The Role of Cognitive Functioning in Predicting Health Outcomes of Cardiac Rehabilitation Patients

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Abstract

Cardiovascular disease (CVD), characterized by a narrowing of arteries due to the buildup of plaque, is the most common cause of death worldwide, being responsible for an estimated 17.9 million death each year. Cardiac Rehabilitation (CR) is a multifaceted set of intervention services designed to afford CVD patients the opportunity to recover to the best of their capabilities and functioning. A variety of individual differences have been shown to effect CR patient outcomes including gender, socioeconomic status, and comorbid health conditions. However, the role that cognitive functioning plays in patient outcomes is poorly understood. This study investigates the role self-regulation and executive functioning play in predicting the physical and mental health status of patients attending Cardiac Rehabilitation. The Physical and Mental Health Status of 114 Phase 4 CR patients were assessed using the SF-12. Executive functioning was assessed using the Behavioural Assessment of Dysexecutive Syndrome (BADS), and the Self-Regulation Questionnaire (SFQ) and Cognitive Failures Questionnaire (CFQ) were used to measure self-regulation. Multiple linear regression analysis showed that increased physical health was predicted by an increase CFQ subscale of Distractibility. Mental health was not predicted by any of the cognitive measures. SRQ total scores correlated with both physical and mental health. Results have implications for CR research, policy, and practice. Incorporating an increased understanding of an individual differences into treatment regimens and recovery plans will help facilitate health improvements. Assimilation of knowledge regarding the role cognitions play in health outcomes would require policy change at various levels of rehabilitation implementation. In addition, further work is necessary to explore the precise nature of the relationships between various subcomponents of executive functioning/self-regulation and both health outcomes and behaviours.

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Introduction

Cardiovascular Disease

Cardiovascular disease (CVD) is an overarching term describing all illnesses of the heart and circulation (Piepoli et al, 2016). Cardiovascular disease is typically characterized by narrowing of the arteries caused by a buildup of plaque known as atherosclerosis (Boron and Boulpaep, 2012). CVD is the most common cause of death worldwide, responsible for an estimated 17.9 million deaths each year (WHO, 2020). In 2015, there were an estimated 7.4 million deaths due to coronary heart disease (CHD), and 6.7 million due to Stroke (WHO, 2017). In the UK, around 160,000 deaths are caused by CVD each year (British Heart Foundation, 2017a). CHD symptoms such as angina and myocardial infarction (MI) are amongst the most prevalent health problems in Western Society (Bhatnagar et al, 2015). There are many potential contributing factors to this disease burden, including obesity (Bastien et al, 2014), high blood pressure (Ettehad et al, 2016), and encroachment of Western diet and lifestyles into other cultures (Finegold et al, 2012). Development of CVD is partially attributable to lifestyle factors (Nyberg et al, 2013; Pattyn et al, 2013), and therefore is an area of much interest to researchers and practitioners working in health behaviour change.

Cardiac Rehabilitation Overview

Secondary prevention of CHD is a primary concern for healthcare providers (NICE, 2015a; SIGN, 2017). One of the most effective methods for improving the health of those suffering from CHD is CR . The British Association for Cardiovascular Prevention & Rehabilitation (BACPR) defines Cardiac Rehabilitation as:

"The co-ordinated sum of activities required to influence favourably the underlying cause of cardiovascular disease, as well as to provide the best possible physical, mental and social conditions, so that the patients may, by their own efforts, preserve or resume optimal functioning in their community and through improved health behaviour, slow or reverse progression of disease" (BACPR, 2017).

Cardiac Rehabilitation typically involves health professional supervised programmes combining exercise and information sessions. The aim of these is to improve the physical and mental health of those who have heart problems (BACPR, 2016). Recent meta-analysis suggests that CR reduces cardiovascular mortality, hospital admissions, and improves quality of life (Anderson et al, 2016; Piepoli et al, 2016). CR is not uniform and takes different forms across geographic locations. In the UK, the British Heart Foundation (BHF) and the Health and Social Care Information Centre (HSCIC) monitor quality and continuity across programmes (Doherty, 2018).

CR takes place over four phases (BACPR, 2016). The first phase (the acute phase of recovery) takes place during the hospital stay immediately post-cardiac event. This involves a period of intensive physical care and working closely with medical staff to regain mobility. Phase two (the sub-acute phase) takes place in an outpatient setting after discharge and usually lasts from three to six weeks. This phase involves monitoring cardiac responses to activity to facilitate safe return to functional mobility, while monitoring heart functioning. The third phase, known as intensive outpatient therapy, consists of both individual and group exercise. Typically lasting around 12 weeks, it involves weekly attendance at an outpatient exercise class, where patients are taught to monitor their own heart rate and level of exertion while exercising, under guidance of Physiotherapy and Specialist Nursing staff. The aim is to increase patient level of exercise tolerance, monitor changes in physical functioning, and become more independent. The delivery of Phase 3 is multidisciplinary in nature. BACPR guidelines (2017) highlight the importance of a multidisciplinary team of competent practitioners working together under the guidance of a senior clinician to achieve maximum benefit for patients. Indeed, the team may include a cardiologist, nurse specialist, physiotherapist, dietician, psychologist, exercise specialist, occupational therapist, and clerical staff. Phase 3 should also include educational aspects aimed at lifestyle and behaviour change (Wenger, 2007; NICE, 2013; BACPR 2017). Phase 4 differs considerably, in that it is open-ended, encompassing the patients' independent ongoing physical conditioning throughout the rest of their life (Bjarnason-Wehrens & Halle, 2017). With CVD patients being able to have a reasonable expectation of many years of life after their initial diagnosis (Clarke et al, 2009), Phase 4 can last much longer than the previous phases. Often, attendance at a Community Based Exercise Programme is part of Phase 4 rehabilitation (Niebauer, 2017). These Health

Professional supervised programmes are run weekly by local CR teams and support groups. In the UK, Phase 4 programmes are led by professionals who have completed the British Association for Cardiovascular Prevention & Rehabilitation's (BACPR) Specialist Exercise Instructor Level 4 Cardiac Qualification.

Health & Phase 4 Cardiac Rehabilitation: A Multifaceted Quandary

The development and maintenance of health and well-being is a lifelong process (Hoeger et al, 2018) and the role lifestyle choices play in maintaining health is well understood (Lim et al, 2012). Within non-clinical and clinical populations, exercise and healthy eating should be encouraged across the lifespan to facilitate health and well-being (Whitehead, 2010; Oja et al, 2010). For CHD patients, Lifestyle modification is multifaceted and ongoing (Lavie et al, 2016). As patients transition through Phase 3 and Phase 4 CR, they shift from recovery from an acute malady to the ongoing management of a potentially chronic condition. Evidence suggests that exercise, healthy eating, good mental health, and smoking cessation are crucial components of prevention of further CVD events (Rutledge, 2013; NICE, 2015a). Fitness maintenance is therefore especially important for CVD patients, and the goal of community-based CR programs is to enhance exercise tolerance, promote healthy eating habits, reduce CVD risk, and improve quality of life (Bjarnason-Wehrens & Halle, 2017). Given the medical autonomy of most individuals in Phase 4, the onus for managing health and health behaviours is therefore heavily placed upon the patient.

Post cardiac event, patients often struggle to come terms with the experience (James et al, 2000; Albarran et al, 2014) and time spent in CR can be crucial to their recovery (Dolansky and Moore, 2004; Kureshi et al, 2016). Not only do community-based CR programs facilitate physical health, but are intent upon contributing to psychological wellness (Mandic et al, 2018). The aim of these programmes is to promote and support independent healthy lifestyle behaviours, and not to solely center on exercise training, but also impart health education, information on nutrition, and offer some counseling. There is debate around the impact of CR on specific mental health outcomes. In a systematic review of 16 papers, Shepherd & While (2012) found that CR attendance decreased the anxiety and depression of heart disease patients.

Similarly, Dolan et al (2018) found that CR positively impacted upon depression in a clinical population.

However, Sibilitz, (2016) found CR did not improve the mental health of heart valve surgery patients. This debate aside, anxiety and depression symptoms are concerns for heart patients (Liu and Ziegelstein, 2010; Davidson, 2012; Correll et al, 2018), and what is rarely debated is the importance of such patients cultivating good mental health to facilitate future well-being (Chesney et al, 2014; Sher et al, 2019; Reavell et al, 2018).

Biomedical healthcare interventions traditionally focus upon treatment of acute biological trauma (Iacobucci, 2018). However, such biomedical approaches are inappropriate for understanding the nature of chronic conditions such as CVD (Murray, 2014; Wade and Halligan, 2004), and treatment thus changes during phases 3 and 4 away from acute care to a focus on increasing self-management. The lifestyle and health of phase 4 CHD patients will vary depending upon a variety of individual differences, including the nature of the underlying condition (NICE, 2013), adherence to medication (Rodríguez et al, 2011), obesity (Forhan et al, 2013), and mood (Swardfager et al, 2011). The open-ended nature of phase 4 rehabilitation means it is important that healthy lifestyle change occurs not only in terms of class attendance, but in other aspects of the patient's life. There is therefore an imperative for phase 4 CR patients to consistently and indefinitely adhere to healthy behavioural patterns that many people struggle with, such as medication adherence, eating healthily, inhibition of impulsive behaviours, and attending healthcare appointments (Middleton et al, 2013). Such change draws to a plethora of individual resources and motivational systems for health lifestyle changes to be maintained (Davis et al, 2015). Change in any (let alone all) of these areas is difficult and has been the subject of generations of Health Psychology research (Schwarzer, 2008; Ogden, 2012; Rhodes et al, 2020).

Cardiac Rehabilitation Outcomes and Effectiveness

Numerous studies have demonstrated the beneficiary nature of Cardiac Rehabilitation. Meta-analysis shows a reduction in cardiovascular mortality and hospital admissions is associated with CR attendance (Anderson et al, 2016), as is increased health-related quality of life compared to controls (Sagar et al, 2015; Anderson et al, 2016).

Completion of CR results in a 1-year decreased mortality rate of 25% (Martin et al, 2013), an increase in functioning (Hazelton et al, 2014), overall quality of life (Shepherd & While, 2012), and a positive impact upon physical activity, anxiety, and depression (Yohannes et al, 2010), though some meta-analysis found no significant impact upon total mortality, myocardial infarction, or revascularization (Anderson et al, 2016). Current clinical guidelines (SIGN, 2017; NICE, 2015a) underline the importance of lifestyle change taking root to sustain and build upon gains across the lifespan. Therefore, it is crucial that patients are motivated in Phase 4 to continue with lifestyle changes and can manage their own health.

With regards what makes CR effective, the most salient area for investigation is the efficacy of the CR programme itself (Taylor et al, 2004), closely followed by other aspects of service delivery (e.g., Health Professional's ability; Bäck et al, 2017; accessibility; Jones et al, 2009, Blair et al, 2011). Beyond these issues, individual differences quickly emerge as an obvious area for investigation. Differences such as the availability of social support (Mookadam and Arthur, 2004), smoking status (Gaalema et al, 2015), socioeconomic status (Bernheim et al, 2007) and personality (Lodder et al, 2019) are all known to influence health status (both physical and mental) of heart patients.

Non-Attendance, Non-Participation, & Behaviour Change

Ideally, CHD patients' adherence to a healthy lifestyle post-cardiac event would be absolute. However, many patients (beginning with non-attendance at CR classes) struggle with achieving and maintaining a healthy lifestyle. Referral rates to CR are around 60% (Arena et al, 2012; Neubeck et al, 2012). In 2019, the National Audit of CR reported that CR uptake had reached 50%, which puts the UK in the top 2% of countries in Europe (British Heart Foundation, 2019; Bjarnason-Wehrens et al 2010), but still leaves many patients not attending. Other studies have suggested that only 15%-30% of those offered CR attended (Arena et al, 2012; Aragam et al, 2015; Pavy et al, 2014; Redfern & Briffa, 2014; Danker et al, 2015).

The casual observer will discern that change is difficult to sustain, and the empirical literature will largely attest to this in relation to dietary (Dansinger, et al, 2005; Liu et al, 2018), exercise (Dishman 1991; Morgan, 2013), and medical adherence (Meichenbaum, & Turk 1987; Mahan et al, 2017), and in smoking cessation (Veldheer et al, 2018). Wyer et al (2001a), Murray et al (2012), and Kelly et al (2016) reviewed the literature on the sociodemographic factors influencing CR attendance. Non-attenders are more likely to be female (Evenson et al. 1998, McGee and Horgan 1992), live in areas with higher levels of social deprivation (Pell et al. 1996; Pell & Morrison, 1998; Melville et al 1999; Gaalema et al, 2017) far away from the programme (Ades et al. 1992, Aikman et al. 1996, Schulz and McBurney 2000) and be older (Schulz and McBurney 2000, King et al 1999, Evenson et al 1998, Ades et al 1986).

Healthcare professionals have developed many theories and models to explain how healthy lifestyle choices are made and maintained. There has been a change in the conception of health management in psychological theorizing (Maes and Karoly, 2005), with trait approaches being succeeded by process models that concentrate on psychosocial means and the mechanisms through which they have an impact. Theories such as the Theory of Reasoned Action (TRA; Fishbein, 1967), the Theory of Planned Behaviour (TPB, Ajzen, 1991), the Health Belief Model (Hochbaum et al, 1952), and the Transtheoretical Model (Prochaska, et al, 1992; Prochaska and DiClemente, 1982) quantify cognitions that influence intention and behaviour. These and similar theories have been used to develop interventions which improve and cultivate health promoting behaviours. Traditionally, various theoretical models that aspired to explain health behaviour choices were founded upon principles of rationality (outlined by Von Neumann and Morganstern, 1947, and elaborated upon in the Subjective Expected Utility Model; Savage, 1954). The regularly utilized Theory of Reasoned Action (Fishbein, 1967; Fishbein & Ajzen, 1975) and its augmentation, the Theory of Planned Behavior (Ajzen & Madden, 1986) are grounded upon rationality principles, suggesting that behaviour is most closely determined by intentions. These models have some utility in explaining the behaviour of cardiac patients. An explorative study by Johnston et al. (1999) compared those who attended CR and those who did not; those who attended had a strong belief that loved ones

wanted them to attend, had higher perceived control of their own behaviour, and were more likely to express positive attitudes towards cardiac rehabilitation. This suggests cognitions play an important role in the health outcomes of cardiac patients. An Interpretative Phenomenological Analysis (IPA) study by Wyer et al (2001b) used the Theory of Planned Behaviour to explore attitudes and beliefs of CR attenders and non-attenders. Attenders had a more psychological internal representation of cardiology, feeling they had more control of their recovery and saw the programme as a means to take responsibility for their own health, while non-attenders medicalized their problem more often and saw medication and health professionals as important. Non-attenders used avoidance to cope with their diagnosis, reporting they "didn't want to know" about their condition. A similar study by Pullen et al (2001) also used IPA to explore women's decisions to attend CR and found that attenders believed they had a poorer understanding of their condition than non-attenders and felt they had need of social support. Attenders also exhibited greater perceived control over their CR attendance and condition. Non-attenders reported feeling independently able to cope and that their understanding of their cardiac condition was complete, despite having demonstrably poorer understanding of the process. A range of positive and negative emotions concerning attendance were expressed by attenders, whilst non-attenders expressed only anxiety, a finding mirrored by a Herber et al (2017). These studies point to the importance of understanding the internal psychological world of the patient in explaining their health behaviours.

As the avoidance demonstrated by non-attenders in the above studies suggest, human behaviour often digresses considerably from classical ideas of rationality (Tversky & Kahneman, 1974; Dawes, 1988, 2018; Kahneman, 2003), and people often act in the benefit of the here-and-now despite potential downsides their behaviour might entail for their future selves (Fong & Hall, 2003; Zimbardo & Boyd, 1999). This pattern extends to CR. Rouleau et al (2016) thematically explored the motivation of participants (who had completed their orientation session, but had yet to begin the programme) to enroll in CR. There were anticipated benefits, including the belief that cardiovascular risk would decrease, and that they would benefit from the knowledge and skills of professionals. Whether they perceived they had the ability to attend was also important, which was influenced by their fitness and functioning, concerns about

exercise, and practical difficulties (distance, transportation, financial considerations, and scheduling conflicts). Contextual variables also influenced the decision-making process. These included their first impressions of CR, the opinion of their Cardiologist of CR, their family/peers' opinion, their own knowledge of CR, and their level of psychological distress. Although there are potential sampling issues here this study highlights some of the cognitions behind the decision-making of potential CR patients. In papers such as these, the act of seeking to categorize patients' reasons for acting (or not) assumes that rationality underpins such choices.

Herber et al (2017) found that a myriad of reasons (like those outlined by Rouleau et al) were given for non-attendance at rehabilitation classes. These ranged from practical factors such as accessibly and work commitments, to personal (illness perceptions, threatened self-identity) and programme factors (i.e., poor understanding of the programme), as well as an inability to comprehend potential benefits. Clark et al (2013) investigated reasons for participation in the period after initial attendance in a qualitative systematic review and meta-synthesis. They synthesized themes from 62 studies into personal and context related barriers. Patients often found it difficult to subsume a diagnosis of CHD into their identities, finding their self-identities contrasted with the identity of the 'type' of individuals who attended such programmes (i.e., 'sick', 'old', 'unfit'). These results perhaps begin to point towards a deeper understanding of motivation and cognition than that of mere rationality and indicate that such an understanding might help facilitate better health outcomes for cardiac patients. As with patients who had not begun treatment (Rouleau et al, 2016), attending programmes could result in increased anxiety and class attendance being seen as a social threat, resulting in reduced participation. Navigating the contextual barriers of distance, transport, and social factors was also important. Similar barriers emerged in Neubeck et al's (2012) systematic review and meta-synthesis of qualitative data. These practical factors chime well with the behavioural economics literature that highlights the importance of temporal dynamics in behavioral decision-making, where inconvenience or other immediate costs are involved (Ainslie, 2013).

However, common health behaviour models' conceptual and epistemological foundations have been criticized, as have their empirical evidence base and testability

(Sutton, 1998; Ogden, 2003; Vogel and Wanke, 2016). While the TRA and TPB have been successful in predicting some of the variance in health behaviours (Armitage & Conner, 2001), a meta-analysis of studies investigating the intention-behaviour relationship found medium-to-large increases in behavioral intention produce small-to-medium changes in behavior (Webb and Sheeranm 2006), suggesting that while the model may predict behaviour to an extent, more work may need to be done (particularly in the field of cognition) in explaining behaviour, going beyond intentions. The existing array of behavioural models have been called incomplete as they fail to include several factors that influence behavioural implementation, such as ecological factors (Sallis et al., 2006), temporal dynamics (Ainslie, 2013), or neurological factors (Hall and Fong, 2015). Indeed, the percentage of variance in behaviour typically predicted by some of the most popular models would seem to bear this criticism out (i.e., in meta-analysis, TBP typically predicts between 27%-41% of variance in health behaviours; Hagger et al, 2002; 2016). Further work needs to be done to investigate the nature of the cognitive functioning and self-regulation that impact health outcomes.

The crystallization of barriers and facilitators to attendance/completion is an important first step in understanding how lifestyle factors that facilitate health recovery from CHD can be cultivated in CHD patients. The logical query to explore here would be to try to understand the cognitive phenomena that might help explain some of the themes detailed above. Cognitive features such as executive functioning may influence many of the qualitative themes emerging from the above literature regarding treatment adherence.

Work has been carried out investigating how cognitive functioning as an individual difference impacts upon aspects of CR patient's health. In the broadest sense, cognitive functioning is defined as all mental processes including reasoning, attention, memory, and language (Robbins, 2011). Mathisen et al (2010) found declining cognitive functioning was associated with a decline in mental health in CR patients, as in other patient groups (Weber et al, 2014; Yates et al, 2015). In a different study (Newman et al 2001), baseline cognitive competence was correlated with quality of life at 5 years post Elective Coronary Artery Bypass Graft (CABG) Cardiac Surgery

(though study does not report effect sizes). Such studies begin to suggest that cognitive functioning can impact not only mental health, but physical health. Immediately attention turns to the role that cognitive functioning may have in facilitating health-behaviours as a mechanism to impact health (Gray-Burrows et al, 2019).

Behaviour Change – A Challenging Prospect

In recognition of the need to better understand why intentions predict behaviour poorly, the literature on health behaviour change techniques has been growing steadily over the last 30 years (Davis et al, 2015; Michie et al, 2018). Abraham & Michie (2008) developed a taxonomy of 26 behaviour change techniques that they expanded to 93 techniques (Michie et al, 2013), from planning, setting homework, and goal setting, to self-monitoring of behavior, behavioral practice/rehearsal, and persuasive argument. Utilizing many of these requires not only a high level of technical skill (and often training) on the part of any clinician working with patients, but also an ability on the part of the patient to form an intention, rationalize, assimilate argumentation, define goals, and delay gratification (Hunter, 2014; NICE, 2014), all of which constitute complex cognitive abilities that have been summarized under the umbrella term of executive functioning (Malenka et al, 2009). As the need for behaviour change techniques grows and their prescription is practiced more within health services (Warburton & Bredin, 2016; NICE, 2013), there may be an implicit assumption that an individual patient will possess a range of high-level cognitive skills that will facilitate their ability to change their behaviour, even if there is 'buy-in' on the part of the patient (Mazza, 2010; Garfield and Caro, 2000). This is worrying, as some studies have found that CR patients with poorer baseline executive functioning obtained less benefit from CR (Kakos et al 2010). There is a need to investigate the legitimacy of making this assumption about executive functioning skills when developing and implementing interventions.

