienced as barriers or facilitators of cognitive recovery?

Table 3 provides a brief overview of the studies.

Methods

Participants

All participants in this thesis were recruited as a part of the RECO project, a randomized controlled clinical trial, primarily investigating the effects of cognitive and aerobic training as additional interventions to a rehabilitation programme for ED (Gavelin et al., 2018). The flow of participants in the RECO study is depicted in Figure 1. Patient participants were recruited from the Stress rehabilitation clinic and the Social insurance agency in Umeå, Sweden. The recruitment was conducted between April 2010 and June 2013. Inclusion criteria were: (1) ED diagnosis, confirmed by a physician and a psychologist; (2) 18–60 years old; (3) currently employed; (4) considered by a physician and a psychologist to be suitable for group-based stress rehabilitation; (5) no known abuse of alcohol or drugs; (6) not in need of more urgent treatment; and (7) not participating in other interventional study. Patients with relevant diagnoses in addition to ED (e.g., neurological or chronic psychiatric diagnoses) that required special care and treatment adjustments were not considered suitable for the standardized group-based stress rehabilitation, and therefore not included in this study.

The patients underwent MMR for 24 weeks, including elements of CBT, physiotherapy, vocational rehabilitation and regular appointments with a physician. The CBT was primarily targeting stress management, including strategies and activities for aiding sleep and recovery, and increased awareness on how emotions influence stress-related problems. The rehabilitation contained individual meetings with a therapist in order to set up and evaluate personal goals for behavioural change during the programme, but was mainly held in group format, with up to eight persons participating in each group. In total, 22 group meetings were conducted. Each session started with a relaxation exercise and was then based around particular psycho-educative themes, such as stress, recovery, sleep, emotions, etc. The patients also got individual prescriptions of physical activity and attended joint meetings with representatives from health care and their respective employers. After 12 weeks, in addition to continued MMR, the patients were randomized to one of three experimental arms: 1. No additional training, 2. additional computerized training, 3. additional aerobic exercise. The add-on interventions both lasted for 12 weeks, with three sessions conducted each week. The cognitive training programme (for details, see Gavelin et al., 2015) comprised six tasks targeting shifting, updating, episodic memory and short-term memory. Each cognitive training session was circa 15-20 minutes. The aerobic training (Eskilsson et al., 2017) entailed indoor cycling, each session lasting 40 minutes.

The participants were continuously assessed with respect to psychological variables, aerobic capacity and work ability. Before randomization, 132 participants completed a two-hour test battery and filled in additional questionnaires targeting psychological variables, including measures of SCCs. The results at this time point are presented in Study 1. This procedure was repeated after the additional interventions were completed (i.e., after 24 weeks), after one year, and again 4.5 years after the interventions were completed. Of the 132 participants assessed before randomization, 60 were invited to further assessment using fMRI, summarized in Study 2. The patients who remained in the study at the 4.5-year follow-up (n=56) were invited to participate in interviews 6-10 years after rehabilitation. Of these, 38 participants completed the interviews, which were analysed in Study 3.

A group of healthy control participants was recruited in the spring of 2016 through advertisement in a local newspaper. 109 individuals responded and the first 60 who matched the patient group on age and sex were invited to participate, making up the control group of Study 1. Initial telephone screening was done to exclude persons with self-reported history of other medical and/or psychological conditions known to affect cognition. 4 control participants were excluded due to prior psychiatric or neurological complications.

Ethical considerations/ statement.

The RECO trial was approved by the Regional Ethical Review Authority in Sweden (Dnr 2015-475-32M) in addition to a prior approvement by the

Regional Ethics Review Board in Umeå, Sweden (2010-53-31M). It was conducted in accordance with the Declaration of Helsinki and all participants were informed that their participation was voluntary, not part of health care, and that they had the right to decline participation at any point. All participants provided written informed consent prior to inclusion.

Measures and procedures

Subjective cognitive complaints

SCCs were measured using Swedish translations of two validated questionnaires: the Cognitive failures questionnaire (CFQ; Broadbent et al., 1982) and the Prospective and Retrospective memory questionnaire (PRMQ; Crawford et al., 2003; Rönnlund et al., 2008).

Focussing exclusively on memory, the PRMQ comprises items stating everyday failures. It is primarily being conceptualized out of three factors: general-, prospective- and retrospective memory (Crawford et al., 2003; Rönnlund et al., 2008). Nevertheless, the items are constructed out of three contrasting pairs of categories: (a) prospective vs retrospective memory, (b) self-cued vs environmental cued memory, and (c) short-term vs long-term memory (Crawford et al., 2003; Rönnlund et al., 2008). All items are consequently categorized in all three dimensions. For example, the item “Do you decide to do something in a few minutes time and then forget to do it?” is classified as a prospective, short-term and self-cued memory failure, whereas “Do you fail to recognize a place you have visited before?” is categorized as being retrospective, long-term and environmentally cued. Answers are given on a Likert scale ranging from never (1) to very often (5). The summed total score, with a possible range between 16 and 80, is hence used as a measure of general memory in this thesis.

The CFQ (Broadbent et al., 1982) is the most widely used instrument measuring SCCs in the research literature (Carrigan & Barkus, 2016). It specifically targets cognitive failures in daily life and consists of 25 statements about everyday situations to which the participants are instructed to respond using a five-point Likert scale: "Do you find that you forget appointments?"; "Do you fail to notice signposts on the road" or "Do you lose your temper and regret it?" For each item, the possible answers range from 1 (never) to 5 (very often). The CFQ was created with the intent to include items tapping memory, perception and motor functioning, which were conceptualized to reflect one general cognitive factor, expressed as the summed score of all items (Broadbent et al., 1982). Some subsequent analyses have suggested that the instrument may rather reflect difficulties with attention (Bridger et al., 2013; Chan, 1999; Wagle et al., 1999) or that it is best understood as a multifactorial construct (Bridger et al., 2013; Rast et al., 2009; Wallace et al., 2002). However, multifactorial solutions have also been cautioned against (Broadbent et al., 1982; Goodman et al., 2022). In this thesis, the total score of the CFQ is used as a general measure of cognitive failures, with a possible range between 25 and 100.

Cognitive test performance

Table 4 briefly describes all cognitive tests included in the thesis. In Study 1, a battery of 10 untrained, validated standardized tests was used to measure cognitive performance across five cognitive domains: EFs, WM, Episodic memory, Perceptual speed and Reasoning ability. An additional test (Flanker) was performed as a part of the functional brain imaging in Study 2.

Psychological distress

Burnout

The SMBQ is comprised of 22 items rated on a 7-point scale. As noted, it theoretically sees burnout as a reflection of exhaustion and comprises the dimensions emotional weariness/ physical fatigue (8 items), tension (4 items), listlessness (4 items), and cognitive weariness (6 items) (Shirom & Melamed, 2006). The outcome measures are the sum of the respective items, as well as the total score (possible range: 22-154), indicating burnout. Notably, as the cognitive weariness dimension comprises subjectively perceived cognitive phenomena, these items were excluded from the total score in Study 2, in order to distinguish the burnout measure from SCCs.

Depression and anxiety

The Hospital anxiety and depression scale (HADS; Zigmond & Snaith, 1983) comprises 7 items targeting symptoms of depression and 7 items targeting anxiety, all rated on a 4-point Likert scale. Hence, the instrument generates two outcome measures, i.e., depression and anxiety, respectively, comprised by the total scores of each set of items.

Neural activity

Magnetic resonance imaging (MRI) allows depiction of anatomical and physiological states and processes within the human body (Glover, 2011). The technique takes advantage of the fact that different chemical compounds display dissimilar magnetic properties (Grover et al., 2015). Exposing the organism to a strong magnetic field while scanning the body thus enables measurement of differences in relaxation times (i.e., the time it takes for a certain molecule to return from alignment with the magnetic field) between different chemicals and physiological structures. By computing such contrasts, MR technology is employed to generate high-resolution anatomical images of brain structures, referred to as structural MRI. Contrastingly, fMRI uses the same technology in order to measure regional changes in haemodynamic properties within the brain, appearing as a response to behaviour or rest (Glover, 2011). Shortly summarized, fMRI methodology assumes that regional changes in blood flow reflects an increased requirement for blood and oxygen in the neurons that are active during the task. Specifically, it measures the so-called Blood-oxygen-level-dependent (BOLD) response, (i.e., the different magnetic properties of oxygenized and de-oxygenized haemoglobin) in local brain areas, providing an indirect indication of brain activity as it correlates with specific behaviour and functions, operationalized by the in-scanner task (Glover, 2011).

The fMRI method used in Study 2 is detailed in the article and summarized here. A 32-channel head coil 3T scanner (GE Medical Systems) was used. All functional images were corrected for slice timing, realigned and un-warped to control for head movements. The anatomic images were segmented into grey and white matter maps, and used for creating a sample-specific group template. The functional images were co-registered to the anatomic images and normalized to MNI space. The voxel size was set to 2 x 2 x 2 mm. A general linear model was designed with event regressors for the incongruent and congruent conditions, and for a baseline block consisting of the last 60s of rest. The regressors were convolved with the hemodynamic response function and a high-pass filter of 128s/0.0078Hz was applied. An explicit mask defined by thresholding the grey-matter part of the DARTEL template in MNI space (probability level 0.2) was applied on all group analyses.

Summary of the empirical studies

Study 1

Aims

Study 1 examined SCCs expressed by patients diagnosed with ED, in relation to the control group of healthy participants. The objectives were threefold. Firstly, the study investigated and compared the level of SCCs and test performance. Secondly, it examined whether the patients differed from controls regarding the type of cognitive complaints being expressed. Thirdly, it probed how level of SCCs was associated with test performance and measures of depression, anxiety and burnout.

Methods

Participants

From the 132 patients and 60 controls assessed at T1 (see Figure 1), 103 patients and 58 controls had complete data for both the SCCs measures and cognitive tests, and were hence included in the analyses. With respect to demographic characteristics, dropout analyses revealed no differences between the analyzed sample of patients (n = 103) and those excluded due to missing cognitive data (n = 29), nor between those remaining in the study (n = 132) and those who dropped out before pretest (n = 29).

Measures

SCCs were measured using both the PRMQ (Cronbach's alpha: 0.94) and the CFQ (Cronbach's alpha: 0.94). The battery of 10 untrained standardized tests (see Table 4) was used to objectively measure performance across five cognitive domains. Composite scores were calculated for the cognitive domains that included more than one test or questionnaire: EFs and WM, global cognitive functioning (i.e., all 10 tests in the battery), as well as SCCs (i.e., the CFQ and the PRMQ).

Analyses

Data was analysed cross-sectionally from pretest assessments, when the participants had finalized 12 weeks of MMR, before randomization to the experimental arms. For the purpose of investigating mean differences between the groups (i.e., patients and controls), independent samples t-tests were performed for the burnout, depression and anxiety variables; one-way analyses of variance (ANOVAs) were used for the cognitive test- and SCCs-variables. In order to analyse differences in type of cognitive complaints reported by patients and controls, 2 (Group: Patients, Controls) x 2 (Type of cognitive complaint) mixed ANOVAs were conducted for the three dimensions of type of complaint (i.e., prospective vs retrospective memory failures, self-cued vs environmentally cued memory failures, short-term vs long-term memory failures). The relationship between SCCs and test performance as well as measures of depression, anxiety and burnout were examined using a three-stage hierarchical multiple regression model, applied separately to the patient group and control group, respectively. The SCCs composite was the dependent variable. To control for demographic variables, age, sex and education level were entered at stage one of the regression. The global cognitive composite was entered at stage two. Burnout, depression and anxiety scores were entered at stage three.

Results

The patients reported substantially higher levels of SCCs than the control participants. This contrasted the cognitive test results which, although revealing worse performance by patients on individual tasks assessing EFs, WM and reasoning ability, also showed non-significant results and markedly smaller effect sizes (Figure 2). As for type of cognitive complaints, the patients reported more self-cued than environmentally cued memory failures, compared to the controls (Figure 3). The regression analyses displayed that, in both groups, SCCs were associated with all variables of psychological distress (i.e., burnout, depression and anxiety levels) and not with objective cognitive test results (Table 5). That is, all scales of the PRMQ and the CFQ were uncorrelated to all cognitive domains when controlling for age, sex and education level. SCCs and cognitive test results were unrelated in the patient sample as well as in the control group.

Study 2

Aims

Study 2 followed up the issue of low correlations between SCCs and test performance. Here, it was investigated in the light of the proposed high-effort strategy towards cognitive testing in the ED population. Specifically considered was the previous finding that burnout levels may be associated with increased activation in frontal and striatal areas during an executive task, but not with task performance (Gavelin et al., 2017). The study also drew from observations made in the aging field suggesting that individuals can compensate for slight deficits by recruiting additional neural resources, as indicated by associations between SCD, or the level of SCCs, and altered neural activity (e.g., Sun et al., 2015). Hence, the aim of Study 2 was to explore the extent to which burnout levels and SCCs were associated with (1) task performance during the Flanker task, measuring response inhibition and (2) neural activity during the same task.

Methods

Participants

The study investigated a subsample of the RECO patients that had participated in Study 1 (i.e., at T1). In sum, 56 patients were included. Regarding central demographic and clinical characteristics, the sample was not significantly different from the participants (n=105) excluded after the baseline assessment

Measures

SCCs were measured using the PRMQ (Cronbach's alpha: 0.89). Level of burnout was assessed using the SMBQ. The subscale cognitive weariness was excluded in order to provide meaningful comparison between SCCs and burnout.