The extent to which there is a mismatch between healthcare providers' assumptions and beliefs in this area and patient reality is not known. It may be that this factor accounts for some of the difficulties in bringing about behavioural change that is

either long-lasting (Wing & Hill, 2001; Hartmann-Boyce et al, 2014) or substantial (Van Sluijs et al, 2004 Kinmonth et al, 2008; Eriksson et al, 2009). Some therapeutic interventions (such as cognitive behavioural approaches) address this problem by taking time to elucidate the principles underpinning therapeutic practice to increase patient endorsement of said principles and hopefully subsequent motivation (Simmons & Griffiths, 2017). Currently, there are few studies which investigate the cognitive mechanisms that may impact upon why interventions are successful for some but not others (i.e., the individual differences). The impact of cognitive functioning may indeed be substantial. Kiessling & Henriksson (2004) found that in patients with coronary artery disease, 43% of the variance in health-related quality of life was explained by cognitive function (concentration, activity drive, memory and problem solving) in those under 70 years old. The same authors also found that self-reported cognitive functioning (along with physical functioning) predicted unemployment (Kiessling & Henriksson 2005). As healthcare programmes such as Phase 4 CR move away from compliance with prescriptive regimens to a collaborative self-management model (Maes and Karoly, 2005), there is a need for studies that identify causal predictors of health outcomes for CVD patients.

Self-Regulation as a Potential Causal Predictor of Health

Self-regulation refers to the system of conscious personal management that involves orientating one's cognitions, behaviours, and affect towards achieving a goal (Baumeister and Vohs, 2003). More generally, self-regulation relates to planned or intentional acts that are initiated from within an individual (Bandura 1989) and shares conceptual overlap with executive functioning (Heatherton and Wagner, 2011). Bandura (2005) states that although the specifics of self-regulation theories may differ, all share three "generic sub-functions":

1) Self-monitoring of health behaviours and the social and cognitive conditions which accompany these behaviours

2) Goal formulation to direct efforts and stratagems

3) The utilization of phenomena that help to maintain positive health behaviours, such as incentives and social support.

Humans can act beyond merely reflexively reacting to immediate sensory information and perform complex, elaborate behaviours aimed at achieving distant goals (Venhorst et al, 2018). To achieve this, humans have evolved means to quash or augment reflexive and habitual reactions – means typically understood as cognitive in nature (Miller, 2000). Self-regulation has been used to investigate and formulate the internal cognitive processes that precede volition to achieve a goal. Baumeister breaks down self-regulation into four components: standards of desirable behavior, motivation to meet standards, monitoring of situations and thoughts that precede breaking said standards, and willpower (Baumeister et al, 2013). Various theorists have incorporated the idea of self-regulation into their understanding of health behaviour. Bandura developed social cognition theory (Bandura, 1977; 1986) and social learning theory (Baudura, 1971), both of which integrate understanding of self-regulation as a theoretical cornerstone. Both propose that humans are not merely sculpted by environmental or internal forces, but are proactive, self-driven, and self-regulating in action. Humans are purposive, and can act with intentionality to influence themselves, others, and the environment. They can make choices and act in ways that work towards the preservation of their health. Social Cognition Theory (Bandura, 1977; 1986) stresses the importance of observational learning, imitation, and modelling in developing behaviours, and integrates a continuous interaction between behaviours, personal factors (including cognition and self-efficacy) and the environment. Social Learning Theory (Baudura, 1971) posits that behaviour is learned from the environment through observational learning, but that processes of self-regulation mediate the relationship between stimuli and response.

Many theorists have scrutinized the self-regulatory process, each utilizing the phenomena to explain behaviour within a variety of fields and in different systems (Zimmerman and Schunk, 2001; Scheier and Carver, 1988; Locke and Latham, 1990; Ryan and Deci, 2000). One of the most widely used is Leventhal's self-regulation model of illness representations (Leventhal et al, 1984; 1997) which stipulates that

cognitions concerning illness cluster into five substructures (identity, cause, timeline, consequences, and control/cure) that are used to structure illness related beliefs. Some have investigated how the nature of such beliefs play-out in relation to CR. In a factor analysis, Weinman et al (2000) found that a belief that lifestyle factors caused their MI was significantly related to improvements in patients' diet and exercise 6 months post-MI. They also found significant cognitive differences between MI patients who attended CR and those who did not, with those who attended having stronger belief at hospital admission that their illness could be controlled/cured (Petrie and Weinman, 1997). Similarly, holding the belief before cardiac surgery that one's illness is chronic or has serious consequences predicted both physical and mental functioning at 3 months post-surgery (Juergens et al, 2010). Therefore, specific cognitions do seem to play important roles in health-related behaviour and outcome of CR patients.

All such investigations are grounded upon the idea that cognitive phenomena are significant contributors to health behaviours. Bandura (2005) points to overlap and redundancies in the labeling of constructs being given different names without any predictive power and posits that should such theoretical constructs be investigated together using factor analysis, a small set of generic factors would emerge, revealing the underlying nature of self-regulation. Self-regulation should therefore be of interest to CR professionals.

The emphasis on the conscious, cognitive process and decisional volition of the individual is emphasized in self-regulation theory. Bandura criticized "personality doctrines" that depict behaviour as being driven by inner forces below the level of consciousness (Baudura, 1971). Indeed, the practice of inferring inner determinants from displayed behaviour has been criticized more recently for resulting in pseudo explanations and interpretative circularities (Johnson and Henley, 2013). Commonly, conceptual models in Psychology infer inner determinants from the behaviour they are said to cause. Those traits that Goldberg (1993) labels as "Phenotypic Personality Traits" have been cited as examples of such circularity. For example, the five-factor model of personality (FFM; McCrae and Costa, 1996) ascribes characteristics such as agreeableness based upon reported displayed behaviour (e.g., questioning include "I

see myself as someone who... is considerate and kind to almost everyone; has a forgiving nature; likes to cooperate with others" Costa and McCrae, 2010), which could be said to be an entirely circular process.

Bandura is also reticent to overemphasize environmental factors and is not a pure behaviourist, though he draws upon behaviourist principles. Although Social Learning and Social Cognition state that an individual requires a social model or environmental cues, modelling effects are mediated by cognitive processes (Johnson & Henley, 2013). Other factors may serve as guides and motivators but are not likely to create lasting change unless the individual can develop a way to be in control of their motivation and health behaviours (Baudura, 2005).

As phase 4 rehabilitation involves motivational and behavioural choices that affect life away from the class, the principles of self-regulation seem ripe for investigation in this area. For CHD patients to enjoy full recovery, there is a need for self-monitoring, assimilation of social models, the capability to regulate their own exercise and to appraise the effectiveness of self-regulated exercise (Ilarraza, et al 2004). A range of studies have investigated the role of higher order self-regulation in behavioural interventions that are relevant to CHD. Teixeira et al (2015) produced a systematic review of self-regulation mediators in obesity behaviour change interventions. They found the best predictors for weight loss and increased physical activity were higher autonomous motivation, self-efficacy, and self-regulation skills. For diet, they found no consistent mediators. Annesi et al (2016) developed and evaluated a weight loss intervention that incorporated the learning of self-regulatory skills to facilitate exercise and controlled eating. They found that over the course of the 6-month intervention, physical activity and healthy eating were best predicted by changes in self-regulation, self-efficacy, and mood. Those better able to self-regulate have better mental health (Shoda et al, 1990; Tackman et al, 2017). These studies again point to the importance of investigating the impact of cognitions associated with self-regulation upon health.

Indeed, it has been suggested that depression is itself a disorder of self-regulation (Strauman, 2002; Trew 2011) being best understood within the context of the two

fundamental neurological systems of approach and avoidance (promotion and prevention respectively). Depression may characterise a cumulative failure of these systems i.e., depression is the loss of motivation to respond appropriately to cues for reward (Akiskal and McKinney, 1973; Whitton et al, 2015). Promotion/approach self-regulation involves advancement or achievement, and perceived advancement results in positive emotion, whilst lack of advancement results in negative emotion. In contrast, prevention/avoidance self-regulatory behaviour entails security and protection behaviours, with failure to avoid negative outcomes resulting in anxiety and successfully avoiding these outcomes results in feelings of calm or relief (Klenk et al, 2011). In this understanding, depression is the consequence of failure to achieve approach goals, resulting in a positive feedback loop of biopsychosocial consequences which results in a dysregulation of the two systems (Strauman, 2002; Scholer et al, 2019).

Understanding depression and anxiety as manifestations of self-regulatory failure has been explored within mental health contexts (Klenk et al, 2011; Strauman and Eddington, 2017; Acuff et al, 2019), but little has been written about how such self-regulatory failures impact the mental health of patients dealing with long-term health conditions; conditions that often require a great deal of self-regulatory behaviour. It would therefore seem opportune to investigate not only the role of self-regulation in physical health outcomes of such patients, but mental health outcomes also.

Some studies demonstrate that the incorporation of self-regulation theory into CR interventions increases programme efficacy. Fleig et al (2011) demonstrated that an exercise self-regulation intervention led to better exercise behaviour, exercise habit, strength, and fruit and vegetable intake than a control group. Sniehotta et al (2006) tested two brief planning interventions in CR to increase exercise following discharge in comparison to normal care. They found those who completed the intervention that focused on a combination of action planning and coping planning fared better than either controls or the action planning only group. Similarly, a program based on self-regulation principles was shown to influence exercise at 15 months follow-up more than standard care (Janssen et al, 2014).

Although self-regulation theories have to some extent been incorporated into behavioral interventions, there are critics who are frustrated that self-regulation merely repeats the problems of earlier cognitive theory (De Ridder and De Wit, 2006). The thought process is crucial to learning in social cognitive theory. Bandura (1986, p.15) anchors thought in neurobiological, stating thoughts are "brain processes not disembodied mental events". However, Bandura has been criticized for using the same flawed logic to develop his self-regulation models that he criticized psychodynamic approaches for using – namely, the process of inferring inner determinants from the behaviour they cause, leading to circular causal explanations (Johnson and Henley, 2013). Hall & Fong (2015) have criticized models of health behaviour change for excluding many important components, including neurobiological factors. Without a more biologically based understanding of the nature of the relationship between thought and neuroscience, it seems cognitive theories of all kinds are condemned to repeat this process, leading us no further forward. It is therefore important to ground the conceptualization of self-regulation in appropriate biological knowledge to help understand how thinking may impact upon the health outcomes of cardiac patients.

Conceptualizing and Modelling Self-Regulation – Can Neuropsychology Play a Role?

The utilization of conceptual models to represent systems is common practice in academic disciplines, and these are used to help explain how concepts relate and can be simulated (Styles and Lewis, 2000). Eart & Ennett (1991) define conceptual models as:

"A diagram of proposed causal linkages among a set of concepts believed to be related to a particular public health problem" Eart & Ennett (1991), p. 163.

Fundamentally, theory building constitutes the articulation of potentially previously ethereal forms into conceptualizations that are malleable and open to scientific manipulation and investigation (Cornfold, 2003). Such models are useful in developing an understanding of human psychology, as they allow (to some extent) the

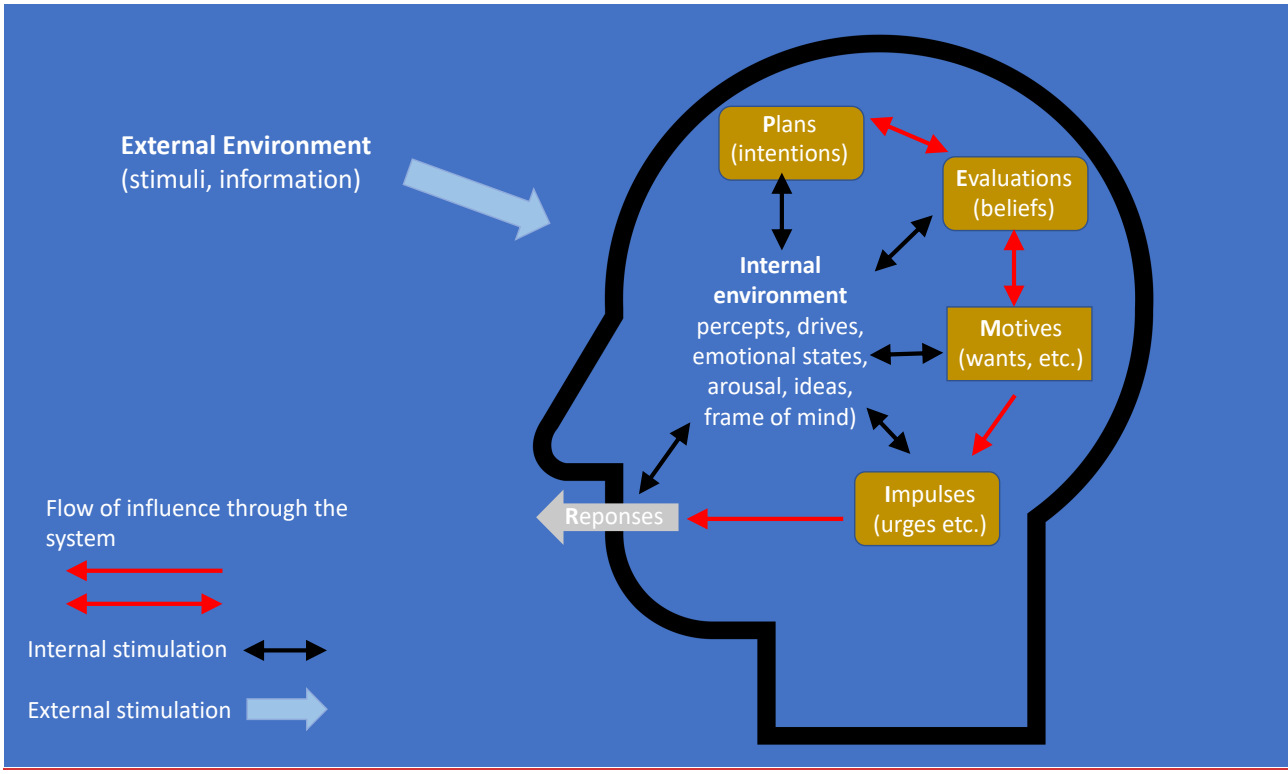
crystallization of ideas and conjecture concerning those ideas into more explicit concepts and affords an exploration of the relationships between these concepts (Sokolowsk et al, 2010). Conversely, they also allow us to generate abstractions from concrete things in the real world, either physical or social (Gregory, 1993). There have been attempts to synthesize Self-Regulation Theory into a coherent conceptual model to address the redundancies in the literature that Bandura (2005) underlined above (MacKenzie et al, 2012).

However, many such psychological models do not consider the neuropsychological modelling and phenomena that may underpin psychological constructs, and that might help further explain how phenomena within conceptual models (such as self-regulation) function at a physiological level (Miller and Keller, 2000; Marshall, 2009; Hofmann et al, 2012). To attempt to amalgamate much of the research on self-control, Kotabe and Hofmann (2015) created an integrative framework of low and high-resolution cognitive models of self-control, identifying seven constructs within the current literature. This integrative self-control model outlines the concept of desire or "wanting" which emerges from subcortical and subconscious processes (Sheeran et al, 2013) which is often set opposite an intentional higher order goal. The tension between these two results in the third component: desire-goal conflict. As the fourth component, control motivation is the wish to control desire or not, dependent upon the goal and fifth: control capacity (constituting other cognitive resources upon which an individual can draw to facilitate control). Control effort is the penultimate component of the model, and enactment constraints (usually environmental) that limit behaviour are the final aspect. Within such a model, self-regulation and executive functioning form aspects of control capacity. Interdisciplinary approaches to building models present the opportunity to advance scientific knowledge by marrying concepts and phenomena from disparate academic disciplines (Larson et al, 2011; Dweck, 2017), and the sub-disciplines within Psychology are areas where this modelling process may be beneficial.

The PRIME theory of motivation (West, 2007) is a satellite view of motivation that attempts to integrate theories of motivation into a five-system structure with the five

systems being labeled plans, evaluations, motives, impulses, and responses (see Figure 1 for an outline).

FIGURE 1 The Human Motivational System According to PRIME Theory



This theory posits that conscious motivation acts through automatic motivation to produce the desire to act at the relevant moment in time. Reponses at any given moment are governed by impulses and inhibitions. These can be either instinctive or can emerge from motives (or desires). Motives are imagined future states where either relief from discomfort or the increase of satisfaction is envisioned and arise from externally triggered stimuli or evaluations. Evaluations are beliefs and value judgments about the nature of what is true or false, harmful or beneficial, etc. These are generated by stimuli, other beliefs, motives, and plans. Plans exist at the conscious level and are characterized by intentions to behave in a particular manner (West & Brown, 2013). Such plans constitute an example of executive functioning, and their practical outworking rely heavily upon self-regulation.

This model attempts to conceptualize both cognitive and emotional motivational elements and to describe the operational interplay between them. Through external stimuli, the model also incorporates a feedback loop whereby output can be incorporated into the system, and emotion and cognition impacted by signs of change in relation to goals. Such feedback loops may be partly responsible for the oft noted bidirectional links between mental illness and CHD (De Hert et al, 2018). The biological can be nested within the internal elements of the model and integrating a biological understanding of motivational systems into our understanding would be a useful next step.

The Neuropsychology of Self-Regulation

The iterative process of theory building requires continued refinement of conceptualizations. It appears that Self-Regulation Theory of health behaviours would benefit from developments that incorporate neuropsychological knowledge. The neuroscience literature on the self-regulatory processes suggests that human beings are likely to have evolved dedicated neural mechanisms to navigate complex social environments where there is a need for the capacity of self-regulation to change or restrain behaviours that could result in exclusion from social groups (Heatherton, 2011; Heatherton & Wheatley 2010). Heatherton (2011) argues that to survive in social groups, humans need the ability to exercise self-control over cognitions, emotions, behaviours, and the ability to change. Indeed, change in the direction of a desired goal generates positive emotion (Panksepp, 2004; Panksepp, 2010; Van Dijk, 2012). Various aspects of psychological functioning are needed to achieve this, including self-awareness, mentalizing, threat detection, and self-regulation (Krendl & Heatherton 2009, Mitchell & Heatherton 2009).

Various brain regions have been associated with self-regulation (Krendl & Heatherton 2009), the most prominent being the prefrontal cortex (Heatherton, 2011). Neuroimaging studies suggest that self-regulation or failure thereof is a result of a balance between the neural systems characterized by salience, reward, emotional importance of stimuli, and self-control, located in the prefrontal cortex (Heatherton &

Wagner, 2011; Sapolsky, 2004). Self-regulation will be unsuccessful either when the prefrontal cortex is not engaged, or when impulses from 'more ancient' brain regions are particularly strong (Garavan et al, 2000; Diekhof & Gruber, 2010). This is important for CR patients as it is imperative for their future health that they can regulate impulses across a variety of areas. Regulation of desires appears to necessitate the top-down management of brain reward systems by prefrontal cortex areas (Volkow et al, 2010; Kober et al, 2010; Delgado et al, 2008). This literature points towards the neurological basis for self-regulation and suggests that incorporating some of the measures traditionally used by neuropsychology to measure prefrontal cortex functioning, into the study of the ongoing management of health post-cardiac event may prove a fruitful avenue for shedding light on how self-regulation propensities may relate to health outcomes.

Self-Regulation and Unconscious Motivation

Implicit in self-regulatory theory is the idea that one is regulating behaviour in a goal directed manner along a chosen trajectory towards a chosen aim (Reason, 1977). Aiming at a target in this manner assumes a set of values that underpin one's orientation in the world, guiding one to move away from one of being (i.e., being high risk for future health and heart issues) to another (being in a state of low risk). Executive functioning is the resource by which one organizes oneself in such a manner as to achieve this.

Some have debated where such value sets come from, if they are stable, and if indeed humans can alter their own values. The all-consuming impulse that can cause self-regulation failure could be said to emerge from such values. Interestingly, the individual values that underpin motivation and recovery have been discussed at length around the area of substance misuse (Unger et al, 2002; O'Sullivan et al, 2015) where there is much debate with regards the extent to which an individual can possess the volition to aim at a postulated goal and move towards it (Hall et al, 2015). In relation to physical conditions, values are spoken of infrequently, or perhaps submerged in the debate on motivation to engage with therapeutic interventions (Nicholas et al, 2011; Gilmore et al, 2015; Glattacker et al, 2018). In this sense, the most popular Health Psychology models (e.g., the theory of planner behaviour, health belief model, etc.)

share the same a faith in human reason that Nietzsche (1969) did; that one can indeed create one's own values through the conscious manipulation of constructs such as attitude, belief, perceived control, perceived social norms, etc.