Analyses

Associations between test performance, SCCs and burnout, were explored using Kendall's tau correlation analyses. Additionally, Bayes factors were estimated to draw inferences about the correlation coefficients, investigating the likelihood of the alternative hypothesis (i.e., a non-zero correlation) in favour of the null hypothesis. These analyses included the PRMQ and SMBQ total scores, as well as RT and accuracy measurements for the inhibition cost and the congruent and incongruent conditions.

With respect to brain activity, a first-level analysis contrasted [Congruent–Rest], [Incongruent-Rest], and [Incongruent–Congruent] for each participant. The latter indicated the neural response to response inhibition (see Table 6 for the regions showing significant activation to this contrast). For all participants, the [Incongruent–Congruent] contrast was included in a t-test using a FWE corrected $p<0.05$ threshold, minimum cluster size 10 voxels. In order to further explore the relationship between functional brain response and level of burnout and SCCs, respectively, second-level analyses were conducted where the total scores of the SMBQ and the PRMQ were added as covariates of interest to the model at the group level, using an uncorrected threshold of $p<0.001$, minimum cluster size 10 voxels.

Results

In summary, the results provided evidence that neither SCCs nor burnout levels were correlated with task performance. One exception was anecdotal evidence that SMBQ scores correlated positively with RT during the congruent condition, perhaps indicating an association between level of burnout and slower responses during easier task conditions (Table 7).

Moreover, no association was seen between neither SCCs nor burnout with the magnitude of activation in the frontal brain areas generally associated with executive control. This may suggest that the link between subjective experience of cognitive failure and neural activity is difficult to capture using the method of the current study. Nevertheless, a correlation was found between the PRMQ and more activity in an occipital cluster containing the superior occipital gyrus and the cuneus (see Figure 4 for coordinates and a visual representation). A further analysis revealed that when compared to the session constant, which included 60 seconds of rest (Figure 4), the beta values of both congruent and incongruent trials suggested lesser neural activity in this area. That is, when the demand of executive control/ response inhibition was relatively higher, more SCCs were associated with a relatively lesser deactivation of these areas.

Study 3

Aims

In order to provide a more fine-grained understanding of the experience of cognitive functioning in ED, Study 3 qualitatively investigated interview data of former ED patients, 6-10 years after rehabilitation. The objective was to explore how cognitive functioning and recovery were experienced from the first-hand perspective. More specifically, the study investigated the experiences of current functioning, and how it had changed during the recovery period. It additionally aimed to explore what was experienced as barriers or facilitators of cognitive recovery.

Methods

Participants

56 participants had participated in T4 and were invited to participate in the interviews (Figure 1). Of these, 38 participants were included in the

analysis. With respect to demographic and clinical characteristics, they did not differ from the 18 persons from T4 not included in this study, nor from the initial sample at the T1. The time that had passed since inclusion in the RECO study ranged between 6 and 10 years.

Materials

Semi-structured interviews were conducted by a member of the research team at the Stress rehabilitation clinic in Umeå, or in some cases over video link. The interviews were held 6-10 years after treatment was finalized. They contained questions of general ED-recovery, analysed in a separate study (Aronsson et al., 2024), as well as specific questions regarding cognition. The latter thus formed the primary subject matter of Study 3.

Analysis

The interview data was investigated using Template analysis, a specific form of thematic analysis centred around the construction of a hierarchically structured coding template, summarizing the interview content as narrower and broader themes (Brooks et al., 2015).

Results

As seen in Table 8, four themes were identified at the broadest level. The first, "'It's different now': Remaining cognitive symptoms", displayed that although experiences of cognitive functioning varied between participants, it was often perceived to be better but with lingering symptoms. Across participants, these difficulties were noted in a range of cognitive domains but still indicated difficulties with upholding executive control and focus over time. The second theme "The bigger picture: Cognitive recovery in context", showed experiences of how cognitive recovery and functioning were influenced by the overall life situation, regarding, for instance, sleep quality, stress-levels and the occupational situation. Consequently, cognitive functioning was considered closely tied to, and in some cases difficult to distinguish from, ED-recovery in general. The third theme, “Overcoming challenges: Strategies for coping with cognitive symptoms”, disclosed experiences of helpful individual strategies. This involved, for example, engagement in cognitively challenging tasks, compensation for difficulties (e.g., using calendars or other external memory support), and also optimization of the circumstances under which cognitive tasks are performed. Lastly, the fourth theme, “The approach towards cognition matters” highlighted how some participants had adopted a new, more acceptant and compassionate view on both themselves in general and on cognitive functioning. This approach was believed to have facilitated cognitive recovery in different ways: by reducing worry, by helping to prioritize the own needs, and by attributing cognitive difficulties more to environmental aspects, rather than to individual failure.

General Discussion

The overarching purpose of this thesis was to gain more empirical knowledge about the subjective experience of cognitive functioning, as it is reported by people diagnosed with ED. Specifically, it aimed to assess the type and magnitude of SCCs and to explore how the latter relates to test performance, psychological distress and neural activity in this clinical group. A further objective was to evaluate the experience of cognitive functioning, how it may have changed during the recovery process, and what has been perceived as helpful or hindering with respect to cognitive recovery.

Briefly summarized, the results showed that people with ED reported high levels of SCCs compared to healthy controls. SCCs indicated more difficulties than what cognitive tests did, and the level of SCCs was not correlated with test performance but instead with self-reported psychological distress. As for type of SCCs, ED patients expressed more problems than healthy controls in multiple cognitive domains, but were relatively more prone to report memory failures in "self-cued" situations, where functioning is not aided by reminders in the environment. The explorative fMRI analysis found SCCs to be positively associated with neural activity in the right occipital lobe as an effect of increased response inhibition, possibly indicating compensational processes. The qualitative results of Study 3 disclosed individual differences regarding the experience of cognitive functioning and recovery 6-10 years after participating in an MMR programme. However, difficulty with upholding concentration and executive control was noted across several specific domains. Moreover, cognition and recovery were seen in context with, for instance, stress-levels, wellbeing and general recovery, which differed between the participants. Hence, experiences of facilitators and barriers varied, and included both restorative and compensatory strategies, external conditions, the degree of worry, and development of a more acceptant or self-compassionate view on cognition and oneself.

This section first discusses the main findings sectionally. It thereafter focusses in on their implications, specifically regarding different levels of understanding cognition and how the results may apply to clinical practice. Lastly, methodological limitations and strengths of this work will be considered, thereby suggesting directions for further research.

The main findings

The experience of cognitive function and change

Level of self-reported difficulty

When comparing a group with ED patients to healthy control participants similar in age and gender, Study 1 revealed that the patients reported markedly higher levels of SCCs. This was equally true for the CFQ (targeting overall cognitive failure), and all scales of the PRMQ (measuring different aspects of memory). In accordance with previous research using either questionnaires (e.g., Krabbe et al., 2017; Österberg et al., 2009; Österberg et al., 2012) or single items (Ellbin et al., 2018; Jonsdottir et al., 2013), the results indicated that people diagnosed with ED experience relatively frequent everyday cognitive failures. The alignment with Krabbe et al. (2017) is particularly noteworthy as that study used the same two questionnaires. In other words, the thesis has replicated the finding that patients with ED report more difficulties (with large effect sizes) on the PRMQ and the CFQ. More generally, this finding also harmonizes with the diagnostic criteria of ED, both in its current and proposed future form, in the sense that they include persistent cognitive difficulties (Socialstyrelsen, 2025; Åsberg, 2024).

Study 3 showed how people with ED reported of lingering cognitive problems 6-10 years after rehabilitation, which accords with previous research seeing elevated levels of SCCs years after the problems started (Dalgaard et al., 2021; Jonsdottir et al., 2017). It is important to note, however, that these qualitative findings revealed variable and different experiences of cognitive functioning and recovery. For instance, several participants who expressed remaining cognitive symptoms also noted that cognitive functioning had improved over time, agreeing with previous studies suggesting that cognitive symptoms may be “better but not well” several years after general recovery from clinical burnout (e.g Oosterholt et al., 2016). Moreover, other participants did not any longer experience, or had never experienced, cognitive difficulties, which further emphasizes that the degree of difficulty is not equal between individuals.

Overall, the results of this thesis suggests that even though everyday cognitive slips and failures are more frequent in the ED population at the group level, and may be a long-lasting problem, the individual course is still uncertain and variable. As elaborated on below, this variability seems to relate to, for instance, overall stress-levels, psychological wellbeing and general ED-recovery, and may be important to consider in future studies and clinical assessment. Therefore, evaluation of cognitive difficulties in stress-related exhaustion may need to factor in where in the recovery process a patient is, rather than to assume a homogeneous, linear course (for a general discussion on this topic, based on the same sample as in Study 3, see Aronsson et al., 2024).

Type of self-reported difficulty

Study 1 showed that patients with ED reported higher levels than healthy controls on all scales of the PRMQ, indicating difficulty in multiple aspects of memory functioning. However, further analyses revealed that the patients were relatively more likely to report problems in self-cued memory situations, i.e., in tasks sans of reminders in the environment. As such external support lower the demands of executive control (Kliegel et al., 2000), this result suggests that the memory difficulties are more pronounced as a result of increasing executive demands, or cognitive load. While this finding should be interpreted with some caution, especially since we did not see a significant group interaction regarding prospective vs retrospective memory (the most commonly used conceptualization of the PRMQ (Crawford et al., 2003)), it is nevertheless conceptually in line with some previous research. Specifically, the results of Österberg et al (2009) displayed that ED patients may report more difficulties than healthy controls with respect to both attention/ concentration and memory, but proportionally more problems in the former domains. Taken together, these findings suggest that, at the group level, people diagnosed with ED experience difficulties in a wide range of cognitive domains, but where executive, attentional processes are a perhaps domain-general, permeating feature, resulting in more concentration than memory problems, and more self-cued than environmentally cued memory failures. The qualitative observations in Study 3 further informed and supported these findings by showing that individual participants often experienced problems in several cognitive areas (e.g., both with memory and concentration). Additionally, when considering the sample as a whole, the reported difficulties spanned across multiple broader and narrower domains. Yet, in the interviews, trouble maintaining focus and executive control over time was a recurring theme extending beyond explicitly executive domains, such as inhibition or flexibility. For example, regarding memory and learning, participants noted particular difficulty in learning new information or procedures, as opposed to more automated processes, and relied more on external aids. Hence, the results of both Study 1 and 3 indicate that the experience of cognitive dysfunction in ED is variable and may be present across domains, but still be particularly related to domain-general executive or attentional processes.

Correlates of subjective cognitive complaints

Test performance

Study 1 showed that patients performed significantly worse than healthy controls in only some of the included cognitive tasks (i.e., the n-back task, measuring WM updating; the letter-number sequencing task, measuring WM; and Raven's matrices, measuring reasoning ability). Furthermore, group differences between ED patients and healthy controls were markedly larger with respect to level of SCCs compared to any measure of cognitive test performance (see Figure 2). This finding aligns with previous research showing the degree of self-reported cognitive deficit to be more pronounced than what is detected using standardized testing (Eskildsen et al., 2015; Österberg et al., 2009). Moreover, no association was found between neither the CFQ nor any measure of the PRMQ with any of the cognitive tests in the battery. Study 2 added to this finding by showing evidence favouring a non-correlation between SCCs and performance on the Flanker task, tapping inhibition. Thus, the results of this thesis align with existent research indicating that level of SCCs is not statistically associated, or interchangeable, with cognitive test performance in the ED population (Ellbin et al., 2018; Franke Föyen et al., 2023; Jonsdottir et al., 2013; Österberg et al., 2009; Österberg et al., 2012; Österberg et al., 2014).

A disconnect between subjective and objective cognitive measures is not unique to ED patients, as low or non-existent correlations between SCCs and test performance have been repeatedly shown in other clinical (e.g., Burmester et al., 2016) and non-clinical (Carrigan & Barkus, 2016) populations. However, given that burnout and ED are conceptually similar or related to depression (Bianchi & Schonfeld, 2018; Burmester et al., 2016; Lindsäter et al., 2022; Torenvliet et al., 2024), and that the latter has been suggested to help explain low associations between SCCs and task performance in other populations (e.g., Burmester et al., 2016), it may be tempting to attribute the SCCs-test performance-discrepancy to depression or other clinical features of the ED population. Similar explanations have been proposed in fields such as fibromyalgia, CFS or functional neurological conditions, where the discrepancy has been ascribed to processes common between these conditions, including a tendency to overinterpret cognitive difficulties or enhanced self-monitoring (Teodoro et al., 2018). However, the results of Study 1 caution against accenting such explanations too strongly, as the pattern of SCCs being related to psychological distress (further discussed in the next section), and not to test performance, was equally observed in the control group.

In short, this thesis has shown that a non-relationship between SCCs and test performance is not unique to ED patients, indicating that methodological or conceptual dissimilarities between the measures may be a better way to understand their disconnect. This finding is in line with previous research and theorizing. For instance, it has been proposed that low correlation between questionnaires and tests may be due to a "reliability paradox", where cognitive tests are often developed with an aim to maximize within-person contrasts and reliability at the expense of lowering between-person variability and reliability (Dang et al., 2020). Furthermore, in the sense that everyday activities are dependent on multiple cognitive functions and the interactions between them, SCCs can be viewed as a more complex phenomenon than what is normally measured with any single cognitive test (Hammar et al., 2022). Similarly, it has been argued that SCCs and test performance may depend on inherently different aspects of cognition and should not be considered measures of the same phenomena but rather as complementary windows into cognitive functioning (e.g., Isquith et al., 2013; Snyder et al., 2021; Toplak et al., 2013). In clearer terms, SCCs and test performance may measure different phenomena, and should for that reason not be viewed as interchangeable.