Cognitive Ability, Self-Regulation, and Behaviour

Research into the functioning of these brain regions regarding self-regulation points to the individual differences in skills required to self-regulate and raises questions for researchers and practitioners in the field of cardiac rehabilitation. Behavioural change is central to the CR process at all stages, but is particularly important in Phase 4, where one's lifestyle is largely self-managed. Individuals have to negotiate innumerable temptations to make health choices that will negatively impact upon their rehabilitation. In CR, as in other areas of life, patients have to resist urges and stifle desires (to consume alcohol, sugar, polyunsaturated fats, and drugs), inhibit impulses, and control their emotions (Heatherton & Vohs 1998). They are encouraged to undertake what may be difficult or unpleasant activities (exercise and smoking cessation). They must cultivate an active life by avoiding the temptations of sedentary comfort. Cohen et al (1999) found that physical gain from CR was strongly correlated with neurocognitive performance. That the ability to self-regulate is associated with several protective factors against secondary MI (including better relationships; von Hippel and Gonsalkorale, 2005; improved mental health; Duckworth & Seligman, 2005, Tangney et al, 2004, and health weight maintenance; Nederkoorn et al, 2010) also gives weight to the importance of self-regulation. More generally, a range of rigorous studies have shown that differences in childhood performance of general cognitive functioning is associated with later life morbidity and mortality (Deary et al, 2004; Gottfredson, 2004; Gottfredson & Deary, 2004; Hart et al., 2003).

The Self – A Neglected Concept in The Health Behaviour Literature

Much of the academic literature on self-regulation focuses on the concept of regulation – its definition, how humans regulate thoughts and behaviour, and the various psychological constructs that compose regulation (Vohs and Baumeister, 2016). However, the concept of "the self" is often ignored within our understanding of self-regulation (Heatherton, 2011), although Baumeister (1998) and Heatherton

(2011) stipulate that the self is implicit in the process of setting goals and being aware of (and altering) thoughts and behaviours that can work towards this goal. Theories of self are not often discussed in relation to regulating health behaviour (Inzlicht and Schmeichel, 2012), but a representation of the self is required to orientate behaviour (Zeman, 2008), and a comprehensive exploration of this area of enquiry demands that we turn our attention to theoretical understandings of the self that have been developed (Schore, 2015).

Cognitive theorists have proposed an understanding of the Self as a schema (or set of schemas) that incorporates abstract semantic knowledge as well as specific memories (Markus, 1977; Hattie, 2014). Conceptual models of health behaviour have normally aimed to explain the realm of the conscious, i.e., the psychological phenomena that one has knowledge of (and where active plans and decisions are made) that can influence behaviour (see the qualitative studies of Neubeck et al, 2012 and Herber et al, 2017 outlined above for examples). PRIME Theory (West, 2007) may be a useful addition to these conceptualisations of self as it considers both the conscious and the unconscious in the form of reflective motivation and automatic motivation. Cognitive psychologists have described how the self-concept acts as a filter and organizing phenomena for processing self-relevant information, focusing attention, and organizing cognition (Rogers, 1959; Epstein, 1973).

Both the idea of current self and the development of the future self are important issues when conceptualizing behaviour change in relation to self-regulation and executive functioning. Planning of health behaviour requires the conceptualization of a future in which one acts out a series of steps to bring into being a potential future version of the self. In order to come to the correct series of steps, one is required to contemplate a variety of potential representations of the self in the future, and imaginatively chart which versions are successful or otherwise (Popper, 2013). At the same time, there is a requirement to represent the current self in order to determine what steps are required to bridge the gap (Popper, 1978). The point at which the current self has been represented in such a manner is where models of self-regulation begin to explain the process of change, though this would not be possible without previous cognitive representations of the self.

Sheeran and Orbell (2000) found that people who perceived exercise as an important part of their self-identity (“exercise schematics”) were more able to translate exercise intention into action than others. To connect this discussion back to the neurological underpinnings of self-regulation, executive functioning could be said to be required to develop the steps to bridge the gap between current and future self (Kelly et al, 2015); imaginative conceptualisation and manipulation of symbolic representations of potential reality being the essence of prefrontal cortex functioning (Binder, 2016). Conceptualising a future Self that is positive after developing coronary heart disease may be difficult (Davidson, 2012; Freedland and Carney, 2013) and without this it is possible that successful Self-Regulation and subsequent positive health outcomes may be unlikely (O’Neil et al, 2016). These concepts are largely left aside by health behaviour theorists but are important to consider (Westen, 1992).

The Requirements for Self-Regulation in Cardiac Rehabilitation

We may surmise therefore that self-regulation comprises of 3 aspects: 1) facets of thought, feeling, or behaviour that an individual supports, mentally represents, and monitors; 2) adequate levels of motivation to expend effort to reduce the discrepancy between the current and desired state; and 3) capacity to reduce the discrepancy despite difficulties along the way (Baumeister and Heatherton, 1996; Carver and Scheier, 1981). Indeed, a very high level of self-regulation is expected of those who have suffered CVD in order to maintain health (See SIGN, 2017 Section 5: Lifestyle Risk Factor Management). However, CVD is predicted by a variety of factors that are themselves predicted by low levels of self-regulation (i.e., obesity Teixeira et al, 2015; Graziano et al, 2010; smoking Milyavskaya et al, 2015; sedentary lifestyle Buckley et al, 2014). To therefore expect such a large change in patients post-cardiac event would seem unreasonable.

Self-regulation also appears to be a finite resource that is fatigued by regular use (Baumeister & Heatherton 1996, Muraven & Baumeister 2000, Vohs & Heatherton 2000). Individuals under a high cognitive load have been shown to have lower self-regulation, resulting in dieters eating more when compared to individuals under low cognitive load (Ward & Mann 2000; Friese et al, 2008). Participants engaged in thought suppression demonstrate impaired impulse control in relation to alcohol consumption than do controls (Muraven et al. 2002). Cognitive load theory describes

the factors that impact how much of working memory is occupied at any given time (Sweller, 2011), and thus the cognitive resources available to an individual. It is currently unknown whether those in CR are under high or low cognitive load when compared to controls, but these patients have concerns regarding change in lifestyle, coping with ill health, the assimilation of new information, and the emotional trauma of loss. Research has shown that when individuals do not have the cognitive resources available to regulate the impact of temptations on their behaviour, they are less likely to resist behavioural temptation (Baumeister, et al, 1998; Vohs & Heatherton, 2000; Friese et al, 2008).

Of all the various aspects of self-regulation, planning skills are particularly important in cardiac rehabilitation, as there is an extensive need for CR patients to be able to plan their daily routines in order to comply with the myriad of necessary lifestyle habits. Allain et al (2005) defined planning as:

"The ability to organise behaviour in relation to a specific goal that must be achieved through a series of intermediate steps". Allain et al (2005), p. 4.

This incorporates both the formulation and execution of steps to achieve a goal. The former requires the ability to mentally create strategies to determine the logical course of action to achieve a goal. The latter relates to implementation and monitoring of those steps (Allain et al 2005; Simerson, 2011). Healthy eating, regular exercise, and class attendance all require planning as is well known in the Health Psychology literature (Sniehotta, 2009).

In addition, those who experience a cardiac event are clearly more likely than controls to have experienced some of the behavioural risk factors that predict a cardiac event. This is problematic, as one of the strongest predictors of future behaviour is past behaviour (Norman & Smith, 1995; Ouellette & Wood, 1998; Van Bree et al, 2015), and can exceed the predictive power of intentions or other social cognitive constructs (Verplanken & Orbell, 2003; Orbell & Verplanken, 2015). This is in part due to the highly habitual nature of frequently enacted behavioural scripts that can be triggered easily from environmental cues with little need for attentional effort (Bargh, 1990; Posner & Snyder, 1975; Näätänen, 2018). Research has worryingly shown that

nonadherence to medication in CHD patients may be as high as 8.2% (Gehi et al, 2007), and merely 15% to 50% of CR attendees continue to exercise 3 time a week or more 6 months after completion of a programme (Ades et al., 1999; Bock et al., 1997; Moore et al., 1998; Dolansky et al., 2010).

Many of the barriers influencing participation in CR programmes outlined above by Clark et al (2013) and others may be affected by self-regulation. The assimilation of a diagnosis of CHD into patients' identities requires the ability to incorporate feedback from others and the ability to reflect upon this. Overcoming transport and distance problems requires planning. Thus any comprehensive understanding of how someone will fair in CR should incorporate a theoretical understanding of self-regulation.

Executive Functioning

The construct of executive functioning is an umbrella term that encapsulates an array of cognitive processes that are required for the control of behaviour (Malenka et al, 2009). Executive functions have been defined by Lezak as:

"Those capacities that enable a person to engage successfully in independent, purposive, self-serving behavior." (Lezak, 1995, p. 42)

The three main elements of executive functioning are working memory, inhibition, and mental flexibility (Miyake, et al. 2000; Hall & Fong, 2015). Subcomponents exist within these domains, including attentional control, cognitive flexibility, and cognitive inhibition (Diamond, 2013). Higher order executive functions require the mobilization of multiple basic executive functions. These include planning, reasoning, problem solving, and fluid intelligence (Chan et al, 2008). A list of executive functions that concurs with Stuss and Benson's theoretical model of executive function (Stuss and Benson, 1986; Busch, et al 2005) is detailed in Table 1.

TABLE 1 Core Executive Functions

Executive Function Name	Description	Source
Working Memory	The ability to work with finite information.	Miyake, et al. 2000; Hall & Fong (2015)
Inhibition	The ability to suspend impulsive responses.	Miyake et al; 2000; Hall & Fong (2015)
Mental Flexibility	The ability to efficiently adapt to changing performance rules.	Miyake et al, 2000; Hall & Fong (2015)
Attentional Control	The ability to focus attentional resources on specific stimuli in a sustained manner.	Chambers et al, (2008)
Cognitive Flexibility	The selective use of knowledge to adaptively fit the needs of understanding and decision making in a particular situation.	Spiro (1988)
Cognitive Inhibition	Active suppression mechanisms that limit the processing of irrelevant stimuli for the ongoing task.	Shallice & Burgess (1991)
Verbal Reasoning	The ability to comprehend and reason using concepts expressed through words.	Sternberg and Powell (1983)
Problem Solving	The through which an individual attempts to identify, discover, or invent effective means of coping with problems encountered in everyday living	D'Zurilla and Nezu (1990)

Executive functioning is often viewed as synonymous with prefrontal cortical functioning, as the concept originally developed from the examination of patients with prefrontal cortex damage (Schneider & Koch, 2005), who often displayed similar impairments of complex behaviour, and yet retained many more basic cognitive functions (i.e., language and memory, Luria, 1973). Indeed, the prefrontal cortex is involved in each of the three main subcomponents of executive functioning (Kim et al, 2011; Rae et al, 2015; Hall & Fong 2015; Funahashi, 2017).

As well as being the central node for executive control, the prefrontal cortex is also intricately connected with other brain areas, allowing more effective control of limbic structures and the basal ganglia (both associated with reward), which are much older and primordial neurological structures (Nauta, 1993; Groenewegen et al., 1997; Tekin and Cummings, 2002). This is demonstrated in the human capacity to balance motivation and control over a sustained period of time (Hare et al., 2009; Figner et al.,

2010; Luo et al., 2012), which is only present in many animals to a limited extent when compared to humans (Bembenutty, 1999; Leonardi et al, 2012; Brucks et al, 2017). This ability to delay gratification is particularly relevant to the types of behaviours asked of CR patients. Behaviours such as taking medication regularly, regular exercise, the denial of pleasurable foods/alcohol, often does not result in immediate pleasurable benefits, and a Common-Sense Model of Self-Regulation (CSM) may argue that the denial of such immediate pleasure would result in negative emotion, rather than a sense of reward (Leventhal et al, 2016).

Research has suggested that executive functioning moderates the relationship between intention and behaviour. Hall et al (2008) found intention to be only minimally predictive of exercise and diet over one week for those with poor executive functioning, but strongly predictive for those with strong executive functioning. Hall & McEown (2005) found a similar moderating effect for alcohol consumption also. Indeed, taken together, executive functioning and intention predict a greater amount of variance in behaviour than rationality models (Hall et al, 2008). Studies have shown that injury to the prefrontal cortex is associated with difficulty in planning and sequencing, failure of goal-directed behaviour, and an increased reactivity to environmental cues (L'hermitte, 1983; Miller & Cohen, 2001; Mobini et al, 2002). In humans, clinical conditions that include impaired functioning of prefrontal cortex areas are associated with impulsivity and planning (Mostofsky et al, 2002; Brevet-Aeby et al, 2016; McCormick et al, 2017).

In recent evolutionary history, the prefrontal cortex has experienced exponential growth, developing in humans more than other primates (Smaers et al, 2017), and in primates more generally than in other animals (Sapolsky, 2017). The prefrontal cortex is the last part of the brain to fully develop and acquire its full complement of synapses in individuals, with complete maturation reached around age 25 (Gazzaniga 2009; Fuster 2015) suggesting it is the part of the brain that is least constrained by genetic disposition, and most sculpted by environmental/experiential factors (Lazar et al, 2005; Kolb et al, 2012). This relatively late development of the frontal lobes likely allows humans to devise cognitive strategies to navigate complex social environments

and increases human capacity for self-regulation of behaviour (Bandura, 1997; Teffer & Semendeferi, 2012; Dohle et al, 2017). Maintaining health requires the navigation of complex social environments and behavioural self-regulation and may therefore be predicted by frontal lobe functioning.

There has been criticism of the rigid assertion that damage to the frontal lobes results in loss of executive functioning (Stuss, 2011), suggesting that anatomical/functional correlation models are too simplistic an understanding of neurological functioning (Stuss et al, 2005). Thus, more sophisticated models of structural connectivity and functional dynamics in the brain are needed (Real et al, 2017). Indeed, the frontal lobes account for between 25-33% of the cortex, and other functions are inevitably entwined with this part of the brain (Alexander et al, 1986; 2009). Much literature highlighting the relationship between brain regions and functioning comes from clinicopathological studies with individuals who demonstrate considerable cognitive difficulties above and beyond executive functioning, or where cortex damage extends beyond only the frontal areas of the brain (Stuss, 2011). Conversely, many brain injuries and illnesses seem to produce executive function impairment with little or no damage to the frontal lobes. These include diffuse trauma (Alexander, 1995), schizophrenia (Briere, and Scott, 2014), and multiple sclerosis (Rocca et al 2015) amongst others. These points raise doubts about the idea of executive functioning being solely controlled by the frontal lobes. For CR patients in general, the specific locale of executive functioning may seem to matter not so much as the nature of the relationship between executive capacity and the behaviours pertinent to cardiac recovery and health status. However, as it is the third most vulnerable brain region to deterioration over time (Mattson and Magnus, 2006), frontal lobe damage is correlated with normal aging (Parkin & Walter, 1992; Parkin et al, 1995; Chan et al, 2019) as are cardiac problems (Ren & Zhang, 2018), and therefore the relationship between function and locale may be of import.

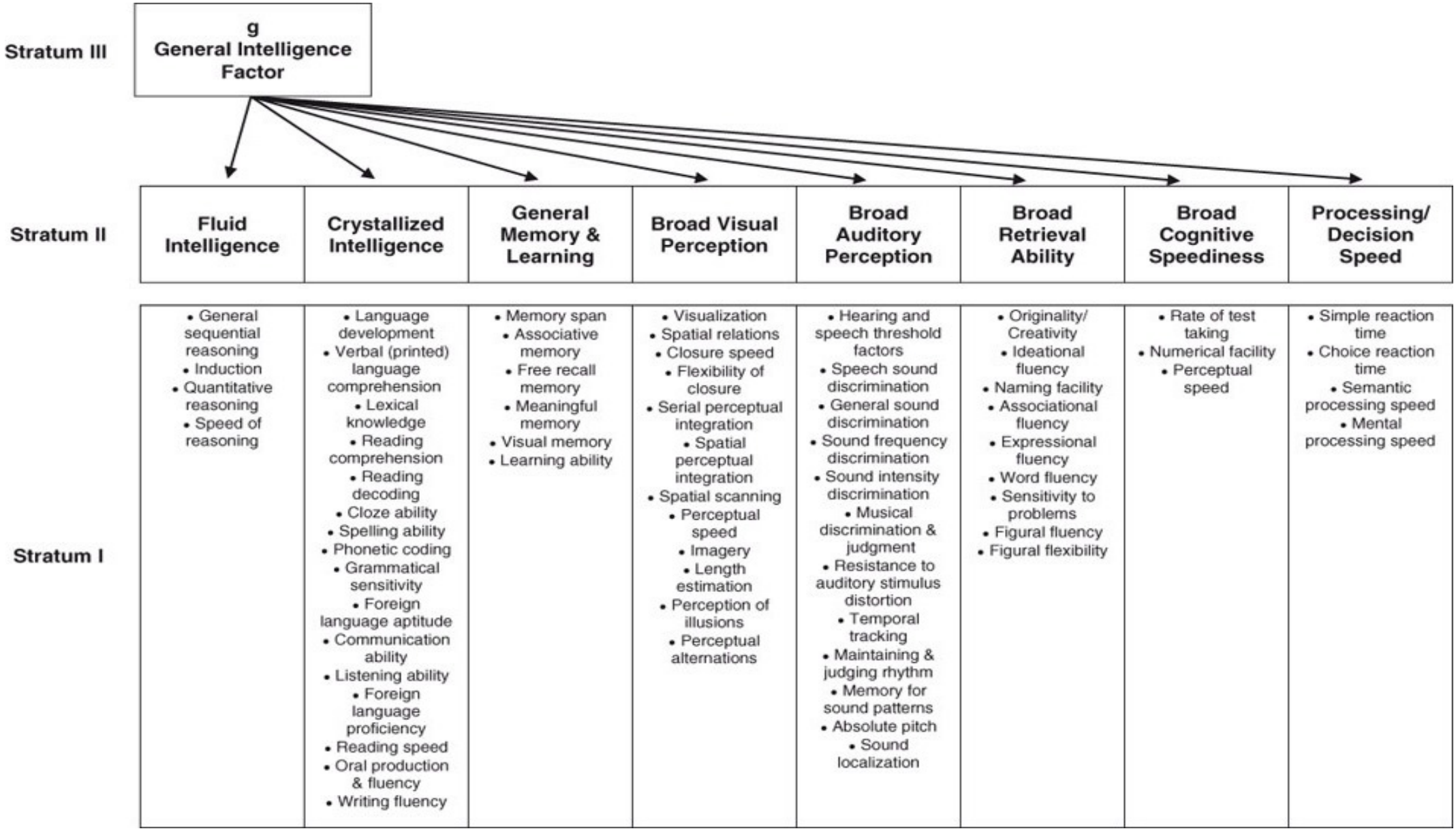
The Conceptualisation of Executive Functioning, Self-Regulation & Cognitive Ability

The study of executive functioning exists as a subcategory within the overall study of cognitive ability, and a detailed discussion of one particular theoretical aspect of cognitive science will be useful to elucidate our understanding of the nature of executive functioning, and how it may impact upon health behaviour decision-making.

Carroll (1993) writes on the nature of 'ability', stipulating that an understanding of what psychometricians mean by this is a crucial step in specifying cognitive ability. Carroll suggests that abilities could be described as measurable attributes that impact success upon a given task/s and that vary across individuals. The more similar the tasks that are being carried out, the more likely it is that the same underlying ability is being used. With relation to cognitive ability, the fundamental function being performed can be defined as the "processing of mental information" (Carroll, 1993, p 10).

Carroll (1993) proposed a hierarchical model of cognitive abilities known as the three-stratum theory of cognitive ability (see Figure 2), which is built upon a factor analytic study of the correlation of individual difference variables, psychometric investigations, academic results, and competence ratings.

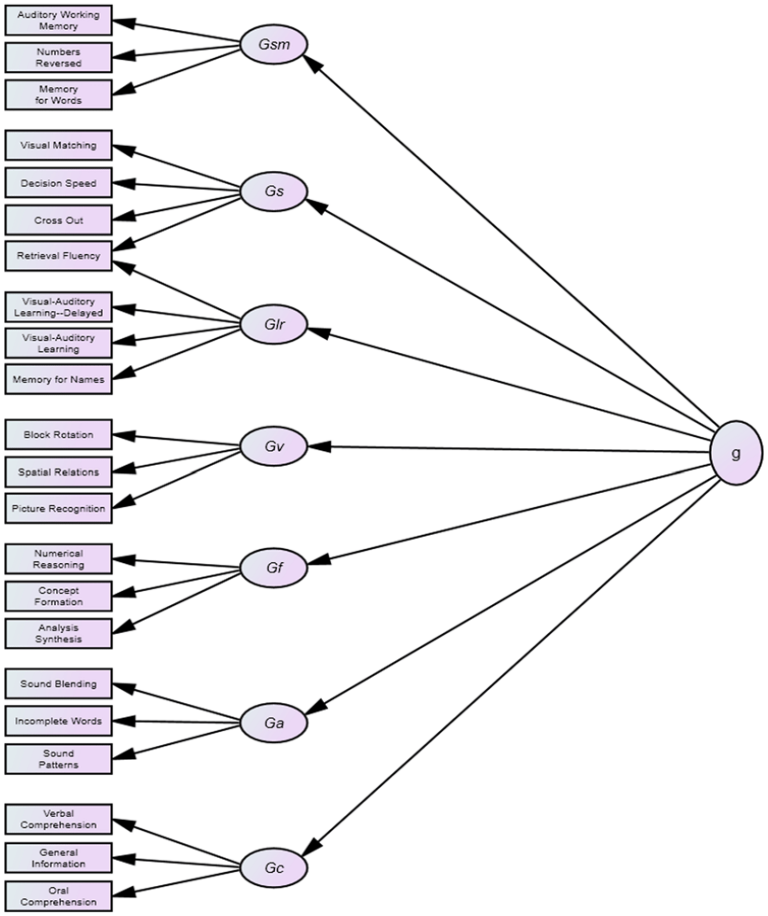
FIGURE 2 Carroll's Three-Stratum Model of Human Cognitive Abilities



Note: Adapted from Carroll (1993, p. 626)

Within this model each strata accounts for variations in the previous tier. The lowest stratum is composed of 69 narrow factors, with eight (later ten) broad factors at the second (Carroll, 2003). The general intelligence factor then resides at the apex of the model. As a result, Carroll's model proposes that all tests of cognitive ability measure one and the same ability, and that all measures of intellectual function collapse into general intelligence, or 'g' (Spearman, 1927; 1987). This evidence of such a singular factor underpinning all cognitive abilities is that supposed fractionated subcomponents of intelligence are correlated with each other at a level of 0.8 correlation coefficient or above. This model and its successor the Cattell-Horn-Carroll (CHC) Model (McGrew, 2005; see Figure 3) have been used as the bedrock for the development of cognitive ability testing over the last two decades (Keith and Reynolds, 2010; Schneider and McGrew, 2018).