Although the general statistical relationship between level of SCCs and test performance seems to be low or non-existent, it is possible that there is still a conceptual overlap between them with respect to type of cognitive difficulties. Both Study 1 and Study 3 indicated that ED patients may experience difficulty in particularly executively demanding tasks, which is conceptually in line with the literature on cognitive testing (Gavelin et al., 2021). In further support of such interpretation, an additional ad-hoc analysis on the T1 data[21] revealed a significant interaction where group differences in WM performance increased as a function of increased executive demands. Moreover, the finding that ED patients reported relatively more self-cued memory failures harmonizes with studies showing that this group perform worse in tests where external support is excluded or manipulated (Eskildsen et al., 2015; Öhman et al.,

[21] The analysis, conducted for the purpose of this thesis summary was a mixed 2 (Group: patient, control) x 3 (WM task: Digit span forwards, Digit span backwards, Letter-memory sequencing) ANOVA. It resulted in a significant main effect of group, (F (1, 183) = 35.36, p = 0.00, η 2 = 0.16), showing that the patients performed worse than the controls. It also disclosed a significant main effect of WM task, (F (2,366) = 19,04, p = 0.00, η 2 = 0.09), indicating that the cognitive tasks were dissimilarly difficult (digit span forward was the easiest; letter-memory sequencing the most difficult). Furthermore, it displayed a significant interaction effect (F (2, 366) = 19.497, p = 0.00, η 2 = 0.17), revealing that the difference between patients and controls increased as a function of WM task. In other words, relative to the controls, the performance by the patients worsened the more difficult and executively demanding (e.g., Egeland, 2015) the task was.

2007). Hence, there may be a theoretical correspondence between what is measured with SCCs and cognitive tests. On this note, previous research in the aging field has shown that questionnaires and tests may be more strongly associated when explicitly constructed to measure the same cognitive functions (Lee et al., 2016; Vestergren et al., 2011). Given that the current results accentuates the importance of external cognitive support, future studies should test the relationship between test results and questionnaires with respect to self-cued and prospective memory specifically, using tasks and items that allow detailed manipulation of these aspects (e.g., Finley & Naaz, 2023; Gass et al., 2022; Rendell & Henry, 2009; Woods et al., 2007; Woods et al., 2010)

Psychological distress

As instruments targeting SCCs normally measure the frequency of the kind of slips and failures which anyone may experience from time to time (e.g., not noticing signposts on the road), it is not discernible from this data only to what degree such failures are perceived as significant problems for the individual. On this point, Study 3 has provided more insight by disclosing that cognitive difficulties can be experienced as highly worrying or distressing. For instance, some participants reported on having feared cognitive symptoms to be signs of dementia or other serious brain dysfunction; others how it had affected their work performance and wellbeing in detrimental ways. These observations suggest that cognitive failures are not only frequent at the group level but may be experienced as upsetting and to significantly affect the life quality of individuals.

On the quantitative side, Study 1 revealed that the degree of SCCs was moderately associated with self-reported symptoms of burnout, anxiety and depression. Hence, the results broadly indicates a link between everyday cognitive failure and psychological distress. Depression in particular has previously been associated with SCCs in the context of stress-related exhaustion. For instance, three studies by Österberg et al (2009; 2012; 2014) exhibited how SCCs were correlated with depression and that improvement in SCCs parallelled that of depression levels (Österberg et al., 2012). The authors hence proposed that SCCs may be better explained as an expression of depression than of cognitive functioning (Österberg et al., 2014). On the other hand, it was also noted that when controlling for depressive symptoms, the patient group still reported elevated levels of SCCs compared to controls, suggesting that depression is not the only factor of importance. Here, it should be pointed out that Study 1 found self-reported burnout, anxiety and depression to be highly correlated, perhaps indicating that there is no single facet of psychological distress that explains SCCs in ED, and that these concepts may be difficult to clearly distinguish in this context. It is also important to see that the cross-sectional design does not provide evidence on whether depressive mood, or any other measure of psychological distress, causes SCCs or if the relationship is the other way around. Nonetheless, the results do indicate that SCCs and psychological health, including depression, are entangled, which may be important to consider in clinical assessment and rehabilitation.

Regarding recovery, the qualitative results of Study 3 underline that cognitive functioning and recovery were seen as contingent on psychological wellbeing, including not only depression but also exhaustion and stress, and that the delineation between these multi-faceted concepts was not always apparent for the participants. This intertwinement suggests that cognitive dysfunction may be indirectly targeted by interventions that help to reduce psychological distress and stress in general. However, a substantial literature has emphasized how the relation between stress and cognition is complex. For instance, distinctive aspects of stress, such as its duration and intensity, likely affects specific cognitive domains and processes in dissimilar ways (Sandi, 2013). Moreover, mild stress has been associated with facilitation of cognitive function (e.g., McEwen & Sapolsky, 1995), especially in relatively simple cognitive tasks with low cognitive load, whereas chronic or high stress seem to worsen performance in executively demanding, high-load tasks, but instead promote habitual, well learnt processes (Sandi, 2013; Schwabe et al., 2007). It is possible that such intricacy has influenced the variable results of the current study, where both stress-levels and type of cognitive problems differed between the participants. An important objective for future research on cognitive functioning in ED should therefore be to further specify these aspects, preferably by deliberate manipulation of cognitive load and stress levels, and by investigating sub-groups of ED patients in different stages of recovery.

To summarize this section, the results indicate that SCCs are interrelated with symptoms of depression, anxiety and burnout. The qualitative analysis has further displayed that cognitive dysfunction in ED is not only frequent but also intertwined with psychological distress. Future studies are recommended to use fine-tuned measurement providing specific information on both cognitive functioning, stress and recovery.

Neural activity

Study 3 showed how some participants reported that they were, or had been, able to uphold cognitive performance at a cost of increasing effort and, by extension, exhaustion. This capability was also noted to having made cognitive problems hard to detect by other people. For example, one participant expressed how she had performed well on cognitive (and other) testing since it was conducted early during the day, when mental resources were still sufficient. Such qualitative observations demonstrate how ED patients may approach cognitive tasks with a high-effort strategy, proposed in previous studies to contribute to increased levels of fatigue, possibly enabling compensation that make slight cognitive deficits go unnoticed in cognitive testing (Krabbe et al., 2017; Oosterholt et al., 2014).

The notion of a high-effort approach and cognitive compensation was a part of the reasoning behind Study 2 exploring the association between SCCs and the neural response during the Flanker task, tapping response inhibition. The results did not indicate a correlation between higher levels of SCCs with activity in the frontal or striatal brain areas previously highlighted in some previous studies on ED (Blix et al., 2013; Gavelin et al., 2017; Gavelin et al., 2020; Golkar et al., 2014; Jovanovic et al., 2011; Sandström et al., 2012; Savic, 2013). Instead, the analysis showed an association with relatively more neural activity in an area within the occipital lobe, containing the right superior gyrus and cuneus, as a response to higher executive demands. While the localisation of this cluster was unexpected, the results might still be a sign of compensational processes at the neural level, perhaps relating to basic visual attention. That is, it is possible that additional occipital activity may help to uphold test performance, despite an experience of cognitive difficulty in everyday life. If this interpretation is correct, SCCs may reflect slight cognitive or attentional changes that is experienced by the individual but not discernible in test performance (for a similar discussion, see for instance Wei et al., 2022).

This finding is difficult to interpret and should be considered with caution. Firstly, it needs to be underscored that the study was exploratory in nature, investigating the whole brain with relatively generous statistical thresholds and without a control group. Therefore, in order to know if these effects will hold true and if they are in any way specific to the ED population, confirmatory research that also includes non-ED participants is needed. Moreover, an additional analysis indicated that the higher level of activation seen when SCCs were added to the model should rather be interpreted as a lessening of deactivation to the task condition that demanded more executive control. More precisely, to measure the neural correlate to response inhibition, the study subtracted the BOLD-response for the congruent trials on the Flanker task to that of the more executively challenging incongruent trials. As seen in figure 3, the additional analysis revealed that both the incongruent and congruent conditions were associated with lesser BOLD-responses compared to the mean session constant, which included a baseline block of 60 seconds of rest; the incongruent trials were associated with a somewhat lesser deactivation. In slightly simpler terms: SCCs were generally associated with a deactivation of the occipital cluster during the task. This deactivation was less pronounced during the task conditions that required response inhibition. One possible explanation of this finding is that SCCs reflect processes involved in the interplay between task-negative and task-positive neural networks. Such interpretation is theoretically supported by some previous resting-state studies on elderly populations. For instance, associations have been seen between SCCs and altered resting-state connectivity, involving the cunei and also the DMN and the visual resting-state network, theorized to reflect a compensational response (Hafkemeijer et al., 2013; Kawagoe et al., 2019; Wei et al., 2022). Additionally, a recent study displayed how network integration may be altered in persons with burnout compared to controls. It specifically showed less effective connectivity in a sub-network comprising structures primarily within the visual network (including the cuneus and the superior occipital gyrus) and to a lesser extent also the auditory network, as well as the cognitive control network, and the DMN (Shang et al., 2022). The same study also revealed less effective connectivity between the visual areas and the hippocampus. These effects were interpreted as compensational coordination of larger scale networks, counteracting deficits in the integration of sensory information, possibly relating to the cognitive difficulties in burnout (specifically dysfunction in obtaining visual information from memory). In other words, the connectivity of larger-scale networks, involving the visual areas implicated in the current thesis, has been linked to SCCs and also to burnout, in both cases posited to reflect compensational processes. Therefore, as discussed in Study 2, a suggestion for future research on stress-related exhaustion is to use methods and designs that allow analysis of the altering between broader neural networks and attentional states, and how it relates to the high level of SCCs in this group.

Overall, with respect to neuroimaging, this thesis has contributed conceptually to the field by showing that the magnitude of self-reported cognitive failures may be associated with altered neural activity, possibly reflecting compensation. It has added pointers on how future, confirmatory research should proceed in order to replicate and extend these findings, such as by examining the integrity of networks involving the cuneus and superior occipital gyrus. Suggestions also include how to further investigate how SCCs and possible neural correlates may interact with perceived effort and fatigue, which could provide important information on the high-effort strategy ascribed to ED patients. Perhaps most importantly, future studies should include both healthy and clinical control groups in order to distinguish the degree to which any effects are attributable or specific to stress-related exhaustion.

Helpful and hindering factors with respect to cognitive recovery

The qualitative results of Study 3 has shown how patients with ED attributed their cognitive recovery and functioning to, for instance, stress, exhaustion and the overall life situation. Consequently, behaviour and circumstances that had alleviated stress and exhaustion were seen as facilitators of cognitive recovery. In the shorter perspective, this included behaviour such as breathing or taking pauses, or engagement in pleasurable activities. On a longer time scale, it involved more general changes or improvements in family- or work-related life. The results thus suggest that treatment that leads to general wellbeing may improve cognitive difficulties as well.

Some participants had benefitted from employing strategies that targeted cognitive functioning in a relatively direct way, such as cognitive training or engagement in challenging everyday tasks, but also from making the environment less cognitively demanding, for instance by using noise-reducing headphones or not sharing an office. Moreover, cognitive functioning was related to the approach towards cognitive performance and the own person. Specifically, a less self-critical and more acceptant stance had helped improve cognitive function. Such view was linked to a reduction of worry and fatigue, enabling resources to be directed towards cognitive undertakings. It was also associated with more limit-setting behaviour and a tendency to see shortcomings as a multifaceted concept, influenced not only by cognitive ability or performance but also with environmental aspects and self-beliefs.

These findings, the latter in particular, seems to broadly harmonize with the aforementioned process-based models of cognition and change. A metacognitive framework may be particularly informative as it bridges several of the results in this thesis. For instance, subjective assessment of cognitive dysfunction (i.e., SCCs) can be seen as a form of metacognitive monitoring (Shimamura, 2000). Moreover, the noted shift to focussing on cognitive problems more as environmental phenomena, rather than as an effect of the own cognitive ability, is consistent with the concept of Detached mindfulness which indicates that overriding an inflexible focus on self-processing may help to interrupt maintenance of psychiatric dysfunction (Wells, 2005). Furthermore, enhanced flexibility in metacognitive regulation has been observed to make cognitive processes less dependent on external cues (Wells, 2011), suggesting that interventions aiming to increase acceptance or detached mindfulness may be clinically relevant in managing difficulties with self-cued memory. Additionally, suboptimal metacognitive monitoring has been associated with work-related fatigue (Querstret and Copley, 2012), and detached mindfulness with increased probability of recovery from stress across populations (Capobianco, 2017). This suggests that metacognitive interventions may be relevant not only to overtly cognitive problems in ED but to the core symptom of exhaustion. Interestingly, cognitive confidence (i.e., a person's beliefs about the own cognitive functioning) is shown to correlate with SCCs (Jacobsen et al., 2016) and fatigue levels (Fernie et al., 2016) in persons with CFS, possibly adding to maintenance of the fatigued state (Jacobsen et al., 2016). Given the similarities in symptoms (Leone et al., 2011), it has been proposed that akin metacognitive processes may be involved in maintaining stress-related exhaustion as well (Almén, 2021). In short, a metacognitive approach may help to provide a theoretical framework for understanding and possibly alleviating the cognitive sequela of ED, and should be evaluated in future trials.

The results of Study 3 demonstrated individual differences in what was perceived as helpful or hindering with respect to cognitive functioning and recovery. This variability is conceptually noteworthy as it emphasizes that cognition may need to be understood in multiple levels of explanation or abstraction, as further discussed below. It also accords with the summed research on treatment effects in ED, showing limited "evidence for any one type of intervention" (Lindsäter et al., 2022), perhaps suggesting that individual differences make effects harder to discover on the group level, at least with respect to cognitive symptoms. In any case, the results indicates that interventions targeting cognitive difficulty may be important and should be individualized in order to be most effective.