FIGURE 3 The Factor Structure of the Cattell-Horn-Carroll Theory of Intelligence



Note: Gsm= Short-term memory, Gs = processing speed, Glr = long-term retrieval, Gv = visual-spatial thinking, Gf = fluid reasoning, Ga = auditory processing, Gc = crystallized intelligence, *g* = general intelligence.
Adapted from Taub and McGrew (2014, p.191)

At its core, the general intelligence factor (or *g* factor) has been described as the ability to abstractly represent and cognitively manipulate those abstractions (Gottfredson, 1998; Chabris, 2007). The conceptualization of executive functioning varies substantially, but broadly is conceived of as the set of cognitive processes that promote purposive behaviour (Lezak, 1995). The suggestion that executive functioning may be yet another way of conceptualising and measuring general intelligence (rather than a separate cognitive entity) must be considered. Van Aken et al (2016) found a correlation of 0.91 between general intelligence and executive functioning. It has been demonstrated that there are subtests of both the adult and child Wechsler Intelligence Scales (Wechsler, 1974; Wechsler & De Lemos, 1981) that evaluate the same constructs evaluated by executive functioning test batteries, such as attention (Leonberger et al., 1992), spatial reasoning (Leonberger et al., 1991, 1992; Sherman et al, 1995), and working memory Chittooran et al, 1993; Leonberger, et al, 1991; Leonberger et al, 1992).

A question arises when self-regulation is discussed within the context of such constructs. Equating executive functioning with self-regulation might suggest that there is nothing over and beyond a general cognitive process being described, potentially negating the idea of an interaction between cognitive and emotional control processes (Garcia-Barrera et al, 2012, 2013) and perhaps limiting our chance to fully grasp the psychological process of decision making. The aspect of executive functioning that perhaps the CHC model does not fully encapsulate is self-monitoring. Self-monitoring is named by the Behavioural Assessment of the Dysexecutive Syndrome (BADS) authors as one of the aspects of executive functioning assessed by the measure (Wilson et al, 1997) but it is not defined. Originally conceptualized by Snyder (1974), self-monitoring describes the way in which individuals manage their cognitive and metacognitive processes to follow performance and outcomes (Zimmerman, 2000). Definitions of self-monitoring resemble an executive functioning conceptualization of self-regulation, and there seems to be a close relationship between the two in the literature (De Bruin and Van Gog, 2012). Self-monitoring would seem to be a subcomponent of self-regulation, conceptualized as an aspect of the second phase of self-regulation in Zimmerman's (1998) three proposed phases of self-regulation (Isaacson and Fujita, 2006).

There are documented clinical observations of patients with vmPFC damage whose perform on intelligence measures is intact, but who still display deficits in everyday self-regulation (Eslinger and Damasio, 1985; Barrash et al, 2000). Similar problems have been evidenced in laboratory studies (Camille et al, 2004; Koenigs and Tranel, 2007) and these deficits have been described as problems in value-based decision making. Whilst the clinical literature has only evaluated intelligence and self-regulation in vmPFC-damaged patients (Hiser & Koenigs, 2018), if problems with this brain area can result in a deficit in decision-making without a related decline in intelligence, this suggests that executive functioning consists of something beyond the *g* factor. The value-based decision-making role of the vmPFC is dependent upon its interaction with the ventral striatum and amygdala (Cauda et al, 2011; Choi et al, 2012; Sesack et al, 1989). Along with the vmPFC, these structures are also associated with the processing of negative emotion (Rosenkranz et al, 2003; Likhtik et al, 2005) highlighting the close nature of the relationship between cognition and emotion.

The introduction of latent variable analysis of psychometric tests has progressed the conceptualisation and operationalization of cognitive constructs (Adrover-Roig et al, 2012; Goldstein et al, 2015). Floyd et al (2010) modeled the relationships between the Cattell-Horn-Carroll (CHC) theory of cognitive abilities and executive functions, finding that measures of both are not easily distinguishable, with all tests measuring the general factor. In a confirmatory factor analysis, Jewsbury et al (2016) found that inhibition did not separate from processing speed (Gs). In a meta-analysis of nine different datasets, Jewsbury et al (2017) found that modelling of CHC constructs rendered the executive function factor redundant, concluding that a specific construction of executive functioning was unnecessary. Jewsbury et al (2017) demonstrates that the construct loading of tests normally grouped together under the banner of executive functions are distributed across several CHC constructs, and that the practice of amalgamating and collapsing across CHC factors to produce constructs like executive functioning is ill-advised. Karr et al (2018) also found evidence for the unidimensionality of executive function, though this diverged as age increased. Indeed, a high correlation between fluid intelligence and executive function is reported frequently (Van Aken et al, 2016). Executive function has been found distributed across fluid reasoning (Gf), processing speed (Gs), short-term memory

(Gsm), and visual-spatial thinking (Gv) constructs (Benedek et al, 2014; Beaty and Silvia, 2013; Blair, 2006; Cho et al, 2010; Decker et al, 2007; Jewsbury et al, 2017; Silvia and Beaty 2012; Silvia et al, 2013). Van Aken (2017) attempted to integrate executive function into intelligence testing using the BADS. They found that the BADS had a high loading onto the perceptual organization index of the WAIS-III, and subsequently that perceptual organization index predicted variance in the fluid intelligence (Gf) and visual processing (Gv) components of the Cattell-Horn-Carroll model.

These studies suggest that a reconceptualisation of executive functioning is emerging, implying that there exists no unitary construct underpinning all executive function tests, but rather that the constructs being measured by executive functioning tests reside within (but are also interspersed within) the third tier of the CHC model. This research suggests that a reconceptualisation of executive functioning is necessary, and perchance one that considers the role of self-regulation will aid this process by beginning to bridge the conceptual divide between social psychology and cognitive psychology constructs.

The literature on the neural correlates between executive function and general intelligence also point to these two being cognitive products of related neural networks. The neuroimaging and lesion literature have demonstrated the importance of prefrontal and parietal areas for intelligence and executive functioning (Haier, 2011; Niendam et al, 2012), although commentators have cautioned that studies on lesions and executive function/intelligence highlight diffuse brain lesions, and that they lack control subjects (Barbey et al, 2012).

Others question the CHC model as the sole explanation of cognitive abilities. Studies suggest that mental flexibility as conceptualised by executive functioning models may contribute significant variance over that explained by the current CHC model. Floyd et al (2010) found that the only aspect of executive functioning that did not correspond well with CHC factors was mental flexibility, and that this could possibly be considered the executive functioning factor that should potentially be represented within the CHC model. Similarly, Van Aken et al (2019) suggested that planning and inhibition as measured by standardized executive functioning tests were not well

represented in CHC measures. Canivez and Youngstrom, (2019) pointed out the incongruence between the Carrol and Cattell-Horn conceptualisations of intelligence and called for a remodelling of intelligence in light of this. They note, however, that the evidence suggests most intelligence tests do indeed primarily measure the *g* factor. Thus , it seems timely to study intelligence related constructs alongside similar conceptualizations such as self-regulation.

Executive Functioning and Health Behaviours

The ability to control impulses explained by executive functioning mirrors some of the aspects of self-regulatory models of health behaviour. In addition to delaying gratification, other aspects of executive functioning also help drive the implementation of health behaviours and are familiar to self-regulatory model theorists. Working memory assists the ability to keep goals in mind when making decisions; having the ability to inhibit may aid in remembering and implementing plans, and mental flexibility may aid in being able to adapt plans when circumstances change, or obstacles emerge (Hall & Fong, 2015). The literature suggests executive functioning is a determinant of behaviours that involve endeavour, consistency, and the suppression of other behavioural options (Hinkin et al., 2002; Insel et al., 2006; Lowe et al., 2014). For example, McAuley et al. (2011) demonstrated that executive functioning predicted exercise class attendance via self-efficacy beliefs in older adults. Hall et al (2006) found that health risk behaviours were positively associated with individual differences in brain function that were specific to frontal lobe performance, rather than nonspecific cognitive capacity.

Recovery from cardiac difficulties is a complex process where much is asked of the individual, in terms of effort, adherence, planning, and self-management skills (NICE, 2013). The individuals' capacity to be an active participant in the rehabilitation process is crucial. Qualitative work carried out by Bäck et al (2017) can shed light on how various aspects of patients' perspective regarding barriers to attendance at CR. Patients faced familiar barriers of travel and time, but also reported feeling that they had difficulty absorbing lot of information from different professionals that was often conveyed in a hurry (potentially underlying the importance of working memory). This

has been supported quantitatively. Swardfager et al, (2011) found that verbal encoding, recall, and verbal memory performance were all lower in those who failed to complete CR when compared to those who did. They also found physiological effects, with verbal memory being associated positively with hyperlipidemia, resting heart rate, and peak volume of oxygen uptake. In the Bäck et al study, setting goals helped facilitate exercise, as did tailored, consistent information). Participants in Bäck et al (2017) also experienced fear and avoidance of exercise, particularly if they had experienced previous angina pectoris precipitated by exertion or had experienced myocardial infarction. Fear-avoidance is a well-understood cognitive behavioural model (Lethem et al, 1983), where challenging the cognitions involved in this requires mental flexibility, inhibition, and working memory (Dajani & Uddin, 2015; Schmeichel, and Demaree, 2010). Self-regulation in the face of a fear-avoidance response may not only be difficult to master, but also undesirable to the individual in any case.

Given the important role that executive functioning plays in the process of regulating health behaviours, it seems to follow that executive functioning should play a central role in the modelling of these behaviours. Hofmann et al (2012) argues date self-regulation and executive functioning have largely been studied in parallel by different academic disciplines, and that there is a greater need for communication amongst these disciplines. The literature on executive functioning comes from cognitive sciences, whilst self-regulation resides in the domain of social and personality psychological literature (Baddeley, 2007; Hofmann et al, 2012). There is good reason to desire the integration of the two research communities, as both could benefit from the others' expertise. Hofmann et al (2012) points out that executive functions subserve self-regulation, supporting an individual's regulatory behaviour, and there is therefore a need to begin to investigate these phenomena in conjunction. Hofmann et al (2012) denotes how the three central components of executive functioning support self-regulation mechanisms (Figure 4).

FIGURE 4 Executive Functioning Central Components That Underpin Self-Regulation Mechanisms

Executive Functions	Self-Regulatory Mechanisms
Working Memory Operations	• Active representation of self-regulatory goals and standards • Top-down control of attention towards goal-relevant information and away from attention-grabbing stimuli • Shielding of goals and standards from interference • Suppression of ruminative thoughts • (Down-)regulation of unwanted affect, desires and cravings
Behavioural Inhibition	• Active inhibition of prepotent impulses and habitual, 'mindfulness' behaviours
Task-Switching	• Flexible switching between different means subserving the same (self-regulatory) goal ('means-shifting') • Switching between multiple goals ('goal-shifting/balancing')

Taken from Hoffman et al, (2012).

Further evidence suggests that executive functioning contributes to self-regulatory outcomes in the form of predictors, mediators, or moderators (Unsworth et al, 2004; Friese et al, 2008; Thush et al, 2008).

Executive Functioning, Self-Regulation, and Cardiac Rehabilitation

Successful CR requires setting and working towards goals, and executive function and self-regulation seem intertwined in the attainment of these. Research suggests working memory is needed to actively represent self-regulatory goals to attain them (Baumeister, and Heatherton, 1996; Miller and Cohen, 2001; Kruglanski et al, 2002). As noted above, the health behaviours required may mean the delay of gratification. This emotional regulation requires working memory to support cognitive reappraisal and the regulation of emotional experiences (Schmeichel and Demaree, 2010; Schmeichel et al, 2008; Riediger et al, 2011).

Successful long-term adherence to a healthy lifestyle in Phase 4 CR requires self-regulation with regards the ability to actively restrain behavioural habits or impulses that are not attuned with goals. Unfortunately, the frontal cortex is the third most vulnerable brain region to normal aging, following the substantia nigra and the hippocampus (Mattson and Magnus, 2006). The average age of attendees in Phase 4 CR is 66 for men and 70 for women (Doherty et al, 2018), and therefore the natural process of aging and its consequences must be considered when asking patients to partake in immense tasks of self-regulation. Motor schemas are activated by habits and impulses once a particular activation threshold is crossed, unless these schemas are inhibited (Strack and Deutsch 2004; Norman and Shallice, 1986), and research has demonstrated that such habits can be harder to break as age increases (Barnes et al, 2004). Studies have shown that participants low in behavioural inhibition are more strongly influenced by these impulses (Hofmann et al, 2009b; Houben and Wiers, 2009; Payne, 2005).

A Synthesis of Self-Regulation and Neurobiology in Physical Health

In recent years, work has highlighted ways in which executive functioning and self-regulation are intricately related. Hofman et al (2012) proposed that self-regulation failure was often facilitated by temporary reductions in executive functioning. Hall and Fong (2013; 2007) explained the reason why any particular human behaviour may appear dysfunctional depends upon the temporal framework in which that behaviour is viewed. Behaviours with long-term costs are usually driven by short-term benefits and, those with long-term benefits can be associated with off putting immediate costs. With reference to health behaviours, it is necessary to recognize that present actions are often linked to future outcomes insofar as one's aim is to regulate behaviour in a healthy manner. Those with a high level of regard for the future consequences of their actions are more inclined towards long-term protective health behaviors (Orbell & Hagger, 2006). The tendency to imagine the future, plan for the future and curb current behaviour in order to benefit the future self is a central aspect of executive functioning (Diamond 2013).

Experimentally, it has been shown that the well-functioning prefrontal cortex is associated with the propensity to choose larger, delayed reward over smaller, immediate ones in decision-making experiments (McClure et al, 2004). This "bargaining" between the current and future self is characteristic of both the executive functioning and self-regulation literature (Barkley, 2001; Oyserman, et al, 2015; Ainslie, 2018). Paus (2001) suggested the existence of self-regulatory circuitry within the brain, incorporating the prefrontal cortex and the anterior cingulated cortex. This represents the beginnings of a neurologically based understanding of self-regulation that could be beneficial to a wide variety of fields (Blair & Diamond, 2008).

Hall and Fong (2013; 2007) proposed the Temporal Self-Regulation Theory (TST) to build upon the existent Social Cognition Models of Health Behaviour. This model places executive functioning as central in determining behaviour, alongside intention and prepotency. It states that when temporal conditions are perfect intention does indeed translate directly into behaviour, but when conditions are not supportive (due to barriers, where there is a large discrepancy between costs and benefits, etc.), executive functioning and prepotency become increasing crucial. The latter state could be said to be the default for all patients with health conditions, including CR patients. Additionally, this model also suggests that there is a positive feedback loop connecting executive functioning and behaviour, so that individuals with stronger executive control are more likely to complete the behaviour, which in turn strengthens the executive control network. Literature that suggests repeated exercise is linked to an enhancement in neurological structures that support executive functioning ; Colcombe and Kramer, 2003; Smith et al., 2010; McAuley et al., 2011; Best et al., 2014; Daly et al., 2015). The model suggests that for CR patients their executive functioning will be a vital contributor to their recovery. It may be suggested – using this model as justification – that there is a biological basis for investigating self-regulatory/executive functioning ability in CR patients.

Building upon this modelling that was first used in the domain of physical activity, Evans et al (2017) found the Temporal Self-Regulation Theory significantly explained some of the variance in intentions and behaviour for fruit (22%), and vegetable (64%)

intake. Other research that utilizes this model downplays the role of motivational factors (including intention and self-regulation), emphasizing the importance of momentary cues (Elliston et al, 2017) . Again, an understanding of executive functioning may help us comprehend these results. A high level of executive functioning may help suppress susceptibility to momentary cues through the implementation of restraint of impulse, even if motivational level attributes are impeded (Dohle et al, 2017; Munro et al, 2017). For a different behaviour (hygienic food handling), Fulham and Mullan (2011) found that behavioral prepotency predicted behaviour over and above intentions. Allom et al (2018) found similar results for supplement use. These suggest the importance of habit building, as the model suggests.

Momentary Cues, Everyday Cognitive Failure, and Health Behaviour

This balance between long-term and short-term in behavioural choices is further developed in the literature on everyday cognitive failures. The early work of Jim Reason (1977, 1979) investigated everyday errors and individuals not acting as planned, beginning with the examination of accident reports, and progressing to developing theories on 'absent-mindedness', or actions not coinciding with intention. This may suggest that in many spheres and disciplines, human failure to act in intended ways is almost a universal. Broadbent et al (1982) dubbed such lapses "failures of cognitive control", conceptualising cognitive failures as errors of perception, memory, and motor functioning. This effect has been demonstrated many times for dieting and other health behaviours, where infringement of abstinence results in relapse (Marlatt & Gordon 2005). In reference to CR rehabilitation patients, intentions and self-regulatory framework may be set to complete health behaviour successfully, but nonetheless there is failure to live a healthy lifestyle e.g., failing to complete an intended exercise, or snacking on calorie dense foods with intent almost being bypassed (Honkanen et al 2012). The effect above may then be evident, and patients may be disinclined to resume working towards health behaviour goals. With regards to why such slips occur, memory failure may be an obvious explanation (Cheyne et al, 2006), though sequencing operations and perceptual selection are also candidates (Robertson et al, 1997; Seligman and Giovannetti, 2015).

Referring to the definition of planning above, the second aspect of planning was defined as the execution, relating to the implementation and monitoring of the plan (Allain et al 2005; Simerson, 2011). Many of the models of action slips suggest slips happen at the decision points between different steps along the road to implementation (Norman, 1981; Botvinick and Plaut; 2003, 2004), potentially because of the attentional demands made at this point in the process (Reason, 1992). Decision points during tasks occur at the transitions between subtasks (Baars, 1992). Attention slips or memory slips can occur at these transition points (Botvinick & Bylsma, 2005). Cognitive failures may be particularly important in planning at decision points between different steps along the road to implementation (Norman, 1981; Botvinick and Plaut; 2003, 2004). CR patients will continually be progressing through plan stages, potentially several at any given time (relating to diet, exercise, etc), and slips may well happen at times when transitioning between steps is taking place.

Take an individual who wishes to change a small daily routine, such as reducing their sugar intake from tea from two sugars to none. The average teaspoon (4.2 g) of sugar contains 16 calories (Putman et al, 2002; Welsh et al, 2011), and the average UK tea drinker will drink 4.3 cups of tea a day (Landais et al, 2018), so the reduction will result in a weekly calorie deficit of 481 calories. Assume that the previous routine is to begin with the teabag in a cup, add water, followed by milk, and then sugar. The transition point in this task comes at the end of adding the milk. The correct next step in the altered routine would be to stop and begin another activity, such as drinking the tea. At this transition point, selecting the correct action requires accessing information about actions already carried out, access information about the change in habit, and the ability to override a long-standing behaviour pattern. Both Reason (1992) and Norman (1981) posit that these junctures necessitate a particular attentional mode. Errors occur at these decision points due to failure to perform this attentional operation. In the example above, the error of adding sugar to tea is attributed to a failure to execute an attentional operation that would have recognized that sugar was now not to be added (Botvinick and Bylsma, 2005). However, such descriptions of attentional mode failure can be criticized for merely pushing the problem one step back rather than providing an explanation. It is clear from this reductionist

examination of a health behavioural routine that an analysis of executive functioning and self-regulation in health is required.

Demographics and Health Outcomes

Without the collecting and reporting of demographic characteristics of research participants, one risks taking the position of "absolutism" and assuming phenomena of interest are the same regardless of age, gender, and other demographic differences (Beins, 2009). Universal psychological processes may manifest differently depending upon such individual differences, and demographics should be considered carefully in any data analysis (Connelly, 2013).

Gender appears to be one factor that impacts health outcomes in cardiac care. Okunrintemi et al (2018) found that women with Atherosclerotic Cardiovascular Disease (ASCVD) experienced poorer perceived health status and health-related quality of life than men. Jain et al (2022) discovered that woman with ASCVD were more likely to experience clinical depression and poorer physical health. Dreyer et al (2015) found a similar pattern amongst patients with peripheral arterial disease, where at 12-months post-diagnosis, women reported poorer overall physical and mental health. Bishop (2002) reported that after 12 weeks of CR, females had lower functional ability and physical quality of life. The consistency of this pattern suggests that gender should be a key demographic in any study of health outcomes in cardiac patient populations.