It is interesting to see that similar points have been made in other fields. This includes research on depression, which is of particular interest given the aforementioned link between SCCs and depressive symptoms, and the conceptual overlap between depression and burnout (Bianchi et al., 2015; Koutsimani et al., 2019). Studies on SCCs in the context of major depression resembles the results of the current thesis in several ways. For example: the subjective experience of cognitive difficulty has been expressed in a range of domains; depressive symptoms and cognitive functioning are experienced as interrelated, possibly amplifying each other in a negative loop; SCCs indicate more problems than cognitive tests, and are at best weakly related to test performance; there is marked variability in how cognitive difficulties are conceived and in the strategies used to manage the difficulties (Hammar et al., 2022; Manit et al., 2017; Morey-Nase et al., 2019). Moreover, although not all depressed patients show worse cognitive test performance (Douglas et al., 2018), cognitive difficulties may still linger long after a depressive episode is over, and SCCs are shown to predict the risk of future depressive episodes (Majer et al., 2004; Ronold et al., 2020).

Hence, it has been proposed that clinical interventions of depression should address cognition overtly both during and after acute episodes, and also to take the individual variability and overall complexity of cognition into account. Specifically, a concept of "Cognitive enhancement therapy (CET) in mood disorders", has been proposed as an alternative to "Cognitive rehabilitation" or "Cognitive Remediation", the latter terms being better suited for traumatic brain injury or schizophrenia, where damage to the nervous system is more obvious (Douglas et al., 2019). The objective of CET is therefore not to reverse such damage, but to improve functioning, also in patients that do not display worsened objective (i.e., tested) cognitive performance. Considering individual variability, CET is conducted in stages: (1) a psycho-educative phase, in which the importance and implications of cognitive difficulties are examined; (2) a cognitive practice phase, where cognitive skills and strategies (including aspects of effort and motivation) are practiced; (3) a transfer to daily life phase, where the learnt skills are transferred to everyday situations relevant to the individual (Douglas et al., 2019). Given the similarities and likely overlap between ED and depression, the current results indicate that the CET approach could be viable also in stress-related exhaustion. A recommendation for future research is therefore to investigate the effectiveness and utility of such intervention in stress-related exhaustion. On a broader note, the results of this thesis may be informed by recent recommendations in clinical depression research underlining the differences between patients with respect to cognition, and the need of individual or sub-group assessment. Granted the general heterogeneity reported in the ED population (Lindsäter et al., 2022), it is plausible that that this sentiment is equally important in this group.

In sum, this thesis highlights different factors and strategies that may facilitate or hinder cognitive functioning and recovery. As several participants experienced stress and cognition to be interrelated, future research should aim to specify this relationship further. Metacognitive theory may be helpful in understanding the processes involved in the cognitive difficulties in ED, particularly the benefits reported from adopting a more compassionate and acceptant stance towards cognition and the own person. A recommendation for further studies in ED is therefore to include measures on metacognitive monitoring and beliefs (e.g., Butzbach et al., 2021; Wells & Cartwright-Hatton, 2004). From the clinical perspective, meta-cognitive therapeutic techniques aiming to enhance flexibility or detached mindfulness may prove useful in treating the cognitive symptoms in ED, as could the concept of CET, proposed in the context of mood disorders. Overall, the results suggest that in addition to gaining more specific information on cognitive functioning, future research and clinical practice should consider individual differences.

Implications

Multiple levels of understanding the experience of cognitive functioning

Cognition is a complex concept, not only because it involves multiple interacting functions, and the aforementioned methodological challenges of subjective and objective measurement. It also applies to different levels of explanation and abstraction, ranging from microscopic, physiological processes, and networks in an individual brain, to social, cultural and evolutionary phenomena (Bender, 2020; Colombo & Knauff, 2020). Such intricacy is manifested in the current findings as they display how SCCs are influenced or associated with, for example, neural properties, cognitive ability, self-assessment, and also with social or occupational relations and context. Additionally, the subjective experience of cognitive functioning and recovery is intertwined with other layered and intricate concepts such as depression, stress and exhaustion. This begs questions regarding the level in which the cognitive symptoms in ED should be understood. For instance: are they mainly a facet of depressed mood or self-image; of suboptimal executive functioning; of brain processes; a manifestation of stress or a toxic work-environment? And does a low correlation between SCCs and test performance indicate that the former is a poor measure of “actual” cognition? (Österberg et al., 2014). The answers to such questions ultimately depend on one’s philosophical beliefs on how reality is construed, the role of explanation in (cognitive) science, and the valuation of subjectivity. These issues are, at least in my view, difficult to resolve assertively and to an extent beyond the scope of this thesis. However, if only for pragmatic reasons, the current results seem to suggest that all levels of cognitive functioning are important to consider. To give a concrete example: the qualitative results have shown how participants with ED may see cognitive dysfunction as being contingent on the degree of distractors in the work setting, and, consequently, that means to change these conditions (e.g., working from home, or not having to share an office) may help cognitive functioning or performance. One way to understand this experience is in terms of executive performance (e.g., that people with ED suffer from problems with inhibiting unwanted sensory impressions). As noted, such ability is dependent on processes on the neural level, in-turn relating to the perception of everyday failure. Contrastingly, another explanation may see the experience as a result of poor work conditions, influenced by occupational, economic or political factors (e.g., Försäkringskassan, 2020; Åsberg, 2024). These dissimilar ways of explaining the same experience likely come with radically different solutions, where the former may support the utility of training or compensating for worsened cognitive ability, whereas the latter might call for action to be taken on an organizational or societal level. Hence, a view that only stresses one of these aspects risk missing crucial aspects of understanding (and potentially alleviating) the cognitive problems associated with stress-related exhaustion. Furthermore, as such different levels of abstraction or explanation may also influence one another (Bertolero & Bassett, 2020; Potochnik & Sanches de Oliveira, 2020), an important role of empirical research seems to be to establish these relations.

This thesis is rooted in a scientific, empirically grounded tradition but nevertheless acknowledges that the concepts under discussion need to be regarded as socially and historically situated. Exhaustion in particular has been considered a response to times of great societal change, and to mark a point where societal demands on the individual become excessive (Johannisson, 2006). This was the reasoning behind neurasthenia, and current-day researchers have also noted that our fast-changing society may be a cause of much of the ill-health we now describe as stress-related, burnout or ED (e.g., Hillert et al., 2020; Socialstyrelsen, 2003). Moreover, as outlined in the introduction, the concepts of exhaustion and cognition are both products of modernity, accenting quantification and strict measurement. It has been argued that this view on human behaviour and rational thought devaluates subjective experience and inquiry (Bornemark, 2018b), and by doing so, contributes to the high prevalence of stress and exhaustion in society today (Bornemark, 2018a). In this light, this thesis has contributed to the field by emphasizing the individual, first-hand experiences of ED and cognitive functioning, and how it may be linked to other levels of understanding cognition. The qualitative interviews in particular has provided information on aspects of cognition that risk to go unnoticed in both testing and questionnaires, which are usually based solely on pre-specified categories and notions on cognition (e.g., Burmester et al., 2015). For instance, the interviews demonstrated how cognitive functioning is contingent on external stressors, distractors, and support, providing important experiential information (Aronowitz & Lombrozo, 2020) which may help to better understand and further investigate cognitive symptoms at the functional or neural levels[22]. Moreover, they further underscore that exhaustion, stress and cognition are indeed interconnected concepts, not only in an academic sense but also in everyday language. Possibly, this may help to explain the high levels of SCCs reported by people diagnosed with ED, who, by definition, are likely to experience various kinds of stressors[23]. In any case, the qualitative results indicates that future studies should seek to better understand what is meant by, for example, memory or concentration for an individual person, and perhaps that there is no single level of "actual" cognition, at least not from an individual's point of view. Crucially, this is not to refute a materialist view of cognition or the world, or to say that cognitive processes are entirely relative or narrative constructs. It is merely to point out that the complex everyday experience that emerges from (many) simpler processes needs to be considered in its own right (Danermark et al., 2019; Lawani, 2021; McClelland et al., 2010; Nellhaus, 2004; Wiltshire & Ronkainen, 2021). Figure 5 depicts a highly schematic model on how SCCs may reflect multiple phenomena in different levels of abstraction or explanation.

In summary, the results align with a view that a full understanding of cognition requires integration of multiple levels of explanation (for a comprehensive discussion on this topic, see Colombo & Knauff, 2020). Specifically, the thesis has shown that in the complicated context of stress-related exhaustion, SCCs may be statistically associated with neural activity[24] and psychological distress. The qualitative interviews have furthermore displayed that the experience of cognitive functioning is indeed individual, and contingent on stress and external circumstances. This intricacy should be addressed in future studies and assessment of cognitive and neural processes. As outlined in the previous section,

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[22] Imaging studies may, for example, include paradigms that are perceived as stressful, or systematically alter the level of internal or external cognitive load.

[23] If environmental aspects/ stressors are seen as conceptually related to, or even partly the same phenomenon as cognitive difficulties, it should perhaps not be surprising to see high levels of cognitive failures being reported in this group. Similarly, as standardized tests may predict behaviour and performance better in controlled environments as opposed to messier everyday settings (Neisser, 1976), it is also possible that such methods are unequipped to catch precisely the cognitive difficulties that are conceptually close to stress and exhaustion.

[24] Importantly, this is not to reduce the subjective experience to its neural substrate (although the results could demonstrate important processes involved).

metacognition may be a viable theoretical framework for linking different aspects of cognitive functioning further.

Clinical implications

The complexity and heterogeneity of cognitive functioning in ED poses clinical challenges, not least given that cognitive test performance indicates relatively modest impairment at the group level. However, the results of this thesis suggest that people diagnosed with ED nevertheless report and experience substantial levels of distressing cognitive problems in everyday life, which for some people lingers long after general recovery. This has got clinical implications. Firstly, it indicates that cognitive problems are important and need to be addressed and evaluated, preferably on an individual basis. Here, the aforementioned CET framework is worth considering as it overtly addresses the variability between patients, and the relatively uncertain connection between everyday life functioning and test performance (Douglas et al., 2019). Specifically, this framework entails a first phase of therapy in which cognitive difficulties are highlighted and individually assessed with respect to their application for everyday life functioning. It moreover proposes that cognitive skills relevant to the individual should be practiced and subsequently transferred to daily life. However, similar to the case of depression, several challenges remain before such interventions may be implemented in clinical practice in larger scale (Hammar et al., 2022). For instance, more research and knowledge are needed on both specific cognitive processes and individual variability in the ED population. Moreover, the utility of the CET-approach, and indeed other ways to address cognitive problems, need to be evaluated in clinical trials, where everyday cognitive functioning should be part of the outcome criteria. Given that the health care system normally provides treatment on the basis of diagnoses, practical solutions on how to follow-up potential lasting, sub-clinical symptoms also need to be put forward.

As the experience of cognitive functioning may be intertwined with general recovery from ED, the current results indicate that means of getting better overall is also helpful with respect to cognitive symptoms, at least for some patients. Additionally, in order to be successful, therapeutic interventions might need to take cognitive difficulties into account (e.g., Hammar et al., 2022; Hronis et al., 2017). Given that the cognitive difficulties differ between individuals in both level and type, a recommendation for clinical interventions is to actively probe the cognitive functioning experienced by the individual patient, rather than to assume a certain profile of cognitive impairment in ED. However, the current results suggest that difficulties in sustaining attention and executive functioning should be assessed first, along with potential benefits from external memory support.

With respect to cognitive measurement, the results indicate that SCCs and cognitive tests are not interchangeable. Hence, clinical practice is cautioned against viewing questionnaires targeting SCCs as a convenient proxy for neuropsychological testing. Similarly, cognitive tests may be ill-suited to capture the cognitive and distressing dysfunction as it is experienced by patients with stress-related exhaustion. To be clear, this is not to say that standardized testing is inadequate per se. Rather, the results indicate that self-report and tests should be viewed as complementary measures of cognition, targeting different cognitive phenomena, and/or at different levels of explanation (Snyder et al., 2021; Toplak et al., 2013). Tests may provide information regarding specific underlying processes, whereas questionnaires reflect the more complex phenomenon of everyday cognitive functioning, which can be perceived in different ways by different patients, and influenced by, for instance, psychological distress. In practice, this again stresses the importance of probing individual circumstances and the weighing of different pieces of information in clinical cognitive assessment (Isquith et al., 2013).

Although the results stresses variability between individual patients, they give some pointers to what may be helpful interventions in targeting cognitive difficulty in ED. In particular, active engagement in cognitive tasks in everyday life, or standardized computerized cognitive training might be a viable approach for some patients (Gavelin et al., 2015; Gavelin et al., 2018). Others could be more helped by compensating for cognitive difficulties, for instance by using external memory aids, or being less exposed to a stressful, challenging environment; or by methods facilitating a self-compassionate and acceptant view on cognitive problems and performance. On the latter note, metacognitive therapeutic techniques (e.g., Wells, 2011) should be evaluated in the context of stress-related exhaustion.

Methodological strengths, limitations and suggestions for future research

This thesis has got strengths that are worth pointing out. Firstly, it studied the experience of cognitive functioning in ED from different perspectives, including both neural, behavioural and qualitative methods, illuminating and informing the complexity of this phenomenon. In particular, the qualitative interviews have provided more fine-grained information on the experience of cognitive functioning, extending beyond the information provided by questionnaires. Moreover, the thesis has presented correlates with SCCs, not only in the ED population but in relation to a matched control group. The analysis of brain activity did not allow for such comparison but enabled a window into possible compensational processes that in a longer perspective may be an important piece in understanding the cognitive sequela of stress-related exhaustion.

Some limitations are also important to consider. The bulk of these restrictions have been specified in the individual articles. Yet, some constraints are worth to address and emphasize here, along with broad suggestions for future research.

Study design

The studies were all cross-sectionally designed, disallowing causal conclusions to be drawn[25]. Hence, the quantitative results can only capture correlation between phenomena, without knowing the specific directions of the relationships. This is an evident disadvantage when

[25] In Study 3, using qualitative methodology, the participants were followed up years after inclusion in the RECO trial. However the analysis was based on data from a single time point.

seeking to understand, for instance, the relation between psychological distress and SCCs, which could point either way. The cross-sectional design is perhaps particularly hampering with respect to investigation of associations between SCCs and test results, as research in other fields has shown stronger such links regarding change over time (Zimprich & Kurtz, 2015), suggesting that SCCs may reflect alterations that are not yet detectable using cognitive testing. Notably, several participants experienced that functioning does get better with time, but with some lingering difficulties. Given that these qualitative observations were made at a single time point, it is of interest to learn how such experience may develop during the course of recovery, if it is transferable to the ED group as a whole, and how self-reported change relates to the course of test performance. An important recommendation for future research is therefore to design longitudinal studies investigating SCCs in stress-related exhaustion and to what extent they are influenced by, or predictive of, other factors. Moreover, such studies should consider using mixed-methods designs (e.g., Creswell & Inoue, 2025) in order to further explore the associations between questionnaire scores, test results, and qualitatively expressed experiences of cognitive dysfunction.

The clinical sample

The patients who participated in this research all took part of an MMR programme. At the T1 assessment (Study 1 and 2) they were 12 weeks into the intervention, which should be considered when interpreting the results. That is, it is possible that the level of cognitive dysfunction or psychological distress would be different in a group that had not begun the clinical intervention. To speculate, if these first weeks of intervention did improve different symptoms in dissimilar ways, the correlation between their measures may have been affected, perhaps hampering generalizability of these results to the ED population as a whole. On the other hand, as MMR is a common intervention in ED (Lindsäter et al., 2022), the sample still reflects conditions relevant to the population.

Nevertheless, future studies are recommended to further investigate the possible impact of treatment effects when investigating cognition in ED.

At the time of the follow-up interviews (Study 3), the participants had been allotted to different arms of a randomized control trial (Gavelin et al., 2018). While a variability in experiences can be considered a strength in the context of qualitative research, it is nonetheless likely that this sample-specific background has affected which aspects were perceived as helpful or hindering. On a similar note, the sample of study 3 were markedly smaller than the initial group recruited to the RECO-trial. Even though drop-out analysis did not show any systematic differences regarding clinical and demographic characteristics, selection effects are still possible and could hamper transferability to the general population of ED-patients. Lastly, it is worth pointing out that the clinical sample was recruited more than a decade ago when the concept of ED was younger. To speculate, this may have affected the participant's view of themselves and their problems in unknown ways. It would therefore be interesting to see future research that compares different cohorts of ED patients with respect to cognition and other symptoms.

Control conditions

Another important limitation of this thesis is the extent to which the findings can be attributed specifically to ED. Study 2 did not include a control group, prohibiting conclusions to be drawn whether the results are typical to ED patients. Study 1 did comprise a group of healthy control participants, which diverged from ED patients regarding level and type of SCCs, and psychological distress. While this contrast provides important information on the characteristics of the ED population compared to healthy people, it does not tell whether people with ED differ from other clinical groups. This is unfortunate given that the cognitive profiles associated to psychiatric conditions are often similar, perhaps indicating a general, transdiagnostic factor across several clinical populations (Abramovitch et al., 2021). Moreover, since ED is a concept where cognitive difficulties have been considered a particularly important feature (Åsberg, 2024), and that has also been critiqued, in-part due to unclear delineation against other diagnoses (Lindsäter et al., 2022), more direct comparisons between ED patients and other populations are needed. Recent research has compared cognitive performance and complaint in ED with Adjustment disorder (Franke Föyen et al., 2023). Given the association between SCCs, depression and anxiety in this group, future studies should seek to include also patients diagnosed with other conditions, including major depression, anxiety disorders and CFS.

Cognitive measurement

This thesis has used two different SCCs-questionnaires. This is a strength considering that the PRMQ provides a relatively detailed measure of type of memory and the CFQ a broad, commonly used metric of cognitive failure. Moreover, the qualitative method employed in Study 3 gives a deeper, more fine-grained view of the subjective experience of cognitive functioning. Nevertheless, as shown, SCCs may be conceptualized in different ways and it cannot be ruled out that other questionnaires would have yielded other results. Overall, future studies are recommended to carefully consider which instruments to use. If the aim is to investigate the relation between SCCs and test performance, questionnaires that specifically target the same cognitive functions that are tested should be opted for (Vestergren et al., 2011), as should instruments allowing analysis of the impact from cognitive load or external support (e.g., Krieglstein et al., 2023; Schuessler et al., 2024; Woods et al., 2010). On this point, the finding that indicates more SCCs in executively demanding memory tasks should be replicated using instruments developed to this end (e.g., Krieglstein et al., 2023).

Regarding the cognitive tests, it is noteworthy that the selection of tasks included in Study 1 was one of many possible conceptualizations of cognitive functions. Although the tests were theoretically sorted into broader domains, their internal relations were difficult to assess. Specifically, some domains (i.e., EFs, WM) were measured using multiple tests, whereas others (i.e., reasoning, perceptual speed and episodic memory) were tapped using single tests only. Given that tasks overlap different domains, future studies should consider using a more comprehensive battery, which would allow for comparisons of the cognitive constructs at the same latent level (Noack et al., 2014).

The battery was also weighted towards executive functioning as it comprised more executive tasks in comparison with, for example, episodic memory. This is important to consider when interpreting the results, particularly regarding the association between cognitive test performance and SCCs, for which the analysis included a global composite score. However, as no correlation was seen between any measure of cognitive test performance or SCCs, it is unlikely that a more comprehensive battery would have detected highly different results in this regard.

Some of the tests included here also came with methodological challenges or drawbacks of their own. Firstly, it has been suggested that use of behavioural assessment, such as the presently used tasks, may be inherently problematic in research on behavioural differences (Hedge et al., 2018). This relates to the aforementioned reliability paradox, which highlights that cognitive tests have often been developed with an aim to minimize variability between individuals. In other words, commonly used tasks that produce relatively stable cognitive effects are reliable precisely because of their effects not varying much between different people. However, for the same reason, the between-person reliability may be hampered, which is problematic when using them in correlation models for assessing cognitive traits of specific groups (Dang et al., 2020; Hedge et al., 2018). This may have influenced the results of the current work, (e.g., the low associations between cognitive tests and SCCs) and again underlines the need to complement the findings with future longitudinal, experimental research in which these issues may pose less of a problem (Dang et al., 2020).

Furthermore, difference scores (such as those produced by the Stroop, Flanker and Trail making tasks) may be particularly disposed to suboptimal reliability. Specifically, the administration of multiple tasks, (making up the contrast) may result in an increased influence of measurement error on the results (Crawford et al., 2008). On a speculative note, it should also be seen that such repeated measurement could interact with fatigue and motivation (Wiley et al., 2024), which might be particularly important to control for in the context of stress-related exhaustion.

Relatedly, this thesis has primarily used RT, as opposed to accuracy scores, as outcome measures for these tasks. The two types of measurement could reflect partly different cognitive phenomena, where the former may rely relatively more on, for instance, processing speed (Kyllonen & Zu, 2016), which should be considered when assessing the results. To learn more about the trade-off between RT and accuracy in stress-related exhaustion, alternative statistical methods, such as diffusion modelling (Ratcliff et al., 2016) should be considered by future studies. Such approach, which for technical reasons was not possible in Study 2[26] ,could also provide important, detailed information about the information processing and possible compensational strategies involved during cognitive tasks.

Neuroimaging

Regarding the brain imaging, Study 2 describes several of the general limitations and recommendations for future studies in some detail. Briefly, future confirmatory studies on compensatory processes are recommended to target specific regions of interest, and to include resting-state measurement and analysis of functional connectivity. Most importantly, however, such research should include control groups. The results of Study 3 give some further clues on cognitive experiences in ED that may be particularly worth investigating on the level of neural processes. In particular, future imaging studies are recommended to investigate the neural response to longer, more exhausting test

[26] RT and accuracy scores were both analysed and presented in Study 2. However, if a participant did not answer within 2 seconds, the response was automatically coded as No answer. Unfortunately, this hindered meaningful assessment of a trade-off between RT and accuracy using diffusion modelling.

procedures, which may display cognitive difficulties, and possibly also their neural correlates, more clearly (Gavelin, 2023). Such research should also consider using paradigms and instruments that can illuminate how neural or compensational processes are affected by external distractions or support, stress, self-criticism, and metacognitive monitoring.

Qualitative methodology

Depending on one's view on the role of thematic analysis (e.g., Braun & Clarke, 2019), the partly deductive approach of Study 3, in which some cognitive domains were defined before analysis started, may be seen as theoretically problematic. That is, since the study aimed to learn about cognition from the first-hand perspective, categorization into pre-decided cognitive domains may seem ill-advised. On this point, a granted risk of the chosen method is that it may affect how themes are presented, prompting terminology relatively far away from the participants own accounts and vocabulary (e.g., what a clinical psychologist may understand as a WM impairment is not necessarily described in those literal terms by a patient). However, it should also be seen that the initial conceptions of cognitive domains were regarded as tentative, meaning that they were not always used, and excluded if not present in the interviews. More importantly, it may be argued that to a substantial degree, categorization is inherent in all thematizing, and that the role of a researcher is to clarify pre-understanding which could affect the results (Palmér et al., 2022). Hence, presenting the conceptualization of, and interest in, certain domains beforehand seems to be a more transparent and reflective approach in this case. Regarding cognition specifically, the possible disconnect between psychological terminology and everyday language is interesting in its own right. It would therefore be interesting to see further qualitative research that examines how patients with stress-related exhaustion themselves verbalize and categorize cognitive phenomena.

Lastly, an important limitation of Study 3 was the long time period (i.e., 6-10 years) that the participants were asked to remember. Given the general limits of, and biases involved in, human memory (e.g., Ash, 2009), an exhaustive account of the course of cognitive functioning is obviously not to be expected. While this constraint should be considered when assessing the findings, it should be seen, however, that the study explicitly aimed to present the participants' experiences rather than such objective reports.

Further suggestions for future research

In addition to the aforementioned points, a proposal for future research is to investigate how patients with ED assess their cognitive test performance (e.g., Butzbach et al., 2021), which may provide important information on metacognitive processes. In order to better understand how these factors may influence monitoring and the overall experience of cognitive functioning, such studies should also consider including measures of depressive symptoms and personality. On a broader note, cognitive research in stress-related exhaustion is recommended to extend its scope beyond controlled test environments and seek to measure cognitive functioning as it appears in everyday life. To that end, an additional suggestion is to find as specific information on the cognitive processes involved as possible, and on how they are impacted by external cueing and cognitive load. Lastly, as indicated by the qualitative results of this thesis, future studies should seek to capture fine-grained information and individual variability, not only in SCCs and testable performance, but in psychological distress, stressors and distractors, self-image and -criticism, as well as in occupational and social conditions.

Concluding remarks

This thesis has added empirical evidence on the experience of cognitive functioning in stress-related exhaustion. It has indicated that people with

ED may experience substantial cognitive difficulties that tap into in multiple cognitive domains, but are particularly salient in executively demanding situations and tasks. The results have furthermore shown individual differences in how cognitive difficulties are perceived and best recovered. Moreover, the experienced problems risk going unnoticed in cognitive testing, which may be due to a number of reasons, including methodological issues, the influence of psychological distress, and possible compensational strategies and processes. Overall, the thesis has demonstrated and emphasized that the issue of cognitive functioning in this group is intricate, and that both clinical practice and future research have got plenty of hard work ahead addressing this complexity. Perhaps more importantly, it has demonstrated that such endeavor is meaningful, not only to the still novel field of ED, but to individual people experiencing cognitive difficulty.

Epilogue

A few days before this manuscript was sent to print, news arrived that ED will not be included in the upcoming 2028 version of the ICD-SE; the reason being that the World health organization has cautioned against nation specific diagnoses (Jernberg, 2025). To some extent, this puts the current findings and recommendations in a new light, as it in unknown how the symptoms and experiences discussed here will be diagnostically defined from that point on.

In 2024, about 20000 Swedish people were diagnosed with the ED, which is an increase from already high levels (Försäkringskassan, 2025). If anything, this recent development and the results of the current thesis underscores that the experiences associated with stress-related exhaustion need to be better understood, extending beyond diagnostic labelling.

Tables and figures

Table 1
Diagnostic criteria for Exhaustion disorder, ICD-10-SE code F43.8A

A. Physical and mental symptoms of exhaustion with a minimum of 2 weeks duration. The symptoms have developed in response to one or more identifiable stressors, present for at least 6 months.
B. Markedly reduced mental energy, which is manifested by reduced initiative, lack of endurance or increase of time needed for recovery after mental efforts.
C. At least four of the following symptoms have been present most of the day, nearly every day, during the same 2-week period:

1. Persistent complaints of impaired memory or concentration
2. Markedly reduced capacity to tolerate demands or to work under time pressure.
3. Emotional instability or irritability.
4. Disturbed sleep.
5. Persistent complaints of physical weakness or fatigue.
6. Physical symptoms such as muscular pain, chest pain, palpitations, gastrointestinal problems, vertigo, or increased sensitivity to sounds.