Likewise, any study looking at this population must also consider aging. It is estimated that by 2030, 40% of deaths in those aged 65 plus will be caused by cardiovascular diseases CVD (Heidenreich et al, 2011), and is already the leading cause of death in this age group (Chiao et al, 2016). Cardio health decreases as we age, with a decrease in heart rate variability and maximum heart rate (Antelmi et al, 2004), as well as pathological alterations in cardiovascular tissues including hypertrophy, increased arterial stiffness, altered left ventricular (LV) diastolic function, and diminished LV systolic reverse capacity, and impaired endothelial function (Lakatta and Levy, 2003; Zieman et al, 2005). Indeed, cardiovascular health is crucial for the health of the whole body, being the system which delivers oxygenated blood to all bodily tissues (North and Sinclair 2012). We would therefore

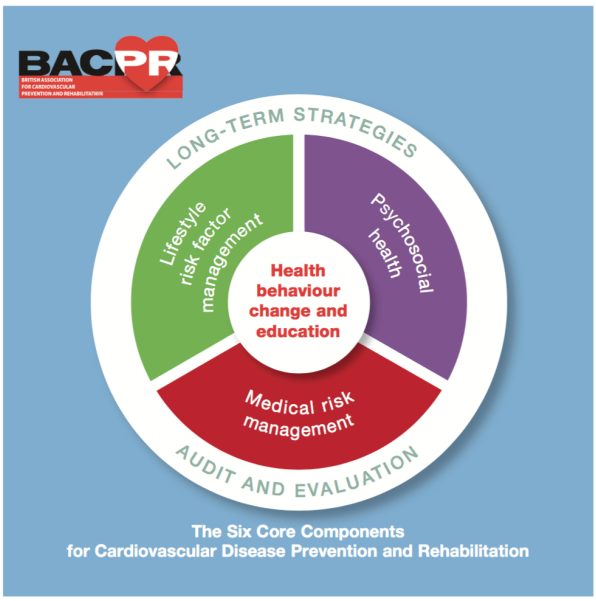
expect to see some of the variance in health status accounted for by age, and as such this must also be included in the demographics of any cardiovascular study.

General physical health markers must also be considered. Objective physiological measurements are good predictors of health status (Guallar-Castillón et al, 2009; Çam and Top, 2021) and must be considered in a study such as this. It is well evidenced that individuals with large waist circumferences have an increased burden of ill health (Lean, et al, 1998), as well as a lower quality of life, decline in physical function, and a higher disability risk (Batsis et al, 2014; Dinh et al, 2019). Indeed, waist circumference is an indicator of risk of CVD development itself (Siren et al, R., 2012). Such a relatively simple measurement has been shown to be better than the more traditional measure of Body Mass Index (BMI) in predicting cardio-metabolic risk and related health outcomes (Koster et al, 2008; Nevill et al, 2022). This study will include the measurement of gender, age, and waist circumference to appropriately account for the variance in health status predicted by these important factors.

Phase 4 – Requirements and Demands

The technical competence required for successful CR is great. The BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation (BACPR 2017) is a manual of the six core components that professionals are required to have for cardiovascular disease prevention and rehabilitation. The Core Components are outlined in Figure 5.

FIGURE 5 BACPR 6 Core Components



Taken from the BACPR Standards and Core Components for Cardiovascular Disease Prevention and Rehabilitation 2017 (3rd Edition).

Health behaviour change and education involve the knowledge and ability to alter patterns of behaviour, and this is core to the standards. Lifestyle risk factor management comprises all aspects of lifestyle that impact upon health, and medical risk management relates to being aware of when to use appropriate medication safely and effectively. Psychosocial health refers to the emotional, psychological, and sociological dynamics of functioning that are part of any holistic model of care. A long-term strategy consists of identifying long term goals for the patient and working towards these. Finally, audit and evaluation relates to service compliance with standards and guidelines.

It is clear that all components (save perhaps the sixth) involve the patient as an integral part of the process. As patients move towards a self-management model of care in their recovery journey (Chiauzzi et al, 2015; Riegel et al, 2017), they must also develop similar competencies to help them manage their own health. Indeed, the standards state that:

"By the end of the programme patients will have been encouraged to develop full biopsychosocial self-management skills and so be empowered and prepared to take ownership of their own responsibility to pursue a healthy lifestyle." BACPR (2017), *p. 17.*

However, the document makes no mention of either the internal or external resources the patient will need to be so empowered. Even making relatively simple decisions might not be as clear to patients as practitioners may think. Qualitative research by Madden et al (2011) found that staff believed all patients were given a choice between a hospital or community-based CR programme. From the patients' perspective however, the situation was less clear. Not all reported being offered a choice, and when they did, they perceived a variety of obstacles including a lack of information on which to base a choice, problems with referral, staff not having appropriate training, geographical and time restraints, and transport difficulties. While the study's conclusions focused on improving service provision to overcome these problems, the issues themselves highlight a myriad of areas where the patient is required to have sophisticated executive functioning skills, over and above those required to manage self-regulation in an environment sympathetic to their needs. Cognitive functioning can impact upon outcomes of CR, with those with poorer cognitive functioning experiencing poorer Quality of Life after CR (Cohen et al, 1999), higher non-completion of program activities (Swardfager et al, 2011), and less benefit derived from CR (Kakos et al, 2010). However, few studies exist which examine the role specific cognitive deficits play in relation to measured CR outcomes.

Executive functioning, self-regulation, and the role they play in the functioning of CR participants is not well understood. It is important, therefore, for further research to investigate the precise nature of how these phenomena impact upon measured clinical outcomes.

Research Aims

The present study builds upon the research outlined above. The aim of this study is to assess whether executive functioning and self-regulation predict the physical and mental health status of Phase 4 CR patients. In addition, the study also aims to assess whether gender, age, and waist circumference predict the physical and mental health status of Phase 4 CR patients.

Based upon the literature reviewed above, two hypotheses will be tested regarding executive functioning and self-regulation:

The first is that physical health will be predicted by executive functioning and self-regulation.
The second is that mental health will also be predicted by executive functioning and self-regulation.

In addition, two further hypotheses will be tested regarding the demographic variables of gender, age, and waist circumference:

The first is that physical health will be predicted by gender, age, and waist circumference.
The second is that mental health will also be predicted by gender, age, and waist circumference.

Methods

Design

A quantitative study was devised to assess the variance in CR outcomes predicted by executive functioning and self-regulation. Standard Multiple Linear Regression analysis was utilized to ascertain the extent to which the predictor variables of executive functioning and self-regulation account for the variance in the criterion variable of CR outcome (i.e., health status). Details of measurements of each variable are given below.

Setting

The study took place within Phase 4 CR classes across the central belt of Scotland. Phase 4 programmes involve the long-term maintenance of exercise and lifestyle change post-cardiac event and are governed by the British Association for Cardiovascular Prevention and Rehabilitation, independent of the NHS (Buckley et al, 2013). Classes are run either by independently organising groups of Physiotherapists or by Local Authority leisure facilities. All instructors must meet the core competencies set out by the BACPR Competence framework to be considered competent to practice (BACPR, 2017). Class structure must also comply with the BACPR Competence framework. Local Authority classes are run by BACPR accredited fitness instructors who are required to renew their training and accreditation every 5 years.

Participants

Inclusion criteria for the study was as follows:

1) Referral to Phase 4 CR class by Phase 3, following on from a cardiac event and the successful completion of Phase 3 (defined as discharge to Phase 4 by a qualified healthcare professional). This referral system ensures that participants are well enough to exercise within a community setting.
2) Able to speak English fluently.
3) Able to give informed consent.

Recruitment and Sampling

Purposive sampling was used to identify Phase 4 CR patients to participate in this study to select a relevant sample. There are of course difficulties with this, as those who attend such classes are a self-selecting group. The literature on hidden populations highlights the importance of researching those for whom there is no existing sample framework (Heckathorn, 1997; Sydor, 2013). In the context of Phase 4, the obvious hidden population consists of those not in attendance at Phase 4 programs. The reasons one might choose not to attend such a class are myriad. Individuals may be attending another exercise class (Ku et al, 2018), utilizing a home-based rehabilitation programme (Clark et al, 2015), be avoidant (Tully et al, 2017) or too unhealthy to attend (Denvir et al, 2015). Unfortunately, the absence of such individuals from any research sample is potentially problematic, as the reasons for nonattendance are also likely to impact upon the health of the individuals, thus rendering the sample chosen as representing a sub-population of CHD patients and not the entirety. Indeed, impaired executive functioning is associated with functional impairment (Marshall et al, 2011), and thus those experiencing executive dysfunction may not be accurately represented in the sample. Purposive sampling researchers can (and do) choose to exclude certain subgroups from the sample (Etikan et al, 2016), which can lead to skewed research outcomes. To avoid such bias, no subgroups were excluded from the sampling frame of those attending the relevant CR programmes. Until the publication of NICE guideline NG185 (NICE 2020) and SIGN guideline SIGN 150 (SIGN, 2017) and the development of the research which these guidelines incorporated (i.e., Taylor et al, 2014), exercise was presumed to increase risk to heart failure patients, and as a result they were discouraged from physical activity and excluded from cardiac rehabilitation (Bozkurt et al, 2021). Indeed, cardiac rehabilitation practitioners are still encouraged to consider several risk factors (such as a patient's relative burden of fatal arrhythmia) when working with heart failure patients in CR (Chun and Kang, 2021). There could therefore be a rationale for excluding such clients, given the uniqueness of their condition. It was decided that to do so would decrease the heterogeneity of the sample in an inappropriate manner. Instead, it was decided to capture a wide range of experiences and outcomes relating to CR and include heath failure patients and reduce the possibility of researcher introduced bias. A further criticism of this sampling strategy is that knowledge of their inclusion is a research project may cause participants to change their behaviour

(i.e., a Hawthorne effect) or actively lie to create an outcome more favourable towards their biases (Sharma, 2017). Whilst Hawthorne effects are possible in all human-based research, this study minimized the possibility of participant lying in two ways. Firstly, one objective measure was included (specifically the BADS) and secondly, participants were not 'actively' selected by the researcher – i.e., not specifically chosen due to desirable characteristics – therefore reducing the potential for them to perceive themselves as being 'hand-picked' and thus motivated to produce certain outcomes.

Participants were recruited through the Phase 4 CR programs as described above. Data collection took place between February 2016 and March 2018. Participants at the class were invited to join the study and given participant information sheets to read and decide. If they expressed an interest, they were asked to approach the researcher at the end of the class to ask any questions and, once questions were answered, state their interest if they felt so inclined. They were informed that the researcher would be back at the same class the following week, and if they wished, they could consider over the interim whether they wished to be involved. Once the participant said they wished to be involved, they were asked to complete the questionnaire and return it at the end of the next rehabilitation class to the researcher. In the initial verbal invite to read the participant information sheet, participants were informed that taking part was entirely voluntary, and that they are free to decline. This process took place once for each class, that is, we did not return to a class to offer a fresh invitation, once participants had chosen whether they were interested or not.

The decision was made to not collect data regarding the percentage of CR attendees who chose not to take part in the study (given the invitation), nor were records kept regarding the number of individuals who initially agreed to take part but did not complete the questionnaire. This decision was based upon the ethical principle of autonomy, grounded upon the classic liberal tradition articulated by John Locke, David Hume, Adam Smith, and Immanuel Kant (Griswold, 1999; Butler, 2015). Classical liberalism is characterised by several principles, the most pertinent to this discussion being: the presumption of freedom, the primacy of the individual, and the imperative to minimise coercion. Classical liberals assert that individuals be allowed to live their lives as they see fit, with the minimal required interference from

authorities or other individuals (Epstein, 2004). Such freedom can of course never be absolute (since an individual's freedoms may conflict with another person's), but the principle holds that an individual's choices should be respected by others. In line with this principle, those who have chosen to not consent to partake in the study have chosen not to have any data concerning their behaviour recorded. It was decided that to quantify their non-participation would therefore amount to a violation of their wishes and transgress the classical literal ethical principles outlined above.

Information regarding the study was presented to potential participants in the participant information sheet (see appendix 1), where participants were informed that participation was voluntary and that declining to take part will not impact upon their usual CR class in any way. Participants were asked to provide written consent at the onset of the study (see Appendix 2), which also includes information regarding their right to withdraw.

Measures

The measures utilized to capture the various variables are noted here.

Predictor Variables: Executive Functioning, Self-Regulation, Age, Gender
Outcome Variable: Health Status

In line with appropriate principles of Patient and Public Involvement (PPI) in research (Brett et al, 2014), advice was sought in the development of the questionnaire and the relevant patient materials from a BACPR CR service provider and a service user. This was done to optimise research quality and relevance of the questionnaire content and format (Stewart and Liabo, 2012). Feedback was sought with regards nature of questions, the appropriateness of methodologies, and the pertinence of sampling and recruitment approaches. This feedback was incorporated into the development of the questionnaire. The questionnaire took approximately 20 minutes to complete. Accessibility of all standardized materials were assessed and deemed appropriate in partnership with the above-mentioned service provide and user. A complete copy of the participant questionnaire can be found in Appendix 3. The following participant demographics were measured.

1) Demographic Variables

1.1) Age

1.2) Gender

Previous studies have found gender differences in health status in the general population (Denton et al, 2004; Mommersteeg et al, 2017) and gender differences in health status has also been demonstrated in various studies of CHD patients (Dreyer et al, 2015a; Dreyer et al, 2015b; Norris et al, 2017; Israelsson et al, 2017). Studies have also shown that age correlates with poorer health in both the general population (WHO 2015; Kalache and Sen, 2017) and in the CHD population (Franklin, 1999; Kernan et al, 2014). In addition, aging is also associated with a decline in frontal lobe functioning that is more severe than that of other brain regions (Mittenberg et al, 1989; Rosselli and Torres, 2019).

Participants' health status was measured using the following:

1) Biological Measure

Waist circumference was measured for each subject. Participants were asked "please tell us your waist size at your navel" as is recommended by several authors (Brown et al, 2018; Ostchega et al, 2019). Waist circumference has been associated with a variety of health outcomes including diabetes (Hajian-Tilaki and Heidari, 2015), cancers (Gaudet et al, 2014; Campbell, et al, 2016), mental health problems (Elena et al, 2015) and mortality (Cerhan et al, 2014; Tanamas et al, 2016). Indeed, some studies suggest that waist circumference is a better predictor than Body Mass Index (BMI) for some health issues (Savva et al, 2000; Janssen et al, 2004; Hajian-Tilaki and Heidari, 2015). BMI (weight divided by the square of height) is widely used in clinical practice as a measure of obesity (Eknoyan, 2008; Daniels, 2009). However, BMI has come under criticism, as the cut-offs that stipulate 'normal', 'overweight', and 'obesity' are arbitrary, and there is debate about whether normal weight should be defined as a BMI of < 25 kg/m^2 (Ness-Abramof and Apovian, 2008) due to an increase in the prevalence of diabetes mellitus and mortality with increasing BMI in patients within normal range (Colditz et al 1995; Manson et al, 1995). Relying on a person's BMT alone to predict health status has been shown to me misleading (Abel

et al, 2008), and authors have called in the imperative to develop better metrics of metabolic health (Ahima, and Lazar, 2013). Accurate measurement of intra-abdominal (visceral) fat is expensive and requires advanced means such as computed tomography or magnetic resonance imaging (Shuster et al, 2012) which are not feasible in a Phase 4 CR environment. However, waist circumference (WC) is recommended as a viable alternative (Ness-Abramof and Apovian, 2008) as it correlates with subcutaneous and visceral fat mass (Després, 1998; Despres et al, 1990) and increased cardiovascular disease risk (De Koning et al, 2007). Self-reported waist measurements have good validity (Rimm et al, 1990) and reliability (Wang, 2003). In general, measuring anthropometric variables is time consuming and entails specific training that implies access to financial resources (Lima et al, 2018) that were not available for this project.

2) Health Status

Health Status (sometimes referred to as Health-related quality of life [HRQOL]) is a crucial conception within the field of healthcare, with varied definitions and realizations (Fayers and Machin, 2013). Health has traditionally been construed through the lens of the Medical Model, with health being the absence of disease (Larson, 1999). Engel (1977) famously said that the medical model was "*no longer adequate for the scientific tasks and social responsibilities of* (healthcare)" (Engel, 1977, p 129) and since then, there has been a move away from the medical model to a broader definition of health. In contrast, health status and similar concepts take a more comprehensive approach, reflecting the impact of disease and treatment on disability and daily functioning, as well as the consequences a condition has on all other aspects of an individual's life such as family relationships, ability to retain gainful employment, etcetera (Mayo, 2015; Haraldstad et al, 2019). This more integrated view of health is embraced in this study. There is debate around appropriate terminology to use, be it biopsychosocial health (Engel, 1977; Bolton & Gillett, 2019), HRQOL (Cuerdaet al, 2016) or health status (Bergner, 1985; Spertus et al, 2020) amongst others. In their meta-analysis, Haraldstad et al (2019) noted that HRQOL, and Quality of Life are often used interchangeably in the literature, and that HRQOL measures are often measuring self-perceived health status, and as such the term is unnecessary (Karimi and Brazier, 2016). In this study we adopt the term health status (rather than health-related quality of life) because of the conceptual overlap

between terms, and to be consistent with the terminology used by Ware et al (1996) in the SF-12 Scoring Manual.

Health Status was measured using the Short-Form Health Survey (SF-12 [Ware et al, 1996]). This tool provides a measure of both physical and mental health. The SF-12 Health Survey was developed as a shorter alternative to the SF-36 (Ware and Sherbourne, 1992) and can be completed in less than a third of the time (Ware et al, 2001), as well as explaining around 90% of the variance of the SF-36 (Ware et al, 1996; 2001). Haraldstad et al's (2019) meta-analysis of QOL measures in health sciences found that the SF-36 and SF-12 were amongst the most used, along with the EQ-5D (Balestroni and Bertolotti, 2012), the EORTC QLQ C-30 (Garratt et al, 2002), and the WHOQOL-BREF (Whoqol Group, 1995). These other measures were considered for use in this study. Authors have concluded that the EQ-5D can only detect large clinical changes in cardiac rehabilitation populations (Schweikert et al, 2006) and would therefore be a poor choice. The EORTC QLQ C-30's cancer focus would make it an inappropriate option in this instance. Finally, Gobbens and Remmen (2019) found that sociodemographic factors accounted for a greater amount of the variance of quality of life in the WHOQOL-BREF (17%) than the SD-12 (6.7%). For these reasons, these other options were not chosen. Other measures, such as the Recovery Capital Questionnaire (Burns & Marks, 2013) are disorder specific and as such are inappropriate for use in cohorts with cardiovascular-related clinical presentations.

The SF-12 was designed for use in clinical practice and research, health policy evaluations, and general population surveys. The SF-12 assesses eight sub-domains of health (Physical Functioning, Role-Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role-Emotional, and Mental Health) each comprising various questions (e.g., "Compared to one year ago, how would you say your health is now?"). The first four of these sub-domains constitute the measure of Physical Health, whilst the latter for constitute the Mental Health measure. In addition, two component summary scales are produced – the SF-12 physical and mental health scales. These are computed as both a raw score and a scaled score. The scaled physical (Physical Component Summary, PCS-12) and mental scores (Mental Component Summary, MCS-12) are produced using a norm-based method. Standardized scores and norm-

based scoring are useful as they allow meaningful comparison with other scales and with population norms. The PCS-12 and MCS-12 were primarily created to allow a direct comparison between the scores of the SF-12 and its parent questionnaire the SF-36 (Ware et al, 1996). Within our sample, the conversion of raw scores into scales scores resulted in a move from a normal distribution to a skewed presentation for the residuals in each of the linear models. Due to this it was decided to use the raw scores as the measures of health. Each item is scored using a Likert scale. Items 1, 8, 9, and 10 are reverse scored. It can be divided into two second-order measures (specifically, mental health and general health) that each incorporates four of the eight first-order subscales. Scores on the general health measure range between 6 and 20 and between 6 and 28 on the mental health measure, with higher values in both second-order measures indicates better health. There are no published cut off points to mark the lowest point at which certain health status is attained for either of these measures, although these may become necessary, as recent authors advocate the use of raw scores rather than scales scores in the SF-12, as scaling distorts measurement and interpretation (Hagell et al, 2017; McKenna and Heaney, 2020). As Phase 4 CR is an ongoing process, characterizing health status as an 'outcome' is perhaps inappropriate, due to the fluid nature of the process. Therefore, investigating health status as a current measure of functioning is appropriate. The SF-12 Health Survey (Ware et al, 1996) has demonstrated good reliability and validity (Ware et al, 1996). The Cronbach's α were good for the physical health measure at .816 and the mental health measure at .721. The Cronbach's α for the overall score was good also, at 0.817.

There is some debate over the use of general health measures such as the SF-12 rather than specific health behaviour. Several studies focus on single aspects of health when assessing outcomes, such as exercise adherence (Aamot et al 2016), smoking cessation (Pipe and Reid, 2018) or hospital admissions and mortality (Anderson et al, 2016) or even aspects of social functioning such as employment (Kiessling and Henriksoon, 2005). The advantage of the use of a broader measure is that health is multifaceted (WHO, 2016). Future studies may focus upon the impact of executive functioning upon specific health behaviours, but at the current stage in the research process, this would fail to give us an overview of the relationship between patient health and executive functioning or self-regulation.

3) Executive Functioning

Executive Functioning was measured as a potential predictor of health outcomes. Two separate aspects of executive functioning were measured using two separate measures, specifically:

3.1 The Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson et al, 1996)

3.2 The Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald & Parkes, 1982)

The utilization of these twin measures affords the measurement of both self-reported and observed executive functioning. Self-report measures have been said to have validity problems, with participants being likely to provide what they perceive as socially desirable or advantageous answers, rather than what is actually the case (Rosenman et al, 2011), or reporting inaccurately due to memory or attentional issues (Garcia & Gustavson, 1997). These and other issues can result in common-method variance. However, Chan (2009) describes this skepticism regarding the validity of self-report as being based on "urban legend" rather than empirical evidence, noting that not all constructs are equally susceptible to social desirability, and that the extent to which validity is a problem for individual measures has rarely been established. The combining of self-reported and observed measurements allows for the comprehensive investigation of various aspects of the phenomena. This mirrors the use above of SF-12 as self-reported health, and waist circumference as an observed measure of health.

To date, there are no factor analytic studies investigating the CFQ and BADS scales together. Studies that investigate performance on the CFQ and elements of the BADS using other methods have found that the two constructs are sufficiently dissimilar from each other to warrant inclusion into analysis as separate entities. Chan & Manly (2002) found that self-report CFQ scores did not significantly predict performance on a BADS sub-test. Similarly, Gehring et al (2009) found that while CFQ scores differed significantly over time, BADS measurements failed to change. Although the two therefore may share some covariance, these studies suggest that investigation of both measures is warranted.

As mentioned above, executive functioning is an umbrella term that encompasses an array of cognitive processes (Malenka et al, 2009). There is therefore a need to highlight which aspects of executive functioning will be represented by the measures chosen and to give a clear rationale as to why these have been chosen.

3.1 The Behavioural Assessment of the Dysexecutive Syndrome (BADS; Wilson et al, 1996)

The BADS is a cognitive assessment battery consisting of six trials and two questionnaires. Two of the six trials from the BADS will be utilized. These measure individuals' capability to plan, initiate, monitor, and adjust behaviour in response to the explicit and implicit demands of each task. The two tasks are:

Zoo Map (ZM): The Zoo Map test requires subjects to demonstrate how they would visit a series of designated locations on two separate maps of a zoo, whilst obeying a set of rules. This test provides an evaluation of spontaneous planning ability when structure is minimal, and the ability to follow a concrete externally imposed strategy when structure is high.

There are two subcomponents to this trial that achieve this. The first element consists of a "high demand" map, where the participant must plan in advance the order in which they will choose to execute the plan. Mistakes are made if the participant visits the locations in the order they are presented in the list of instructions. This provides an evaluation of spontaneous planning ability. The second version of the map is "low demand", in that the participant is given a prescribed plan, and is asked to follow the steps needed to complete the task. Following these instructions will result in an error-free performance. This task assesses the ability to execute an actual externally imposed strategy (Allain et al, 2005). Taken together, the two Zoo Map subtests assess planning (Wilson et al, 1996). Comparing performance on both tasks affords quantitative evaluation of spontaneous planning ability contrasted to the ability to follow instructions (Wilson et al, 1996). See Appendix 3 for a copy of both maps and instructions. Participants are given a raw total score between 0 and 16 for their performance on these two tasks together (there are 8 potential points to be gained from each task). They are awarded a point for each location on the map that they visit

in the correct order, and loose a point for each time they break one of the prescribed rules. No standardised scores for the individual BADS tasks are available.

The ability the Zoo Map affords to evaluate planning makes it an appropriate option. The influential taxonomy of Miyake, et al. (2000) denotes the three basic executive functions (see Table 1 above) as working memory, inhibition, and mental flexibility, or mental set shift. These three act mutually to direct higher order constructs of cognition such as planning (Rabinovici et al, 2015). The Zoo Map tasks scrutinize mental flexibility, inhibition, planning, and working memory (Miyake, et al, 2000; Wilson et al, 1996; Zelazo, 2015). Planning is a construct closely associated with working memory (Koechlin et al, 1999; Eriksson et al, 2015), and involves the ability to remain free from distraction and retain information in an active and readily retrievable state (Baddeley, 2007; Kane et al, 2001; Jonides and Smith, 1997). Inhibition is also required in planning, as it refers to the capacity to:

"*Deliberately inhibit dominant, automatic, or prepotent responses when necessary*" Miyake, et al. (2000), p. 57

This is particularly pertinent to the first task, where one must inhibit the urge to follow the list of designated locations in the order they are given in the instructions. Mental flexibility is also required in planning (Zelazo, 2015), especially working between the two subcomponents of the Zoo Map. Mental flexibility refers to the ability to shift back and forth between various tasks (Monsell, 2003). This ability also inherently relies on working memory (to keep hold of the current goal) and response inhibition (ignoring previously pertinent information to concentrate upon the current task), demonstrating the inherent interdependence of the elements of executive functioning (Rabinovici et al, 2015).

Key Search (KS): In this trial, subjects are presented with an A4-sized piece of paper with a 100mm square in the middle and a small black dot 50mm below it. The subjects are told to imagine that the square is a large field in which they have lost their keys. They are asked to draw a line, starting on the black dot, to show where they would walk to search the field to make absolutely certain that they would find their keys. This task examines the ability to plan an effective and efficient plan of

action and to self-monitor performance. Please see Appendix 3 for a verbatim account of the instructions.

Wilson et al, (1996) provide four reasons for the development of this task that each corresponds to the rationale for its use here. Firstly, the task is analogous to a real-life activity. Secondly, it affords the opportunity to observe the ability to plan an effective and efficient course of action. Third, the task provides insight into the participant's ability to monitor their performance through the usage of the actual lines drawn on the paper. Lastly, there are aspects of the problem that are not explicitly stated that must be taken into consideration, such as how to keep track of where one has already been in a large area. The three basic executive functions denoted in the Miyake, et al. (2000) taxonomy all underpin the performance on this task also, as the planning and self-monitoring required are reliant upon working memory, inhibition, and mental flexibility (Zelazo, 2015).

Participants achieve a total score between 0 and 16 for the Key Search task. They are awarded points for executing each of the appropriate stages needed to successfully complete the task (see table 2 for an overview of the methodology for awarding points). Scoring of the Key Search requires the participants to have shown evidence of employing a systematic methodology for searching (utilising such a strategy is awarded 5 points towards the total). A random search pattern would by no means result in the keys being located, and therefore the only way to be certain is to use the field's boundaries as reference points and to search in parallel to these boundaries in a systematic fashion. To this end, the marking scheme (see Appendix 4) reflects the relevant underpinning strategy formation that would most likely result in successful completion of the task.

TABLE 2 BADS Key Search Marking Scheme

Assessed Phenomena (& max. potential points)	Marking Criteria
Entering the field (total = 3)	• Within 10mm of a corner (base of square) = 3 • Base of square (other than within 10mm of corners) = 2 • Somewhere else = 1
Finishing the search (total = 3)	• Within 10mm of any corner = 3 • Base of square (other than within 10mm of corners) = 2 • Somewhere else = 1
Making a continuous line (total = 1)	• Making a continuous line = 1
Making all parallel lines (total = 1)	• Making all parallel lines = 1
Making all vertical/horizontal lines (total = 1)	• Making all vertical/horizontal lines = 1
Search patterns (total = 5)*	• Followed one of the pre-defined search patterns or super-imposed one pre-determined pattern over another = 5 or 3 • Duplicated or combined one or more pre-defined search patterns = 2 • Followed some other obviously systematic, but inefficient and/or unsuccessful search pattern = 1 • Ad hoc – not systematic or pre-planned = 0
Has made an obvious effort to cover all the ground (total = 1)	• Has made an obvious effort to cover all the ground = 1
Using their chosen pattern, they would find the keys (95% certainty) (total = 1)	• Using their chosen pattern, they would find the keys (95% certainty) = 1

*See appendix 4 for more on specific search patterns

The BADS contains 4 other tests for consideration that make up the total score:

1) Rule Shift Cards Test

This test is a measure of ability to change from one rule to another (i.e., shifting mental set)

2) Action Program Test

This requires the participant to create a plan of action to solve a problem.

3) Temporal Judgement Test

This evaluates the ability to estimate the time to complete a task.

4) Modified Six Elements Test

This exercise tests the individual's ability to plan, organise, and monitor behaviour.

Each of these tests correlates highly with all other aspects of the BADS assessment battery (Wilson et al, 1996). The high degree of crossover of constructs, combined with an awareness of the burden being placed on participants (Hulley et al, 2001; Laws et al, 2013) resulted in the decision being made to omit these tests from the current investigation. Each BADS test produces a total score based upon the participants' performance on the individual task. Each test score is converted into a profile score and a profile score for the whole test battery is found by totalling across all 6 subtests (see Appendix 4 for the complete BADS scoring process). These profile scores can then be converted into standardised scores to mirror outcome the WAIS-R measure of IQ (Weschsler, 1981) Total raw scores (rather than profile scores) for each test will be utilized as the measure of executive functioning, as these provide more sensitivity to subtle differences between individuals' ability. The BADS measures have good demonstrated validity (Norris & Tate, 2000). It has been argued that test-retest reliability is an unsuitable measure for tests of executive functioning that aim to assess capability to resolve novel problems (Chamberlain, 2003). The BADS does have good inter-rater reliability (Wilson et al, 1996). Cronbach's α values for the Zoo Map raw scores was low at 0.482, although this would be expected given that Cronbach's α is used to determine internal consistency reliability, and the nature of the two components of the test are designed so that the first component consists of a high demand task (where planning skills are rigorously investigated) and a low demand task (where participants must follow a set of instructions). In the first, following the instructions as written will result in a high amount of error, whilst in the second, following the instructions as written will result in a low amount of error (see Appendix 3 for the instructions provided to participants). Cronbach's α for the Key Search was good at .833.

Other measures of executive functioning were considered. The BADS is one of a group of traditional executive functioning tests perceived as paramount within the literature (Aken et al, 2014) along with the Wisconsin Card Sorting Test (WCST; Berg, 1948) and the Stroop Colour Word Test (Stroop; Hammes, 1971). The WCST is a seminal psychological test of frontal lobe dysfunction. Designed to measure "shifting-set" (more commonly referred to as cognitive flexibility), the test is an effective tool in that regard, but does not involve some aspects of executive

functioning included in the BADS, such as tests being analogous to real-life activity. As recently as 2021, the Stroop was being criticised for their still being a lack of consensus concerning its underpinning cognitive constructs (Parris et al, 2021). Other measures such as the Multidimensional Card Selection Task (MCST; Podjarny et al, 2017) have been criticised as measuring working memory rather than executive functioning (Morra et al, 2018). The BADS is therefore an appropriate choice for measuring executive functioning for this study.

3.2 The Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, FitzGerald & Parkes, 1982)

The Cognitive Failures Questionnaire (CFQ) is a self-report assessment tool that measures everyday cognitive failure - specifically, the frequency with which people experience cognitive failures (such as absent-mindedness) in everyday life. The CFQ was developed to be a blanket measure of common errors, and was built upon three constructs: memory slips, attention slips, and psychomotor slips (i.e., action slips). Self-report provides an insight into participant's perception of their own cognitive functioning and potential failure thereof (Kiessling and Henriksson, 2005). Each item is scored using a 5-point Likert scale (very often=4, quite often=3, occasionally-2, very rarely=1, never=0), and a higher score indicates greater cognitive failure. No outright cut-offs for CFQ scores have been published and no population norms are available (Bridger et al, 2012). Utilizing a self-report measure such as the CFQ is an interesting counterbalance to the observed data collected using the BADS, as it allows us to gain an insight into the failures that the participant themselves perceive.

When examining the validity of self-report tools generally, researchers have found two salient issues labelled cognitive and situational issues (Brener et al, 2003). Cognitive issues involve whether the participants have sufficient knowledge, comprehension, memory, or other cognitive capacities to answer successfully. On any test looking at cognitive deficit such as the CFQ, this immediately becomes an important consideration. However, the populations of interest to researchers likely to use this tool are those in which an element of cognitive impairment is either expected or known to exist. Therefore, the design of the questionnaire has been constructed in

such a way as to take this into account, and indeed, the CFQ has demonstrated reliability and validity (Bridger et al, 2013; Ekici et al, 2016). The scale had good reliability, with Cronbach's α value of .929.

Situational issues (including the influence the physical setting in which the tool is utilized) might have an impact upon answers. For example, if asked questions in a clinical setting, participants may be less inclined to admit to difficulties for fear of reprisals. This was taken into consideration, and participants were informed clearly early on that their data would be confidential, anonymized, and not shared with the Health Professional overseeing the CR class.

The CFQ was developed as a unidimensional measure of attentiveness (Broadbent et al, 1982; Bridger et al, 2013) and designed to be non-specific regarding the underlying cognitive processes that brought on slips, as Broadbent et al assumed there would be multiple layers underlining slips (Cheyne et al, 2006). Therefore, the CFQ does not only measure attention-related errors (Smallwood et al., 2004), although this has been the way in which it has been utilized at times (Robertson et al, 1997; Tipper & Baylis, 1987). This is useful for us, as it affords the opportunity for theorizing as patterns in the data emerge. In line with this, later authors (Rast et al, 2009) noted that the CFQ articles load on to three factors which are described below (each definition is taken form Rast et al, 2009):

- Forgetfulness: "*a tendency to let go from one's mind something known or planned, for example, names, intentions, appointments, and words*"
- Distractibility: "*mainly in social situations or interactions with other people such as being absentminded or easily disturbed in one's focused attention*"
- False Triggering: "*interrupted processing of sequences of cognitive and motor actions*"

This describes cognitive failure as having a three-part structure. Forgetfulness relates to memory and its impact upon functioning, whilst distractibility and false triggering are concerned with attentional focus and its consistency. These three will be used as the cognitive failure measures within the current study.

Alternative measures of cognitive failures were considered. In their systematic review of the cognitive failures literature, Carrigan and Barkus (2016) found that the CFQ, and three other measures are frequently used to assess cognitive failure. The Cognitive Slippage Scale's (CSS; Miers & Raulin, 1987) objective is to measure speech deficits and confused thinking. However, this scale has only been shown to be reliable and valid in clinical populations suffering schizophrenia and schizotypal personality disorders (Osman et al, 1992), and as such is often used in samples of individuals with clinical and subclinical presentation of formal thought disorder (Feigenson et al, 2014; Gooding et al, 2001) and so would not be appropriate for the current study. Carrigan and Barkus' review also identified the Prospective and Retrospective Memory Questionnaire (PRMQ; Smith et al, 2000) as being utilized within the relevant literature. Despite its use in many studies on cognitive failure, the PRMQ was designed to assess the frequency and nature of memory failures, specifically to differentiate between the effects of normal aging and Alzheimer's disease (Sala, 2020). In contrast, the CFQ encompasses attention and psychomotor slips as well as memory deficits. The final questionnaire to consider is the Dysexecutive Syndrome Questionnaire (DEX; Burgess et al, 1996). The DEX is a two-part questionnaire, the first being a self-rated measure, the second a carers' rating of the patient. The practicalities of including a carer (if one exists) as study participants make the use of this unfeasible in this study. Given these considerations, the CFQ would appear the most logical measure to utilised.

4) Self-Regulation

The Self-Regulation Questionnaire (SRQ; Brown et al, 1999)

The Self-Regulation Questionnaire (SRQ) is a measure of self-regulation, defined as the ability to develop, implement, and flexibly maintain planned behaviour to achieve one's goals (Kanfer, 1970a, 1970b). Brown formulated a seven-step model of self-regulation (Brown, 1998; Miller & Brown, 1991). In this model, behavioural self-regulation may falter because of failure or deficits at any of these seven steps:

1. Receiving relevant information
2. Evaluating the information and comparing it to norms
3. Triggering change
4. Searching for options
5. Formulating a plan
6. Implementing the plan
7. Assessing the plan's effectiveness

The SRQ assesses each aspect through a series of self-reported questions. Items are scored using a 5-point Likert scale (strongly disagree=1, disagree=2, uncertain or unsure=3, agree=4, strongly agree=5). Although this sevenfold model was developed to gain understanding of addiction, the processes it describes have been generalised to other areas of behavioural self-control (Carey et al 2004; Kliemann et al, 2016). The scale has good demonstrated reliability (Aubrey et al, 1994) and validity (Aubrey et al, 1994; Brown, 1994). Cronbach's α for the SRQ Impulse Control and Goal Setting subscales were .80 and .606 respectively, and Cronbach's α for the total scale was .830.

Carey et al (2004) found that a single-factor solution emerged when completing a factor analysis on the SRQ, and indeed the original authors recommend using the total score as a measure of self-regulation. A subsequent study by the same authors (Neal & Carey, 2005) yielded a two-factor solution (termed Impulse Control and Goal Setting). This study will utilize the two factors identified in the latter paper. Impulse control refers to the ability to utilize executive control over emotional and motivational impulses. Impulses that have most relevance to health are those underpinning health behaviours, such as food and alcohol consumption. Example items assessing impulse control include, "*It's hard for me to notice when I've "had enough" (alcohol, food, sweets)*" and "*I'm usually careful not to overdo it when working, eating, drinking*". Goal setting involves the creation of action plans to motivate and guide one towards a desired goal, as well as monitoring progress towards that goal and adjusting behaviours appropriately. The relevant SRQ items include, "*Once I have a goal, I can usually plan how to reach it*" and "*I can stick to a*

plan that's working well". Scores range from 11 to 55 on impulse control and 10 to 50 on goal setting, with higher scores on both indicating better control.

The SRQ is the most utilized measure within the literature, and very few others profess to quantify self-regulation. Many studies (Zimmerman and Kitsantas, 2014; Schnaidman, 2018) utilize the concepts of self-regulation within a learning framework and measure self-regulated learning as a construct, using measures such as the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al, 1993) and the Rating Student Self-Regulated Learning Scale (RSSRL; Zimmerman and Martinez-Pons, 1988). Given their sole focus on learning, these measures would not be appropriate for this study. The Hannover Self-Regulation Inventory (HSRI; Jäger et al, 2012) is a more recent measure of self-regulation developed in Germany. Whilst this measure has good reliability and validity, the conceptual framework underpinning it is removed slightly from that traditionally underpinning self-regulation. As well as self-regulation, the HSRI measures "ego function" (Jäger et al, 2012) and the authors recommend that the scale is used to diagnose "weak vs. stable ego functions" and to develop treatment plans. Because of this divergence from traditional conceptualisations of self-regulation, it was decided that this scale would not be appropriate for this study.

Power Analysis

G*power was used to estimate the sample size required to yield adequate statistical power (Cohen 1992). As the main outcome variable is a continuous variable (SF-12 score) G*power for multiple regression analysis was conducted to determine the sample size required (Faul et al, 2009). Prior to commencing the study, the most predictor variables estimated to predict health status were 9 (listed in Table 3). As no previous studies could be found which offered guidance as to the effect size for the variables included, a medium effect size was estimated (0.15), with a power of 0.8. and setting alpha at .05 were chosen. This yields a total sample of 114.

TABLE 3 List of Potential Predictor and Criterion Variables

Predictor	Criterion
Age	SF-12 Physical Health Status
Waist	SF-12 Mental Health Status
Gender	
BADS Zoo Map Score	
BADS Key Search Score	
CFQ Forgetfulness	
CFQ Distractibility	
CFQ False Triggering	
SRQ Impulse Control	
SRQ Goal Setting	

Confidentiality and Ethics

The University of the West of England's Faculty Research Ethics Committee (FREC) granted ethical approval on 6th March 2017 (see Appendix 5). To ensure confidentiality and anonymity as per ethical and legal guidelines (EU General Data Protection Regulation, 2016), the Caldicott principles were followed (Caldicott Committee, 1997). All details of the participants were kept confidential both during and after the study. All completed questionnaires were anonymized to maintain confidentiality of all participants.

Analysis

The study aimed to investigate the extent to which the dependent variable of health status was predicted by the independent variables of executive functioning, cognitive failure, and self-regulation. Means and standard deviations for all variables were computed for the total sample, as well as for males and females. Multiple linear regression was utilized to assess whether any of the variables that significantly correlated with health status were predictive of the variance in this outcome variable. Consideration was given to alternative forms of hypothesis and analysis, including mediation and moderation. Given the lack of available research that affords an understanding of the relationships between executive functioning, self-regulation, and health status, it was decided that the requirements for the use of mediators and/or moderators in causal modelling were not met. Specifically, there is not enough evidence currently to specify the nature of the relationship (causal or otherwise) between executive functioning and self-regulation. The computer software Stata

Version 16 was used to provide statistical analysis of the data as well as to produce relevant charts for presentation.