D. The symptoms cause clinically significant distress or impairment in occupational, social or other important areas of functioning.
E. The symptoms are not due to the direct physiological effects of a substance (e.g., drug abuse, medication) or a general medical condition (e.g., hypothyroidism, diabetes, infectious disease).
F. If criteria for major depressive disorder, dysthymic disorder or generalized anxiety disorder are met, ED is set as co-morbid condition.

Note. All criteria signified by capital letters need to be fulfilled for the diagnosis.

Table 2
Clinical burnout studies including measures of subjective cognitive complaints

	Participants	Description of SCCs	Instrument	Design[a]	Between-group differences in SCCs	Within-group associations between burnout and SCCs	Association between SCCs and other measures of psychological distress	Association between SCCs and cognitive test performance	Country
Baseline studies									
van der Linden et al., 2005	Clinical burnout (patients diagnosed with Undifferentiated somatoform disorder, adding work-related causes (DSM-IV; (n=13). Subclinical burnout (i.e., persons reporting burnout but not qualifying for diagnosis; n=16). Healthy controls (n=14).	Cognitive failure.	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional.	The clinical burnout group reported more SCCs than the subclinical burnout group which in turn reported more SCCs than the control group.	Not investigated.	Not investigated.	Not investigated.	The Netherlands.
Öhman et al., 2007	Patients on sick-leave for chronic stress (n=19). Healthy controls (n=19).	Subjective memory concerns.	*The 5-item Questionnaire on Everyday Memory Problems* (5-QEMP; Nilsson et al., 1997). Outcome measure was the summed score of all items.	Cross-sectional.	Patients reported significantly more SCCs than the controls.	Not investigated.	Not investigated.	Not investigated.	Sweden.
Österberg et al., 2009	Patients on sick	Subjective cognitive problems.	*The Euroquest 9: Memory and*	Cross-sectional.	Patients reported significantly more	Not investigated.	Not investigated.	No associations were found between level of	Sweden.

	leave with work strain as probable cause. Diagnosed within the ICD-10 category Reaction to severe stress and adjustment disorders (n=65). Healthy control group (n=65).		*concentration scale.* Outcome measure was the summed score of all items.		SCCs than the controls.			SCCs and performance on any of the tests included in a battery tapping episodic memory, perceptual speed, incidental learning, sustained attention, spatial learning and vocabulary.	
Oosterholt et al., 2012	Clinical burnout (patients diagnosed with Undifferentiated somatoform disorder, adding work-related causes (DSM-IV)) (n=13). Healthy control group (n=16).	Self-reported cognitive difficulties.	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional/ longitudinal.	Patients reported significantly more SCCs than controls at both baseline and after 10 weeks of cognitive behavioural therapy. Unlike the control participants, patients reported a significantly lower level of SCCs at the latter time point.	Not investigated.	Not investigated.	Not investigated.	The Netherlands.
Jonsdottir et al., 2013	Patients diagnosed with ED (n=40). Healthy control group (n=49).	Self-reported memory.	A single unvalidated item focussing on current memory functioning.	Cross-sectional.	Patients reported significantly more SCCs than the controls.	Not investigated.	Not investigated.	No association was found between SCCs and performance on any test included in a battery tapping speed, attention, WM, episodic memory, learning, EFs, visuospatial functioning and language.	Sweden.

Oosterholt et al., 2014	Clinical burnout (patients diagnosed with Undifferentiated somatoform disorder, adding work-related causes (DSM-IV; n=13) Subclinical burnout; persons reporting burnout but not qualifying for diagnosis (n=29) Healthy controls (n=30)	Self-reported cognitive difficulties.	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional.	The clinical burnout group reported more SCCs than the subclinical burnout group which, in turn, reported more SCCs than the control group.	Not investigated.	Not investigated.	Not investigated.	The Netherlands.
Eskildsen et al., 2015	Patients with mental health issues considered a reaction to work-related strain (excluding psychiatric disorders; n=60). Healthy control group (n=59).	Self-reported cognition.	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional.	Patients reported significantly more SCCs than the controls.	Not investigated.	Not investigated.	Not investigated.	Denmark.
Krabbe et al., 2017	Patients diagnosed with ED (n=25) Healthy control group (n=25)	Subjective cognitive function.	*The CFQ.* *The PRMQ.*	Cross-sectional	Patients reported significantly more SCCs than controls.	Not investigated	Not investigated	Not investigated	Sweden.
Ellbin et al.,, 2018	Patients diagnosed with ED (n=83). Healthy control group (n=111).	Self-reported memory.	The same single item used in Jonsdottir et al., 2009.	Cross-sectional.	Not investigated.	Not investigated.	Not investigated.	Using a battery comprising six tasks tapping speed and attention, learning and episodic memory, visuospatial	Sweden.

								functioning, language, and EFs (inhibition), SCCs were significantly associated with worse performance on solely the episodic memory task.	
Jensen et al., 2022	Patients diagnosed with work-related stress using ICD diagnoses F43.2, F43.9, Z56, and who also exceeded the cutoff for clinical burnout, measured using the KEDS (n=82).	Subjective measure of cognitive status.	*The CFQ.*	Cross-sectional.	Not investigated.	Not investigated.	Not investigated.	The study investigated how the CFQ total score was associated with performance on a screening instrument comprising subtests measuring verbal memory, WM/ executive skills and visuomotor processing speed, as well as results on more comprehensive tasks assessing the same functions. In both cases, the results did not show any correlation between CFQ and cognitive test performance.	Denmark.
Franke-Föyen et al., 2023	Patients diagnosed with either Adjustment disorder (n=131) or ED (n=135) were included in the analysis.	Subjective memory impairments.	A digitalized version of the *6-QEMP*. Outcome measure was the summed score of all items.	Cross-sectional.	The ED group reported significantly more SCCs than patients with Adjustment disorder.	Burnout level (measured with the SMBQ) was significantly correlated with SCCs.	Not investigated.	The level of SCCs was largely uncorrelated with a test battery administered online. The battery included	Sweden.

								measures in three general domains: attention and processing speed, executive functioning, and memory.	
Renaud & Lacroix, 2023	Patients receiving health care and granted sick leave for burnout, and who also exceed the cutoff for clinical burnout, measured using the KEDS (n=29).	Self-reported cognitive function.	A French version of the *BRIEF*. The questionnaire generated several outcome measures: a General executive composite, comprised of a Behavioral index and a Metacognitive index, in-turn comprised of still narrower domains.	Cross-sectional.	No direct between-group analyses were performed. However, the study did compare the SCCs reported by the sample of patients to test norms. The results revealed the burnout group to report significantly more SCCs, with moderate to large effect sizes, in all but one domains (the narrow domain of self-monitoring).	Burnout levels were significantly correlated with more SCCs. When assessing the BRIEF's individual indexes, The Behavioral index but not the Metacognitive Index showed significant association with SCCs.	Personality variables Neuroticism and Perfectionism, as well as emotion suppression were associated with more SCCs in some measures, particularly with respect to BRIEF-A items indicating negativity.	Using a cognitive test battery targeting memory and EFs, a total of 56 correlation analyses of objective and subjective measures were conducted. Of these, three were statistically significant, all showing associations between the inhibition (Stroop performance) and the narrow BRIEF-A-measures Self-monitoring, Planning, and Organization of material. On this note, the authors highlighted that Stroop performance was uncorrelated to the inhibition measure of BRIEF-A.	France.

Follow-up studies									
Österberg et al., 2012.	1.5-year follow-up of the patients from Österberg et al., 2009 (n=45).	Subjective cognitive problems.	*The Euroquest 9: Memory and concentration scale.* Outcome measure was the summed score of all items.	Longitudinal.	Not investigated.	Not investigated.	Improvement in SCCs was significantly correlated with improvement in depression levels (SCL-90).	Improvement in SCCs was uncorrelated to improvement in cognitive test results.	Sweden.
Österberg et al., 2014	2+ years follow-up of the former patients and controls from Österberg et al., 2012. Patients (n=54). Healthy control group (n=50).	Self-ratings of cognitive problems.	*The Euroquest 9: Memory and concentration scale.* Outcome measure was the total score, summing all items. Some analyses also included two subscales measuring concentration/ attention and memory, respectively. *5-QEMP*. Outcome measure was the total score, summing all items. Some analyses included the five individual items.	Cross-sectional	When controlling for depression levels, the 5-QEMP but not the Euroquest score was significantly higher in the patient group compared to controls. When not controlling for depression levels, the patients reported significantly more SCCs than controls with small to medium between-group effect sizes. This effect was seen for not only the total scores of both instruments but also for the two subscales of the Euroquest and the five specific items comprising the 5-QEMP.	Not investigated.	Levels of SCCs and depression were highly correlated.	SCCs (the total scores of the two instruments) were largely unrelated to test performance. When controlling for depression levels, gender and medication, three out of 106 correlation analyses showed p values smaller than 0.05, indicating that, in the patient sample, higher levels of SCCs were associated with both worse (accuracy on a sustained attention task), and better (response on the same sustained attention task) performance. In the control group a single significant association was seen between the	Sweden.

								Euroquest and another measure of visual sustained attention.	
Eskildsen et al., 2016	1 year follow-up from Eskildsen et al., 2015. Patients (n=56). Healthy controls (n=56).	Cognitive complaints	*The CFQ.* Outcome measure was the summed score of all items.	Cross sectional.	Patients reported significantly more SCC than controls at the 1 year follow up.	Not investigated.	Not investigated.	Not investigated.	Denmark.
Eskildsen et al., 2017	Patients from Eskildsen et al., 2015. Longitudinal follow-up 1,2,3,6,9 and 12 months after inclusion (n=57).	Self-reported cognitive complaints	*The CFQ.* Outcome measure was the summed score of all items.	Longitudinal.	Not investigated.	Not investigated.	The extent of improvement in perceived stress and sleep quality predicted the concurrent improvement in SCCs. These relationships were bidirectional as SCCs successfully predicted change in both perceived stress and sleep quality, respectively. Perceived stress was a stronger predictor of SCCs than sleep quality.	Not investigated.	Denmark.
Oosterholt et al., 2016	1.5 year follow up from Oosterholt et al., (2014). Clinical burnout (n=31)	Self-reported cognitive problems	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional/ longitudinal.	At the 1.5-year follow-up assessment, the clinical burnout group still reported more SCCs compared the control group	Not investigated.	Not investigated.	Not investigated.	The Netherlands.

	Non-clinical burnout (n=27). Healthy control group (n=27).				but not to the subclinical burnout group. Only the clinical burnout group showed a significant change (decrease) in SCCs at the follow-up assessment.				
Dalgaard et al.,, 2021	4-year follow up from Eskildsen et al., 2015, 2016. Former patients (n=41). Healthy control group (n=35).	Subjective cognitive complaints	*The CFQ.* Outcome measure was the summed score of all items.	Cross-sectional.	At the 4-year follow-up assessment, the patients still reported significantly more SCCs compared to the control group.	Not investigated.	Not investigated.	Not investigated	Denmark.
Ellbin et al., 2021	Patients still fulfilling criteria for ED 7-10 years after diagnostic assessment (n=51). Patients no longer fulfilling criteria for ED 7-10 years after diagnostic assessment (n=98). Healthy control group (n=50).	Self-reported cognitive difficulties.	*The Sahlgrenska self-reported cognitive impairment questionnaire* (SASCI-Q; Eckerström et al., 2013) Outcome measures were five subscales (Difficulties related to communicating with others, Feeling cognitively insecure and making mistakes, Getting comments from others about	Cross-sectional.	The patients still fulfilling criteria for ED reported more SCCs than the formerly diagnosed group which in turn reported more SCCs than the control group. Differences between the three groups were found for all subscales.	Not investigated.	When excluding participants scoring high levels of depression and anxiety, the group differences in SCCs-levels were still significant with the subscale "Difficulties related to general/ executive cognitive function" as a single exception. This scale still differed between the patient and recovered patient groups, but not between	Not investigated.	Sweden.

			my functioning, Using memory aid, Difficulties related to general/ executive cognitive function).				recovered patients and controls.		
Worm et al., 2023	Patients diagnosed with work-related stress using ICD diagnoses: F43.2, F43.9, Z56, and who also exceeded the cutoff for clinical burnout, measured using the KEDS (n=82). Patients were followed up after 6-months with questions regarding occupational status.	Subjective cognitive impairments.	*The CFQ.*	Cross-sectional/ longitudinal.	Not investigated.	Not investigated.	Not investigated. It was noted, however, that SCCs was not associated with occupational status, but that cognitive test performance was, including the brief screening battery used in Jensen et al., 2022.	Not investigated.	Denmark.

Note. [a] Design specifically refers to analyses involving subjective cognitive complaints.

Table 3

Overview of the studies included in the thesis

	Study 1	Study 2	Study 3
Design	Cross sectional (between-group and within-group analyses).	Cross sectional (within-group analyses).	Qualitative (at 6 to 10-year follow up).
Participants	Patients diagnosed with ED (n=103). Healthy control group (n=58).	Patients diagnosed with ED (n=56).	Former ED patients (n=38) who had taken part in MMR-intervention.
Method of data collection	***Subjective cognitive complaints*** PRMQ. SMBQ. ***Cognitive test performance*** Executive functions: *n-back, Colour-word interference test, Trail making test.* Working memory: *Digit span forward, digit span backward, Letter-number sequencing.* Episodic memory: *Recall of concrete nouns.* Perceptual speed: *Digit Symbol.* Reasoning: *Raven's matrices.* ***Psychological distress*** SMBQ. HADS.	***Subjective cognitive complaints*** PRMQ. SMBQ. ***Psychological distress (burnout)*** SMBQ. ***Cognitive test performance*** Executive functions (Inhibition): *Flanker.* ***Neuroimaging*** Functional magnetic resonance imaging.	***Subjective experience of cognitive functioning and the recovery process*** Individual Semi-structured interviews.
Methods of data analysis	***Mean group differences*** Independent samples t-tests/ one-way ANOVAS. ***Type of cognitive complaints*** Mixed ANOVAS. ***Factors associated with SCCs*** Hierarchical multiple regression models.	***Associations between cognitive performance and SCCs and burnout*** Bayesian correlations. ***Neuroimaging*** Regression analysis (General linear models).	**Thematic analysis.**

Note. PRMQ: Prospective and retrospective memory questionnaire, CFQ: Cognitive failure questionnaire, SMBQ: Shirom-Melamed burnout questionnaire, HADS: Hospital anxiety and depression scale; ANOVA = Analysis of variance.

Table 4
The cognitive tests included in the thesis

Cognitive domain/ Task	Description of the procedure	Included in	References
Executive functions			
Updating			
Letter-memory running span	10 lists of letters (A, B, C, or D) were displayed serially on a lap-top screen. The letters were presented during 2 seconds each, with a 1 second interval between them. The instruction was to recall and respond the four last letters in correct order after each presented list, using four adjacent keys on the keyboard. The list lengths varied and were unknown for the participants. Two parallel versions of the tests were used and counter-balanced between the participants. Number of correct recalled four-letter sequences (max= 10) was used as the outcome measure.	Study 1	Miyake et al., 2000; Pollack et al., 1959; Sandberg et al., 2014 (Pollack et al., 1959)
n-back	27 sequences of digits (1–9) were presented on a lap-top screen, one digit at a time. Each digit was displayed for 1500 milliseconds, with a 500-millisecond interval. For each sequence, the participants were instructed to decide if the current number matched the number presented either one, two, or three positions before (i.e., constituting 1-back, 2-back or 3-back-conditions). The participant responded using two adjacent keys on the keyboard denoting yes (index finger) or no (middle finger), respectively. The outcome measure was the number of correct answers minus error for each condition.	Study 1	Miyake et al., 2000, Sandberg et al, 2014
Inhibition			
The Colour-word interference test	The Colour-word interference test (also known as the Stroop task) was conducted according to the instructions in the Delis-Kaplan executive function system (D-KEFS) test battery. The participants were presented with two conditions. In the first congruent condition they were instructed to read words denoting colours (printed in black) as fast and accurately as possible. In the second incongruent condition the names of colours were printed in other colours (e.g., the word red was printed in green). Here the participants were instructed to name the printed colours as fast and accurately as possible. The outcome measure was the inhibition cost, i.e., the time in seconds to complete the incongruent minus the congruent condition.	Study 1	Delis et al., 2021; 2024
Flanker	68 trials were performed in which five horizontally aligned arrows appearing on a computer screen, within the MR-scanner. The participants were instructed to answer if the middle arrow pointed to the left (<) or right (>) and told do this as quickly and accurately as possible, using their index and middle finger on their right hand. The four adjacent arrows (i.e., the flankers) either pointing in the same or opposite direction as the targeted middle arrow, hence forming either a congruent (<<<<< or >>>>>) or incongruent (<<><< or >><>>) condition. Each trial consisted of a fixation cross (+) presented for two seconds, immediately followed by a two second display of the principal stimulus (i.e., the arrows). The number of possible correct answers were 34 per condition. If a person failed to respond within a time limit of two seconds, the event was coded as “No answer”. Two measures of response inhibition performance were generated from the task: RT (i.e., the difference in time	Study 2	Eriksen & Eriksen, 1974; Sandberg et al., 2014.

	(seconds) between the congruent and incongruent task conditions, and Accuracy (the difference in number of correct answers).		
Shifting			
Trail-making test	The Trail making test was also conducted according to the instructions in the D-KEFS. The task is to draw continuous line between pre-printed points on an A3-size paper, and comes in two conditions. The first is to connect points in numerical order (1 to 2 to 3, etc). The second condition entails both numbers and digits, where the objective is to switch between two sets of rules, numerical and alphabetical order (1 to A to 2 to B, etc). The outcome measure was the time in seconds to complete the shifting condition minus the time to complete the number-sequencing condition.	Study 1	Delis et al., 2021; 2024
Working memory			
Digit span	The digit span task was administered according to the instruction in the WAIS-R battery. Specifically, the forward and backwards conditions were used. In both cases, lists of digits were read out loud by the test leader. Immediately after the list was read, the participants were instructed to repeat the list in either the same (the forward condition) or in reverse order (the backwards condition). The number of digits increased for every two lists, with a maximum of 9 digits. Hence, there were two trials for every list length. If a person succeeded to repeat any the digits correctly for a list length, the test continued, or was otherwise aborted. The outcome measure was the total number of correctly recalled sequences in each condition.	Study 1	Wechsler, 1981
Letter-number sequencing	The Letter-number sequencing task was administered according to the instruction in the WAIS-III battery. Here lists of digits and numbers were read out loud. The participants were instructed to sort the numerically and the letters alphabetically. Similar to the digit span test, there were two or three trials for every list length. If a person succeeded to repeat any of these lists, the test continued. The outcome measure was the total number of correctly recalled sequences.	Study 1	Wechsler, 1997
Episodic memory			
Buschke's procedure of selective reminding	18 nouns were presented to the participants on a lap-top computer screen. For a first trial, the words were presented one by one, five seconds per word. For this first trial all 18 nouns were presented. The participants were subsequently instructed to recall and say every word they remembered in any order. Words that were not recalled were subsequently presented again orally for three more trials, to be recalled again. The outcome measure was the total number of recalled nouns across the four presentations. Three different lists of words were used and counter-balanced between the participants.	Study 1	Buschke, 1973
Perceptual Speed			
Digit Symbol	Digit Symbol was administered according to the WAIS-R [32]. Here a coding key is given, showing eight symbols each attached to a certain symbol. A list of numbers is also given. The task is to decode and transcribe as many symbols as possible during 90 seconds, using pen and paper. The outcome measure is the total number of correctly drawn symbols.	Study 1	Wechsler, 1981

Reasoning ability			
Raven's matrices	Patterns of images or symbols are presented in 3 x 3 pattern matrices where one part is missing. The test consists of 36 matrices and was split into two parts using odd and even items, counterbalanced to the participants. Hence, 18 matrices were presented to each person. The task is to logically deduce which piece that is missing from a range of alternatives. Before the task was administered, a 5-minute, unscored test administration was also conducted for instructional purposes. The outcome measure was the total number of correctly solved matrices in 10 min.	Study 1	Raven, 1998

Table 5

Summary of hierarchical regression analyses showing associations with subjective cognitive complaints

	Patients						Control group					
Variable	β	*SE*	*p*	*R*	R^2	ΔR^2	β	*SE*	*p*	*R*	R^2	ΔR^2
Step 1			*.04*	.28	.08	.08			*.04*	.37	.14	.14
Age	-.25	0.10	*.01*				-.05	0.13	.70			
Sex												
Female	.07	0.39	.45				.38	0.33	*.01*			
Education level												
University	.13	0.28	.20				.02	0.26	.88			
Step 2			.64	.29	.08	.00			.46	.39	.15	.01
Global cognitive composite	.05	0.15	.64				.10	0.14	.46			
Step 3			*.02*	.42	.18	.09			*.00*	.64	.41	.26
Exhaustion	.12	0.15	.37				.16	0.14	.26			
Depression	.20	0.93	.12				.31	0.17	.07			
Anxiety	.04	0.14	.74				.15	0.17	.39			

Note. Reported beta coefficients are from the step in which the variables were first entered. Significant results are italicised.

Table 6

Regions showing significant activation in the incongruent relative congruent interference contrast

Brain region	Nr of voxels	BA	L/R	x	y	z	*t*
Cluster 1	2241						
1. Inferior occipital gyrus		19	R	38	-80	8	9.45
2. Superior parietal lobule		7	R	22	-64	46	7.79
3. Inferior occipital gyrus		19	R	44	-78	-6	7.54
4. Superior occipital gyrus		19	R	28	-70	30	6.77
5. Middle occipital gyrus		19	R	34	-82	22	6.07
6. Superior parietal lobule		7	R	34	-48	48	5.76
7. Inferior occipital gyrus		19	R	44	-64	-10	5.68
8. Inferior temporal gyrus		37	R	48	-54	-16	5.52
9. Supramarginal gyrus		40	R	38	-38	40	5.52
Cluster 2	786						
1. Inferior occipital gyrus		19	L	-46	-74	-6	7.60
2. Middle occipital gyrus		18	L	-32	-82	8	7.08
3. Inferior occipital gyrus		18	L	-36	-80	-2	5.89
Cluster 3	79						
1. Middle frontal gyrus		6	R	26	-2	52	5.94
Cluster 4	63						
1. Supplementary motor area		6	R	6	12	46	5.60
2. Supplementary motor area		6	L	-6	12	44	5.49
Cluster 5	51						
1. Superior parietal lobule		7	R	-22	-62	54	5.55
Cluster 6	15						
1. Insula		13	R	32	28	-2	5.52
Cluster 7	13						
1. Precentral gyrus		6	L	-26	-10	54	5.23
Cluster 8	11						
1. Superior occipital gyrus		19	L	-24	-72	26	5.21

Note. $p < 0.05$ FWE-corrected. Locations are reported in MNI-space.

Table 7

Associations PRMQ and SMBQ levels and flanker task performance

Variables	1	2	3	4	5	6	7	8
1. PRMQ	-							
2. SMBQ [b]	.25 (.05 - .42) [3.58]	-						
3. Congruent RT [c]	-.00 (-.18 - .18) [0.18]	.22 (.02 - .38) [2.15]	-					
4. Congruent accuracy [c]	.04 (-.15 - .22) [0.20]	-.13 (-.30 - .06) [0.43]	-.21 (-.37 - -.03) [2.16]	-				
5. Incongruent RT [c]	.00 (-.19 - .18) [0.18]	.16 (-.03 - .33) [0.66]	.76 (.54 - .87) [>100]	-.25 (-.41 - -.07) [7.26]	-			
6. Incongruent accuracy [c]	.08 (-.11 - .26) [0.26]	-.10 (-.27 - .09) [0.30]	-.10 (-.27 - .08) [0.30]	.38 (-.19 - .53) [>100]	-.08 (-.25 - .10) [0.25]	-		
7. Inhibition cost RT [c]	.03 (-.16 - .21) [.19]	.09 (-.09 - .27) [0.28]	-.08 (-.25 - .09) [0.26]	.12 (-.06 - .28) [0.38]	-.33 (-.48 - -.14) [82.65]	-.04 (-.21 - .14) [0.19]	-	
8. Inhibition cost accuracy [c]	-.10 (-.28 - .09) [0.32]	.07 (-.12 - .24) [0.23]	.01 (-.17 - .18) [0.17]	-.03 (-.20 - .15) [0.18]	-.02 (-.19 - .15) [0.18]	-.82 (-.91 - -.59) [>100]	.05 (-.13 - .22) [0.20]	-

Note. Kendall's tau correlations. Values in rounded brackets indicate the 95% confidence for each correlation. Values in square brackets indicate Bayes factor 10 [a] *n*=50. [b] *n*=52. [c] *n*=56. PRMQ=Prospective and retrospective memory questionnaire. SMBQ= Shirom-Melamed burnout questionnaire.

Table 8

Overview of the coding template's two highest levels of themes

"It's different now": Remaining cognitive symptoms	**The bigger picture: Cognitive recovery in context**	**Overcoming challenges: Strategies for coping with cognitive symptoms**	**The approach towards cognition matters**
Changes in cognitive functioning	Inner and outer barriers for cognitive functioning	Individual strategies	Distress relating to cognitive functioning
Type of remaining problems: difficulty maintaining attention and executive control over time	Cognitive functioning is facilitated by general recovery from ED	Optimizing outer conditions	Acceptance and self-compassion: A shift in perspective facilitates cognitive functioning

Note. Top-level themes are bolded.

Figure 1.

The flow of participants in the RECO-trial.