Missing Data

The mishandling of missing data can undermine the validity of empirical research, leading to bias or the exclusion of a large proportion of the original sample (Sterne et al, 2009). It is therefore important that appropriate statistical methods that can contend with problems arising from missing data are utilized to avoid such pitfalls. Multiple imputation is an adaptable and general-purpose approach to dealing with missing data (Royston, 2004; 2005). The logical converse to multiple imputation is complete-case study methods which discards any cases with missing data, unrealistically assuming that data are missing at random (Collins & Slayer, 2001). This option was not chosen, as it requires stronger assumptions be made than those of imputation (Stuart et al, 2009). Initially, explorative analysis was carried out to ascertain the extent to which data was missing. The extent to which data was missing is outlined in Table 4.

A total of 36 cases were marked as incomplete. The pattern of missing data was analyzed using Little's Missing Completely at Random (MCAR) test (Little, 1988). The test provided a p-value of 1.000, suggesting that the missing data is missing at random (MCAR). The pattern of missingness was analyzed using the missing value patterns chart produced by SPSS.

Imputation replaces missing values with reasonable estimates based upon the distribution of and relationships between variables in the data set (Schafer & Graham, 2002). Multiple imputation was used as the procedure for replacing missing data with substituted values. As the pattern of missingness was arbitrary, a Markov Chain Monte Carlo (MCMC) method (Schafer, 1997) was used to approximate expected values. Multiple (rather than single) imputation was used as it is less biased, due to the use of multiple set of filled in value for each missing value, rather than only one. Ten imputations were run for the results presented, as recommended by Raghunathan et al (2002) and Stuart et al (2009). Table 4 provides details of the imputation process.

TABLE 4 Number of Total Observations & Missing Values Imputed for Each Registered Variable

Variable	Observations			
	Complete	**Incomplete**	**Imputed**	**Total**
Waist	99	16	16	115
SF12-Physical Health	114	1	1	115
SF-12 Mental Health	112	3	3	115
SF-12 Health Status	112	3	3	115
BADS Zoo Map Raw Score	109	6	6	115
BADS Key Search Raw Score	110	5	5	115
CFQ Forgetfulness	113	2	2	115
CFQ Distractibility	111	4	4	115
CFQ False Triggering	110	5	5	115
SRQ Impulse Control	102	13	13	115
SRQ Goal Setting	101	14	14	115

Assumptions

Multiple linear regression analysis was utilized to ascertain whether the predictor variables of age, waist circumference, BADS Zoo Map total score, BADS Key Search total score, CFQ Forgetfulness, CFQ Distractibility, CFQ Triggering, SRQ Impulse Control, and SRQ Goal Setting predicted the outcome of health status. Initially, the data was scrutinized to ascertain whether the assumptions (normality, linearity, homoscedasticity and non-multicollinearity) for multiple regression were met (Field, 2013). Assumptions were tested for both the overall score (Health Status) of the SF-12 measure and the two measures of the SF-12 (i.e., Physical and Mental Health Status). Assessment of assumptions was carried out on the observed data set prior to imputation (Colubi et al, 1999) to avoid oversensitivity to deviation from normality (Ghasemi and Zahediasl, 2012).

Normality

Normality assesses the degree to which a dataset is well modelled by the normal distribution (Field, 2013). Frequency distributions (see Appendix 6) and Shapiro-Wilk tests were used to test for violation of normality for predictor and criterion variables. Issues of non-normality are apparent when considering some of the frequency distributions, particularly the BADS tests and the criterion variables. Shapiro-Wilks

tests p-values for a variety of variables were lower than 0.05, suggesting these significantly deviate from the expectations of a normal distribution (see Table 5).

TABLE 5 Shapiro-Wilks Test Outcomes

Variable	W	p
Age	0.966	0.006*
Waist	0.985	0.333
BADS Zoo Map	0.927	0.000*
BADS Key Search	0.983	0.197
CFQ Forgetfulness	0.989	0.547
CFQ Distractibility	0.982	0.138
CFQ False Triggering	0.957	0.001*
CFQ Total Score	0.973	0.026*
SRQ Impulse Control	0.942	0.002*
SRQ Goal Setting	0.993	0.879
SF-12 Physical Health	0.898	0.559
SF-12 Mental Health	0.997	0.380
SF-12 Health Status	0.995	0.968

* Date significantly deviates from the normal distribution

There are a variety of authors who suggest that the notion that linear regressions models must meet the "normality assumption" is a misconception (Li et al, 2012) and indeed, statistical manuals indicate that the necessity is for the residuals (or prediction error i.e., the deviation of the model prediction results from observed results) to be normally distributed, rather than independent and dependent variables (Dancey and Reidy, 2007; Field, 2009). Kernel density estimates of the residuals for the Physical Health regression model, the Mental Health regression model, and the Health Status regression model can be seen in Figures 6, 7, and 8 respectively.

FIGURE 6 Kernel Density Estimates - Residuals for the Physical Health Regression Model

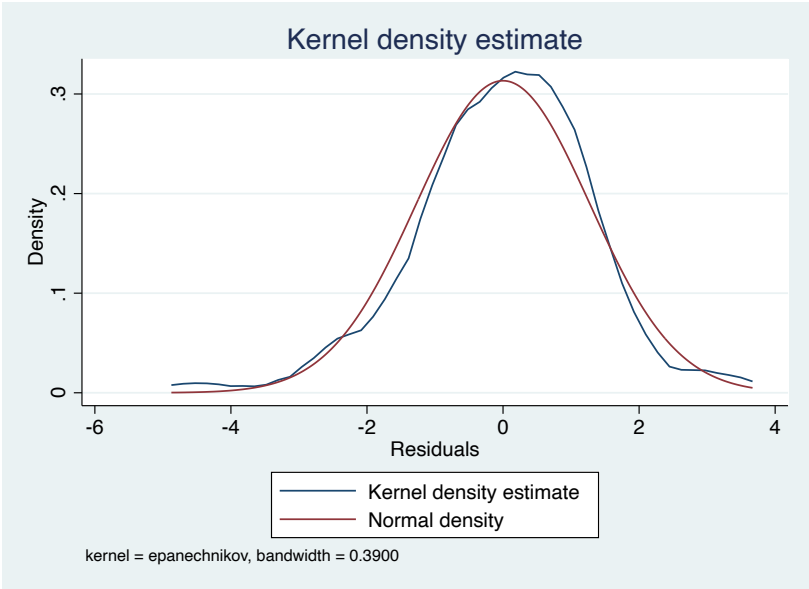


FIGURE 7 Kernel Density Estimates - Residuals for the Mental Health Regression Model

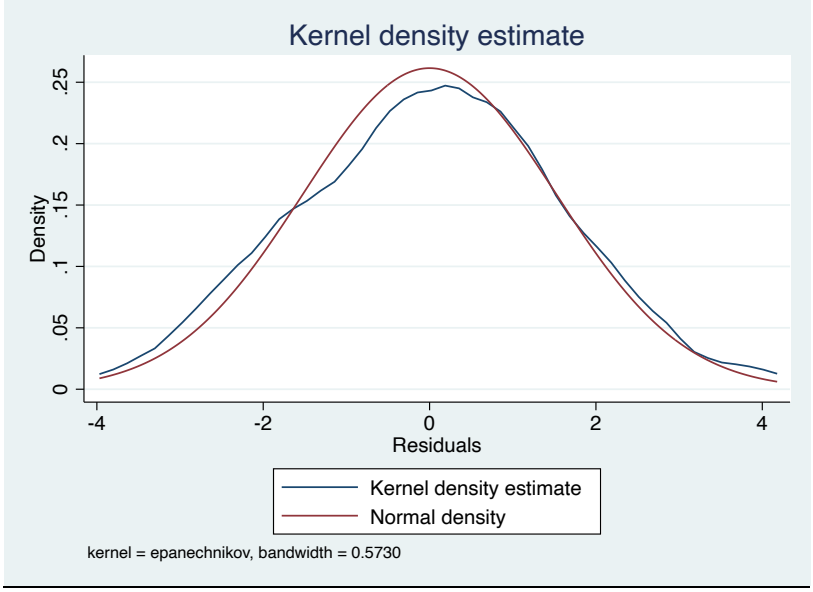
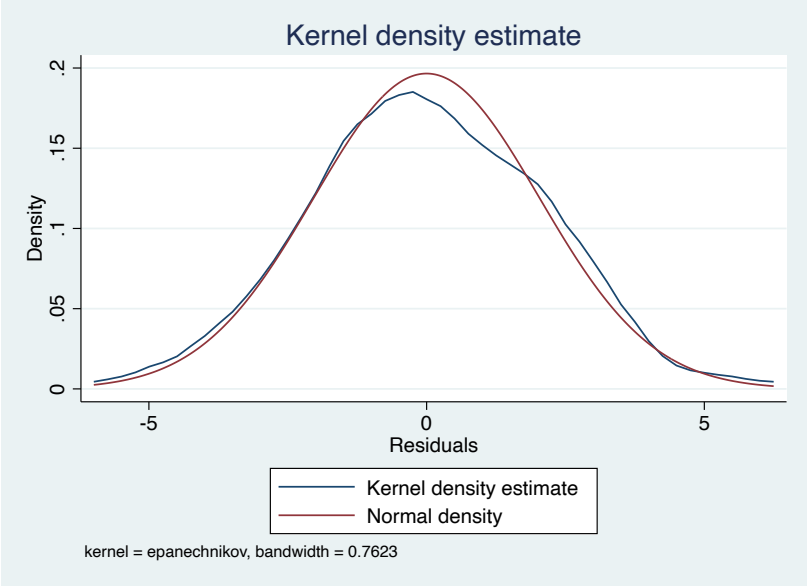


FIGURE 8 Kernel Density Estimates - Residuals for the Health Status Regression Model



Further analysis using the Shapiro Wilks test indicates that the residuals for all models are normally distributed (see Table 6).

TABLE 6 Shapiro-Wilks Test Outcomes (residuals)

Variable	W	p
Residuals Physical Health	0.979	0.158
Residuals Mental Health	0.990	0.813
Residuals Health Status	0.996	0.998

Linearity and Homoscedasticity

Regression requires the relationship between outcome and predictor variables to be linear and homoscedastic. Linearity was assessed using Scatterplots (Hair 2006; Pallant, 2001; see Appendix 7). All scatterplots demonstrated linear rather than curvilinear relationships. Homoscedasticity is present where the variance of the residual in a regression model is constant (Field, 2013). The Breusch–Pagan test (Breusch and Pagan, 1979) was used to assess the presence of homoscedasticity in both linear regression models. The null hypothesis of the test is homoscedasticity, and the alternative hypothesis indicates heteroscedasticity. Breusch–Pagan results for the regression models of Physical Health Status ($\chi^2(9) = 15.53$, $p=0.077$) and Mental Health Status ($\chi^2(9) = 13.14$, $p=0.1564$) both indicate homoscedasticity.

Multicollinearity

Multicollinearity is defined as a high correlation between measured variables and violates the supposition of independence of regressor variables in linear regression models (Farooq, 2017; Mishra, 2016). Multicollinearity is implied when linearly correlations between regressor variables indicate high incidences of correlation (Field, 2009; O'Brien, 2007). Although a high degree of multicollinearity amongst regressor variables has little impact upon the accuracy of regression coefficients, strong multicollinearity amongst these variables can lead to a failure to reject a false null hypothesis (type II error). Pearson's correlation coefficients between each of the predictor variables and the variance inflation factor (VIF) were calculated to investigate multicollinearity. A common "rule of thumb" (Curto and Pinto, 2011) for evaluating VIF states that a VIF value of more than 10 indicates multicollinearity (Michael & Abiodun, 2014; Clark, 2013), although some authors maintain that this is too lenient for application in behavioural sciences and advocate for values of 6 or 7 as the VIF threshold (Cohen et al, 2013). As illustrated in Table 7, for the Physical Health model, our results indicate that all of the independent variables had VIF values of less than 10. The same is found for the Mental Health Model in Table 8. Consequently, although some correlations are statistically significant (see Table 10), the data does do not incur multicollinearity.

TABLE 7 Variance Inflation Factors (Physical Health Model)

Variable	VIF
Age	1.11
Waist	1.11
BADS Zoo Map	1.13
BADS Key Search	1.28
SRQ Goal Setting	1.89
SRQ Impulse Control	2.37
CFQ False Triggering	3.88
CFQ Distractibility	4.31
CFQ Forgetfulness	4.84

TABLE 8 Variance Inflation Factors (Mental Health Model)

Variable	VIF
Age	1.12
Waist	1.12
BADS Zoo Map	1.13
BADS Key Search	1.27
SRQ Goal Setting	1.87
SRQ Impulse Control	2.41
CFQ False Triggering	3.87
CFQ Distractibility	4.21
CFQ Forgetfulness	4.81

Model Assumptions Summary

In summary, the assumptions for linear regression are Normality, Linearity and Homoscedasticity, and Multicollinearity. There are no issues of multicollinearity, all data are linear and homoscedastic, and residuals are normally distributed. These indicate that it is appropriate to progress to regression modelling.

Results

Descriptive Analysis

An outline of the demographic information of the sample is detailed below in Table 9 (details of this information for the subscales and conversion scores not utilized in the inferential analysis can be found in Appendix 8). A total of 115 participants took part in the study. The mean age of the sample was 73.43 years (SD=7.81), with a range of 44 (46-90 years). There were more males (64.35%) than females (35.65%).

Comparing each of the predictor measures with normative data from the general population is useful to aid in understanding the present data. Females had an average waste circumference of 84.80cm (SD=10.09, Range=56.49-108.51cm), and males an average of 95.74cm (SD=10.34, Range=76.2–129.82cm). These were both slightly lower than the national average. The Scottish Health Survey does not publish national statistics for waist circumference. However, the Health Survey for England 2018 reported that the mean waist circumferences for males and females were 97.1 cm and 88.8 cm respectively (Conolly and Craig, 2019). The means for both males and females in our sample were considered high (in relation to healthy waist circumferences), as defined by the same survey. These differences between males' and females' mean age and waist were significant ($t(473)=3.23$, $p<0.001$ and $t(457)=11.19$, $p<0.001$ respectively). The BACPR (2020) National Audit of Cardiac Rehabilitation states that the mean age for those participating in CR programmes was 67 (66 for males and 70 for females). At 73.43, the mean age of our sample was considerably higher, as indeed it was for males and females (74.37 and 72.04 respectively). CFQ total scores are slightly higher than normative date provided in the literature. In a study of healthy older adults, Knight et al, (2004) reported normative data for 65 to 74-year-old of 31.2 (SD=11.17) for the total sample, 32.06 (SD=10.97) for males and 32.12 (SD=10.43) for females. Boyce et al (2017) used the CFQ to assess cognitive impairment in patient 18 years or more post MI. Using 32 as the cut-off score for impairment, they found only 3 out of 65 patients with a score lower than 32, suggesting our scores are comparable. The published ranges for interpreting SRQ total scores place those scoring below 213 (in the bottom quartile) with low (impaired) self-regulation capacity, scores between 214 and 238 (middle quartiles) as

intermediate (moderate) self-regulation capacity, and those scoring 239 and above (i.e., the top quartile) as possessing high (intact) self-regulation capacity (Brown et al, 1999). The mean SRQ scores in the present study fall into the lower part of (moderate) self-regulatory capacity, with a mean of 218.73 for the total population, 221.56 for males, and 215.12 for females. Normative data for BADS profile scores are provided by the authors of the test (Wilson et al, 1997). Corrected for age, BADS scores were borderline impaired compared to normative standardized scores.

TABLE 9 Means, Standard Deviations, and T-Tests for Variables for Total Sample and Gender

Variable	Total M (SD)	Male M (SD)	Female M (SD)	t (df)	p-value	Bonferroni Adjusted p-value
Age	73.43 (8.81)	**74.37 (8.33) ****	**72.04 (6.76) ****	**3.23 (473)**	**0.0013**	**0.0156**
Waist	91.40 (11.55)	**95.74 (10.34) ****	**84.80 (10.1) ****	**11.19 (457)**	**<0.001**	**<0.001**
Zoo Map Total Raw Score	11.31 (4.87)	**11.73 (4.68) ***	**10.71 (5.08) ***	**2.22 (467)**	**0.027**	**0.324**
Key Search Total Raw Score	8.21 (5.22)	**7.78 (5.73) ***	**8.86 (4.28) ***	**-2.21 (468)**	**0.028**	**0.336**
CFQ Forgetfulness	14.75 (5.15)	14.48 (5.33)	15.15 (4.85)	-1.41 (471)	0.161	0.999
CFQ Distractibility	11.38 (5.11)	11.29 (4.98)	11.52 (5.30)	-0.48 (469)	0.629	0.999
CFQ False Triggering	9.23 (4.36)	8.93 (4.25)	9.67 (9.02)	-1.81 (468)	0.071	0.852
SRQ Impulse Control	40.21 (6.15)	40.01 (6.01)	40.5 (6.36)	-0.846 (460)	0.398	0.999
SRQ Goal Setting	37.14 (3.87)	**37.53 (3.94) ****	**26.56 (3.69) ****	**2.656 (459)**	**0.008**	**0.096**
SF-12 Physical Health Status	12.51 (1.51)	12.6 (1.42)	12.38 (1.63)	1.527 (472)	0.128	0.999
SF-12 Mental Health Status	19.77 (1.65)	19.72 (1.74)	19.84 (1.51)	-0.75 (470)	0.454	0.999
SF-12 Health Status	32.25 (2.2)	32.28 (2.14)	32.22 (2.29)	0.269 (470)	0.788	0.999

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

Turning our attention more specifically to the data displayed in Table 9 (looking at the non-adjusted p-values for the time being), with regards BADS subscales, males and females differed significantly on a variety of the subsections of the Zoo Map tests,

though the standout results were the significant differences between males and females on Zoo Map (t(467)=2.22, p=0.027) and Key Search (t(468)=-2.21, p=0.028) tests raw scores. Interestingly, males scored higher on Zoo Map (males M=11.73, SD=4.68; females M=10.71, SD=5.08) and females scored higher on Key Search (males M=7.78., SD=5.73; females M=8.86, SD=4.28). No differences were observed between males and females with regards Cognitive Failures. There were differences between males and females on several of the seven steps of self-regulation described in the SRQ, specifically: receiving (t(340)=-2.29, p=0.023), triggering (t(316)2.21, p=0.028), planning (t330)=2.44, p=0.015), implementing (t(319)=3.02, p=0.003), and assessing (t(318)=3.93, p<0.001) although neither gender was consistently superior across these domains to the other (see Table 9 above for means and standard deviations). Significant differences were also observed on the SRQ subscale of Goal Setting (male mean=37.53, SD=3.94; female mean=26.56, SD=3.69; t(459)=2.66, p=0.008) and SRQ Total (male mean=221.56, SD=14.11; female mean=215.12, SD=19.1; t(303)=3.386, p=<0.001).

When attention is turned to the outcome variables (i.e., health outcomes), no significant differences between males and females were observed on total SF-12 score, nor either of the main measures (Physical health status and Mental health status). Significant differences were evident between males and females on five of the eight first-order subscales. Males scored higher on Role-Physical (t(462)=3.87, p<0.001), Social Functioning (t(451)=2.9), p=0.004)), and Role Emotional (t(462)=2.46, p=0.014), whilst females scored higher on Vitality (t(440)=-4.68, p<0.001). Means for these tests can be seen in Table 10.

A Bonferroni correction was applied to produce adjusted p-values for each test to minimise the risk of a type I error (specifically familywise error) due to multiple comparisons (Lee and Lee, 2018). The Bonferroni adjusted p-values can be seen in Table 10. When adjusted p-values are produced, all differences between males and females are non-significant save those for age and waist. Balancing the risk of a type I error with that of a type II error is a continual issue for statistical analysists. Bonferroni correction is a conservative test which - whilst protective against Type I Error - is vulnerable to Type II errors (Nakagawa, 2004), especially if there are many tests and tests statistics are positively correlated (Moran, 2003), Further critique of the

Bonferroni method states that as the method is concerned with the general null hypothesis (that all null hypotheses are true simultaneously), it does not test the hypothesis of interest and as such researchers should be wary of relying uncritically on Bonferroni adjustments for data interpretation (Perneger, 1998). Considering the quantity of tests, positive correlations (see below), and these theoretical considerations, it was decided to utilize the non-adjusted p-values in the interpretation of the data analysis across the analysis.

Standardized SF-12 scores (PCS-12 and MCS-12) were calculated for the purpose of comparison with normative data available in the literature. Both the Physical and Mental health measures are transformed to have a mean of 50 and a standard deviation of 10 in the US general population (Ware et al, 1998). Patients in this study had lower average PCS-12, but higher MCS-12 scores than these averages. This trend was true for males, females, and the total sample. In a sample of 186 patients hospitalized with CHD, Failde et al (2010) also found that PCS-12 scores were lower than MCS-12 scores whole sample mean values for this study were lower than our own for both PCS-12 (40.8, SD: 10.5) and the MCS-12 (47.8, SD: 11) scores. However, patients in this study were hospitalized, and as such a large discrepancy in health when compared to patients in Phase 4 rehabilitation might well be expected. De Smedt et al (2013) reported data on 8745 coronary heart disease patients from 22 European Countries assessed at least 6 months after their original hospital admission. They reported total population means of 42.14 for the PCS-12 and 49.15 for the MCS-12. Our means were higher than both these means. The trend is for MCS-12 means to be higher than PCS-12 scores, and our own data confirms this trend.