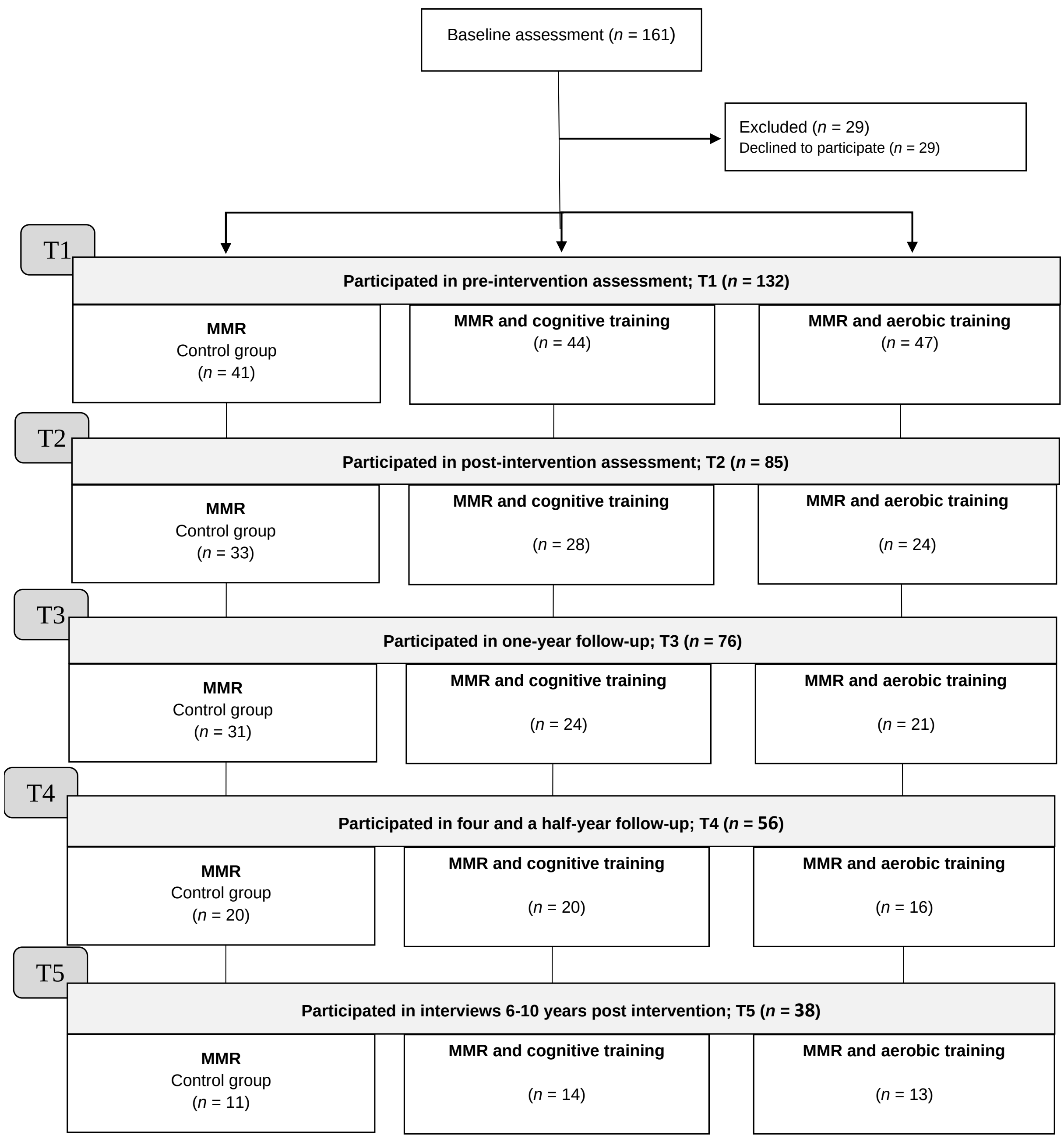
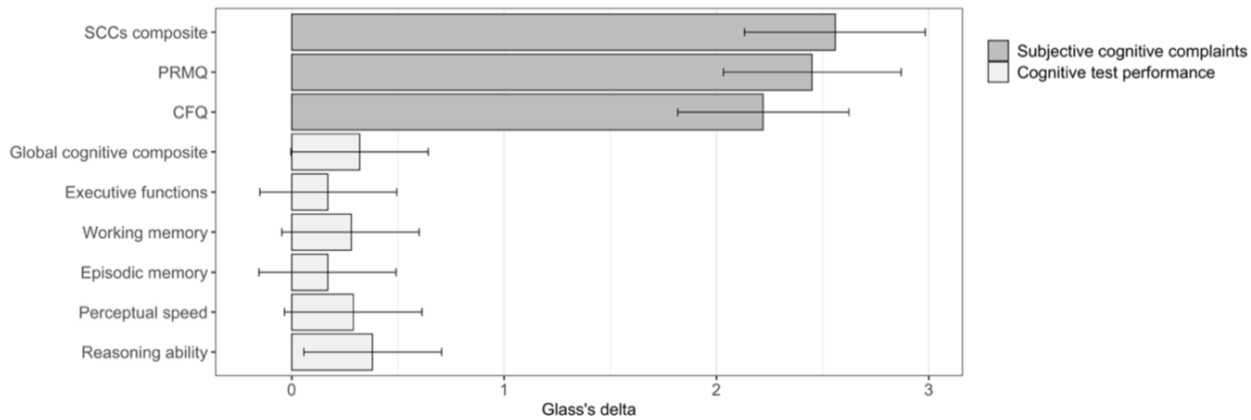


Figure 2

Effect sizes of differences between patients and controls in SCCs and cognitive test performance.

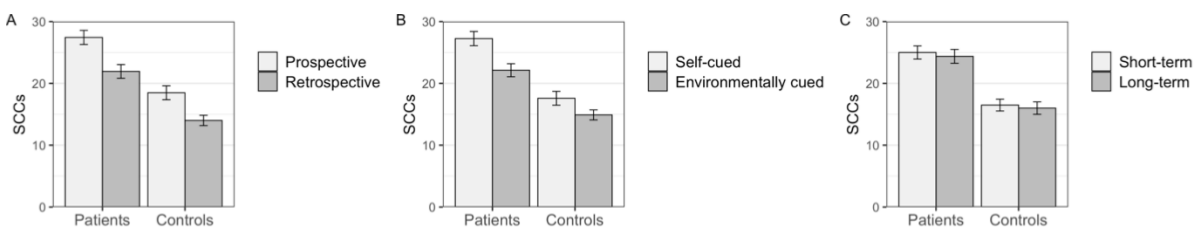


Note. Bars indicate group differences in Glass's Δ. Error bars indicate confidence intervals (95%).

$^{*}p < .05$. $^{**}p < .01$.

Figure 3

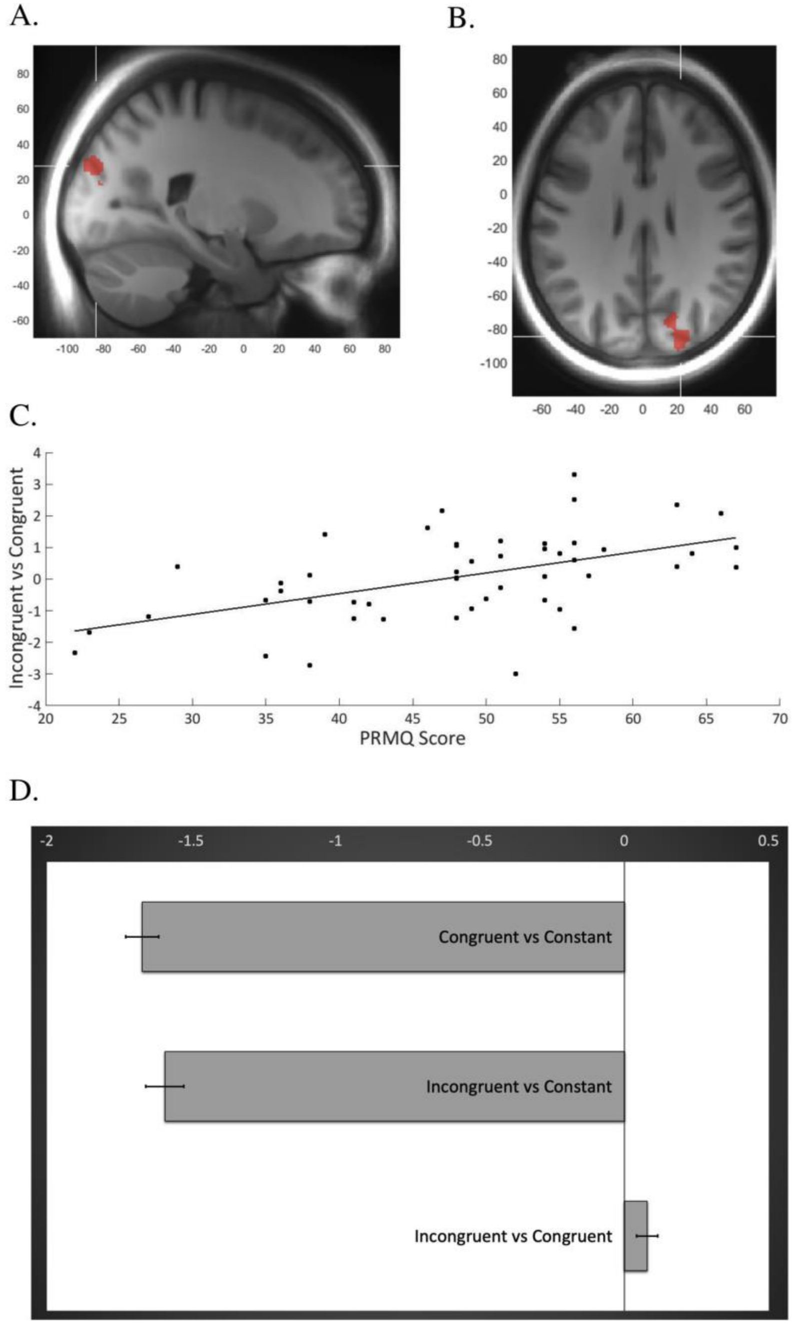
Mean of reported memory failures for patient and control participants



Note. Error bars indicate confidence intervals (95%).

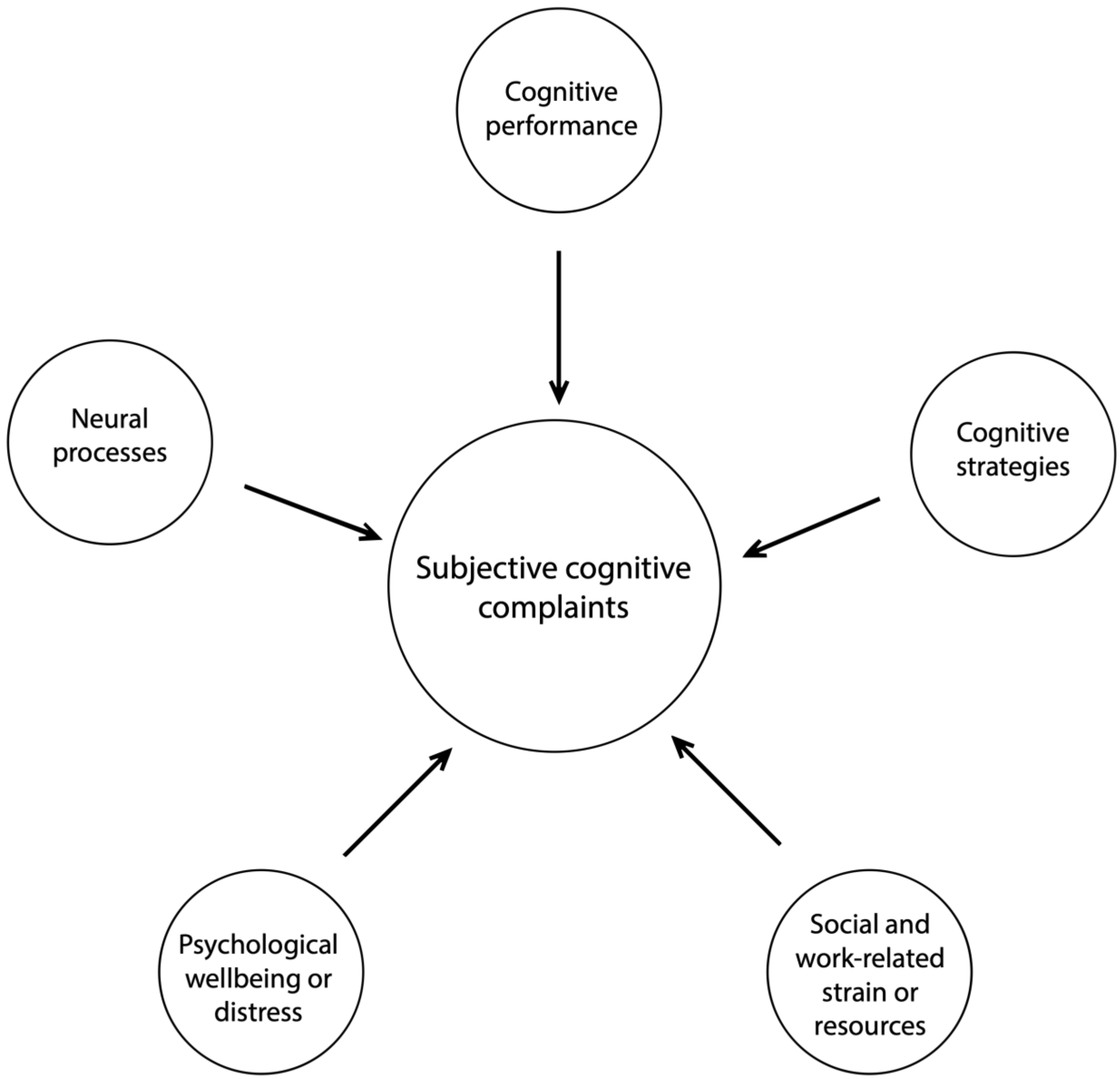
Figure 4.

Cluster showing a positive correlation between beta weights and PRMQ-score when contrasting incongruent and congruent Flanker trials.



Note. *A-B. Sagittal and axial views of the cluster (x=22, y=-84, z=28; t=4.22) comprising the right superior occipital gyrus and cuneus. C. The regression analysis revealing a significant positive association between beta weights of this cluster for the incongruent vs congruent contrast (y-axis) and PRMQ score (x-axis), R=0.27, p=0.0001. D. The additional analysis showing differences in beta values of the same cluster (x-axis) when contrasting the two task conditions (i.e., the incongruent and congruent trials, respectively) to the session constant, indicating lower neural activity during task compared to mean session activity. The bar furthest down in the chart displays the difference in beta values when contrasting incongruent vs congruent trials.*

Figure 5.
Examples of factors, in different levels of explanation or abstraction, reflecting SCCs.



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Self-reported cognition in Exhaustion Disorder

This thesis aimed to add more empirical knowledge on the self-reported cognitive difficulties experienced by patients diagnosed with stress-related Exhaustion disorder. Using different methods and from different perspectives, it has investigated how questionnaires targeting everyday problems relates to test performance, psychological distress and brain activity. Moreover, qualitative interviews demonstrate experiences of cognitive functioning 6-10 years after participating in rehabilitation, the course of cognitive problems, and what have been helpful or hindering during the recovery process.

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