Inferential Analysis

Correlations

Pearson's Correlations were calculated to ascertain the nature of the relationships between potential predictor variables and outcome variables. These are outlined in Table 10. In addition, correlations between SF-12 Physical Component Summary (PCS-12), Mental Component Summary (MCS-12) and all outcome variables are

presented in Table 11 and correlations between all outcome variables themselves are shown in Table 12.

Physical Health Status was negatively correlated with age, $r(472)=-0.436$, $p< .001$ as was Health Status $r(470) =-0.247$, $p< .001$, whilst Mental Health Status was not significantly related to age or waist circumference. None of the SF-12 scales significantly correlated with the BADS Key Search task. However, Zoo Map score did significantly correlate with Physical Health Status, $r(467)= 0.093$, $p<0.05$, and negatively correlated with Mental Health Status, $r(476)=-0.139$, $p<0.01$. No significant correlation existed between the Cognitive Failures Questionnaire (CFQ) main constructs and Mental Health Status, but significant correlations did exist between Physical Health Status and CFQ Distractibility, $r(468)= 0.111$, $p<0.05$, and also between Physical Health Status and CFQ False Triggering, $r(467) -0.117$, $p<0.05$. The Self-Regulation Questionnaire (SRQ) subscales did not significantly correlate with Physical Health Status, although SRQ Total and Physical Health Status did significantly correlate, $r(302)= 0.123$, $p<0.05$. However, Mental Health Status did correlate significantly with SRQ Impulse Control ($r(458)=0.155$, $p<0.01$) and SRQ Total ($r(301)=0.168$, $p<0.01$). Significant correlations were also found between Health Status and both SRQ Impulse Control ($r(459)=0.137$, $p<0.01$), SRQ Goal Setting ($r(458)=0.099$, $p<0.01$), along with SRQ Total ($r(301)=0.243$, $p<0.01$).

TABLE 10a SF-12 Measures Correlations with Outcome Variables (Age and Waist Circumference)

	SF-12 Physical Health	SF-12 Mental Health	SF-12 Health Status	Age	Waist
SF-12 Physical Health	1	-0.028	0.679**	-0.436**	-0.072
SF-12 Mental Health	-0.028	1	0.691**	0.085	0.087
SF-12 Health Status	0.679**	0.691**	1	-0.247**	0.022

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

TABLE 10b SF-12 Measures Correlations with Outcome Variables (BADS Measurements)

	Zoo Map V1 Sequence Score	Zoo Map V1 Errors	Zoo Map V1 Raw Score	Zoo Map V2 Sequence Score	Zoo Map V2 Errors	Zoo Map V2 Raw Score	Zoo Map Raw Score	Zoo Map Profile Score	Key Search Raw Score	Key Search Profile Score
SF-12 Physical Health	0.127**	-0.025	0.102*	0.227*	-0.019	-0.205*	0.093*	0.036	0.034	0.061
SF-12 Mental Health	-0.190**	-0.030	-0.102*	-0.018	-0.005	-0.016	-0.139**	-0.045	0.047	0.044
SF-12 Health Status	-0.046	-0.035	-0.002	-0.149**	-0.042	-0.126*	-0.027	0.007	0.059	0.079

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

TABLE 10c SF-12 Measures Correlations with Outcome Variables (CFQ Scores)

	CFQ Forgetfulness	CFQ Distractibility	CFQ False Triggering	CFQ Total
SF-12 Physical Health	-0.057	0.111*	-0.117*	0.032
SF-12 Mental Health	0.089	-0.062	-0.063	-0.040
SF-12 Health Status	0.051	0.045	-0.111*	0.015

*Significant difference, p<0.05
**Significant difference, p<0.01

TABLE 10d SF-12 Measures Correlations with Outcome Variables (SRQ Score)

	SRQ Receiving	SRQ Evaluating	SRQ Triggering	SRQ Searching	SRQ Planning	SRQ Implementing	SRQ Assessing	SRQ Impulse Control	SRQ Goal Setting	SRQ Total
SF-12 Physical Health	-0.071	0.130*	0.093	0.161**	-0.043	0.052	0.03	-0.006	0.056	0.123*
SF-12 Mental Health	0.097	0.046	0.130*	0.021	0.157**	0.098	0.033	0.155**	0.053	0.168**
SF-12 Health Status	0.059	0.127*	0.186**	0.152**	0.117*	0.150**	0.063	0.137**	0.099*	0.243**

*Significant difference, p<0.05
**Significant difference, p<0.01

Correlations between SF-12 scaled scores (Physical Component Summary, PCS-12 and Mental Component Summary, MCS-12) are presented in Table 11. Waist circumference did not significantly correlate with either scaled score, and age was only significantly and negatively correlated with PCS-12 ($r(462)=-0.30$, $p< .001$). MSC-12 did not correlate with any of the BADS subtest total scores, whilst PCS-12 did significantly and negatively correlate with Key Search raw score ($r(457)=-0.156$, $p< .001$). In contrast, all CFQ subscales significantly and negatively correlated with PCS-12 (CFQ Forgetfulness $r(460)=-0.214$, CFQ Distractibility $p< .001$; $r(458)=-0.158$,$p< .005$; CRQ False Triggering $r(458)=-0.11$, $p< .005$; and CFQ Total $r(398)=-0.107$,$p< .005$) as did all CFQ subscales and MCS-12 scores (CFQ Forgetfulness $r(460)=$,-0.402 $p< .001$; CFQ Distractibility $r(458)=-0.484$, $p< .001$; CRQ False Triggering $r(458)=-0.45$, $p< .001$; and CFQ Total $r(397)=-0.445$, $p< .001$). With regards to self-regulation, PCS-12 significantly correlated with the SRQ Total, ($r(296)=0.257$, $p< .001$), while MCS-12 scores correlated significantly with SRQ Impulse Control ($r(449)=0.388$, $p< .001$), Goal Setting($r(448)=0.161$, $p< .001$), and Total scores ($r(292)=0.278$, $p< .001$). These scales scores were not use in subsequent regression due to the more ordinal nature of the component summary scales and the continuous nature of the raw scores, which are more appropriate for linear regression (Field, 2013).

TABLE 11a SF-12 Physical Component Summary (PCS-12) and Mental Component Summary (MCS-12) Correlations with Outcome Variables (Age and Waist Circumference)

	SF-12 PCS	SF-12 MCS	Age	Waist
SF-12 PCS	1	0.017	-0.30**	-0.087
SF-12 MCS	0.017	1	0.06	0.055

*Significant difference, p<0.05
**Significant difference, p<0.01

TABLE 11b SF-12 Physical Component Summary (PCS-12) and Mental Component Summary (MCS-12) Correlations with Outcome Variables (BADS Measurements)

	Zoo Map V1 Sequence Score	Zoo Map V1 Errors	Zoo Map V1 Raw Score	Zoo Map V2 Sequence Score	Zoo Map V2 Errors	Zoo Map V2 Raw Score	Zoo Map Raw Score	Zoo Map Profile Score	Key Search Raw Score	Key Search Profile Score
SF-12 PCS-12	0.139**	0.050	0.061	-0.150**	0.227**	-0234**	-0.052	-0.023	-0.156**	-0.158**
SF-12 MCS-12	-0.143**	-0.157**	-0.006	0.086	-0.042	0.098*	0.041	-0.02	-0.052	-0.021

*Significant difference, p<0.05
**Significant difference, p<0.01

TABLE 11c SF-12 Physical Component Summary (PCS-12) and Mental Component Summary (MCS-12) Correlations with Outcome Variables (CFQ Scores)

	CFQ Forgetfulness	CFQ Distractibility	CFQ False Triggering	CFQ Total
SF-12 PCS-12	-0.214**	-0.158*	-0.11*	-0.107*
SF-12 MCS-12	-0.402**	-0.484**	-0.45**	-0.445**

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

TABLE 11d SF-12 Physical Component Summary (PCS-12) and Mental Component Summary (MCS-12) Correlations with Outcome Variables (SRQ Score)

	SRQ Receiving	SRQ Evaluating	SRQ Triggering	SRQ Searching	SRQ Planning	SRQ Implementing	SRQ Assessing	SRQ Impulse Control	SRQ Goal Setting	SRQ Total
SF-12 PCS	0.064	0.311**	0.359**	0.218**	0.056	0.099	0.14*	0.07	0.079	0.257**
SF-12 MCS	0.375**	-0.313**	0.221**	-0.062	0.569**	0.45*	-0.048	0.388**	0.161**	0.278**

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

TABLE 12 – Correlations Between All Outcome Variables

	Age	Waist	Zoo Map V1 Sequence	Zoo Map V1 Errors	Zoo Map V1 Score	Zoo Map V2 Sequence Score	Zoo Map V2 Errors	Zoo Map V2 Score	Zoo Map Total Score	Zoo Map Profile Score	Key Search Total	Key Search Profile Score	CFQ Forgetfulness	CFQ Distractibility
Age	1													
Waist	0.092*	1												
Zoo Map V1 Sequence	0.033	0.083	1											
Zoo Map V1 Errors	0.006	-0.293**	-0.361**	1										
Zoo Map V1 Raw Score	0.017	0.22**	0.848**	-0.799**	1									
Zoo Map V2 Sequence	0.056	-0.063	-0.069	0.14***	-0.122*	1								
Zoo Map V2 Errors	-0.057	-0.19**	-0.344**	0.486*	-0.5**	0.063	1							
Zoo Map V2 Raw Score	0.076	0.018	0.076	-0.068	0.090	0.913**	-0.351*	1						
Zoo Map Total	0.013	0.149**	0.66**	-0.655**	0.798**	0.337**	-0.547**	0.54**	1					
Zoo Map Profile Score	0.025	0.141**	0.587**	0.636**	0.741**	0.324**	-0.474*	0.499**	0.88**	1				
Key Search Raw Score	-0.029	0.005	0.078	-0.193**	0.163**	0.041	0.008	0.035	0.237**	0.236**	1			
Key Search Profile	-0.053	0.0003	0.014	-0.263**	0.151**	0.007	0.005	0.005	0.23**	0.251**	0.965**	1		
CFQ Forgetfulness	-0.05	0.027	-0.117*	0.177**	-0.176**	-0.246**	-0.026	-0.221**	-0.27**	-0.168**	-0.105*	-0.108*	1	
CFQ Distractibility	-0.109*	0.013	0.062	0.116*	-0.025	-0.316**	-0.038	-0.281**	-0.139**	-0.126**	-0.049	-0.063	0.805**	1
CFQ False Triggering	0.028	-0.087	-0.06	0.253**	-0.182**	-0.237**	0.014	-0.229**	-0.351**	-0.233**	-0.234**	-0.242**	0.854**	0.698**
CFQ Total	-0.054	-0.025	-0.012	0.189**	-0.116	-0.296**	-0.034	-0.269**	-0.276**	-0.169**	-0.199**	-0188**	0.957**	0.9**
SRQ Impulse Control	-0.02	0.152**	-0.066	-0.153**	0.044	0.095	-0.08	0.122*	0.156**	0.168**	0.133**	0.144**	-0.252**	-0.507**
SRQ Goal Setting	0.077	-0.014	0.043	-0.271**	0.18**	-0.014	-0.279**	0.102*	0.194**	0.179**	-0.15**	-0.231**	-0.272*	-0.323**
SRQ Total	0.008	0.048	-0.034	-0.376**	0.198**	0.071	-0.242**	0.18**	0.257**	0.354**	0.005	0.113	-0.29**	-0.445**

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$

Multiple Regression

Multiple linear regression was carried out to determine the effect of the psychological variables, age, and waist circumference on health. Separate regressions were run using each of the summary scales (SF-12 Physical Health and SF-12 Mental Health) of the SF-12 as the outcome variables. For each model, Stata runs a linear regression with each of the 10 imputed datasets to derive 10 sets of estimates (coefficients and standard errors) and combines these estimates to create one set of inferential statistics.

SF-12 Physical Health Model

The first multiple regression ascertained the extent to which SF-12 Physical Health was predicted by Gender, Age, Waist Circumference, BADS Zoo Map and Key Search scores, CFQ subscales (Forgetfulness, Distractibility, False Triggering), and SRQ subscales (Impulse Control and Goal Setting). The model was significant ($F(10,101)=2.41$, $p=0.013$) indicating that the results were unlikely to have arisen by chance, assuming the null hypothesis to be true. The adjusted R^2adj of .131 indicated that 13% of the variance in SF-12 Physical Health can be explained by the variance in predictor variables. The model indicates that CFQ Distractibility (β=0.367) was the most influential, followed by Age (β=-0.294). These were the only two significant predictors of SF-12 Physical Health. The effect for the physical health model (f^2=0.26) was small to medium (Sedgwick, 2012). The results of this analysis are presented in Table 13.

TABLE 13 SF-12 Physical Health Regression Model

Model Summary	Variable	*B*	*SE*	*β*	*t*	*p*
R^2 =0.207	Intercept	16.83	2.404		7	<0.001**
Adjusted R^2 =0.131	Gender	-0.524	0.332	-0.177	-1.58	0.119
F(10,101)=2.41*	Age	-0.049	0.015	-0.294	-3.15	0.002**
	Waist	-0.015	0.015	-0.124	-0.99	0.325
	BADS Zoo Map	-0.007	0.026	-0.026	-0.27	0.789
	BADS Key Search	0.009	0.028	0.034	0.35	0.731
	CFQ Forgetfulness	-0.031	0.060	-0.109	-0.52	0.604
	CFQ Distractibility	0.107	0.533	0.367	2.01	0.047*
	CFQ False Triggering	-0.07	0.056	-0.219	-1.24	0.220
	SRQ Impulse Control	0.029	0.043	0.129	0.93	0.353
	SRQ Goal Setting	0.003	0.043	0.009	0.08	0.937

*Significant, p<0.05

**Significant, p<0.01

SF-12 Mental Health Model

Table 14 summarises the predictor variables used in the second multiple regression to predict SF-12 Mental Health Status. The model was not significant (F(10,100)=0.96, p=0.488), with an adjusted R^2adj of 0.014 indicating that the model only accounted for 1.4% the variance in Mental Health Status. All potential predictor variables entered into the model were shown not to be statistically significant predictors of Mental Health Status. The effect size for this model was small (f^2=0.11).

TABLE 14 SF-12 Mental Health Regression Model

Model Summary	Variable	*B*	*SE*	*β*	*t*	*p*
R^2 =0.099	Intercept	19.84	3.213		6.17	<0.001**
Adjusted R^2 =0.013	Gender	0.118	0.423	0.034	0.28	0.781
F(10,100)=0.96	Age	0.006	0.019	0.031	0.31	0.761
	Waist	0.019	0.019	0.129	0.94	0.355
	BADS Zoo Map	-0.057	0.034	-0.175	-1.69	0.094
	BADS Key Search	0.029	0.036	0.087	0.81	0.419
	CFQ Forgetfulness	0.022	0.075	0.065	0.30	0.768
	CFQ Distractibility	-0.052	0.069	-0.148	-0.75	0.457
	CFQ False Triggering	-0.079	0.071	-0.210	-1.12	0.265
	SRQ Impulse Control	-0.009	0.040	-0.033	-0.21	0.832
	SRQ Goal Setting	-0.025	0.056	-0.059	-0.45	0.651

*Significant, p<0.05
**Significant, p<0.01

SF-12 Health Status Model

The third and final multiple regression devised to predict overall SF-12 Health Status is summarised in Table 15. The model was not significant (F(10,100)=1.40, p=0.192), with an adjusted R2 of 0.051 indicating that the model only accounted for 5.1% the variance in Health Status. None of the potential predictor variables entered into the model were statistically significant. The effect size for this regression was small (f^2=0.155).

TABLE 15 SF-12 Health Status Regression Model

Model Summary	Variable	*B*	*SE*	*β*	*t*	*p*
R^2 =0.134	Intercept	32.54	3.953		8.23	<0.001**
Adjusted R^2 =0.051	Gender	-0.326	0.529	-0.710	-0.62	0.539
F(10,100)=1.40	Age	-0.403	0.025	-0.188	-1.93	0.057
	Waist	0.004	0.024	0.021	0.17	0.865
	BADS Zoo Map	-0.042	0.043	-0.098	-0.97	0.335
	BADS Key Search	0.043	0.045	0.099	0.94	0.350
	CFQ Forgetfulness	0.015	0.097	0.034	0.16	0.875
	CFQ Distractibility	0.097	0.088	0.214	1.10	0.275
	CFQ False Triggering	-0.132	0.091	-0.368	-1.45	0.150
	SRQ Impulse Control	0.023	0.050	0.158	1.08	0.285
	SRQ Goal Setting	0.023	0.071	0.041	0.32	0.750

*Significant, p<0.05
**Significant, p<0.01

Discussion

The chronic nature of cardiovascular disease calls for patients to learn to manage their own health and health behaviours over a long period (Ma et al, 2017). Such management requires effort and exerts a cognitive load (Byrd-Bredbenner and Eck, 2020). The role health behaviours play in recovery from CHD and preventing further illness is well known (Nyberg et al, 2013; Pattyn et al, 2013). However, the specific cognitive structures most relied upon to facilitate this process - that underpin and enable health behaviour change - have not been clearly articulated. This study aimed to investigate the role played by executive functioning and self-regulation in the prediction of both physical and mental health in Phase 4 CR patients. Participants in Phase 4 CR programmes completed measures of said variables and demographics. It was hypothesised that executive functioning and self-regulation would significantly predict variance in physical and mental health.

The results show that increased physical health was significantly predicted by an increase in Distractibility. Physical health decreased significantly for each year of life. Change in mental health status was not predicted by self-regulation or executive functioning, nor was mental health predicted by age. Neither physical nor mental health were significantly associated with waist circumference.

In addition, the raw score of overall health was not associated with executive functioning or self-regulation measures, nor indeed with age or waist circumference. Combining the SF-12 measures raw scores does not constitute a single index measure within the literature, and as a result the discussion will focus upon the physical and mental health measures.

The healthcare landscape at the beginning of the twentieth century (and for most of human history) was dominated by illnesses whose explanatory models were unadorned by complexity, with single cause and single consequence relationships: for example, single viruses for polio and yellow fever producing only those conditions (Sapolsky, 2004). Since the near eradication of such conditions in the West (Kew et al, 2005; Monath and Vasconcelos, 2015), the healthcare landscape is populated

predominately with multi-factorial diseases, such as cancer, stroke, and heart disease and factors that increase risk for disease development (Mozaffarian et al, 2015; Stewart and Wild, 2017). There is a necessity therefore to now conceptualize health as an emergent state proceeding from adaptive dynamics between social and biological systems (Sturmberg et al, 2019) and this study attempts to contribute to such an understanding.

Bearing this in mind, it would seem appropriate to begin with a discussion of the relationships between health outcomes and the physical predictor variables outlined above. The relationship between physical health and age points to the deterioration of physical health as CR patients get older. Decline of health with age is evident within the literature (Case and Deaton, 2005; Mitnitski et al, 2007; Celidoni and Rebba, 2017) and multiple theories regarding the biological (Truscott, 2010; Kohanski et al, 2016) and psychosocial (Schünemann et al, 2017; Sommer et al, 2019) mechanisms behind senescence abound (Williams, 1957). Similarly, an association between an increase in waist circumference and a decline in physical health is well documented (Lean et al, 1995; Janssen et al, 2004; Stephen and Janssen, 2009; Liao et al, 2018). Indeed, waist circumference would seem to explain obesity-related health risk better than BMI (Janssen et al, 2004; Bray et al, 2018). The lack of significant relationships between the outcome variables and waist contradicts this research. Potentially phase 4 CR participants constitute a self-selected subsection of the general population who are invested in health, and steps they have made towards healthy behaviour change have impacted upon their perceived health but are yet to manifest in objective measures such as waist circumference. Whilst perceiving oneself as making healthy change is positive, it is important for CR clients to remember to take objective health measures as the ultimate marker of improvement.

Obesity has long been associated with an array of mental health problems (Calugi and Dalle Grave, 2020; Kamody et al, 2018; Lam & Mok, 2017; Mammen and Faulkner, 2013; Kyrou et al, 2018; Gariepy et al, 2010), and many authors report an underappreciation of the interconnectedness of mental and physical health (Prince et al, 2007; Patel & Prince, 2010). In contrast, this study found no relationship between mental health and waist circumference. Depression and obesity often appear to occur concurrently (Wurtman and Wurtman, 2018) and although differing in their

etiopathological pathways, there is expanding evidence indicating bidirectional relationships between the two conditions (Luppino et al, 2010). By engaging in structured exercise programmes, our phase 4 CR sample may have begun experiencing the effects of increased exercise outlined by Monda et al (2017) and Allen et al (2018) who suggest that exercise can modify gut microbiota, resulting in improved health outcomes e.g., in depression. Cognisance of relevant social phenomena is also important. Weight stigma impacts greatly upon mental health of overweight and obese adults (Wu and Berry, 2018; Emmer et al, 2020) and weight stigma has been proposed as a psychosocial contributor to obesity (Puhl et al, 2020; Sarwer and Grilo 2020). CR attendance may contribute to the extinction of any relationship between mental health and waist circumference, as attendance acts of a social signal of status and social intent (Grossman, 2015; Karing, 2019).

Executive Functioning and Self-Regulation in Cardiovascular Disease

The above results demonstrate the complexity in health and disease conceptualized by Sturmberg et al, (2019). The regression models tested found although one aspect cognitive failure phenomena predicted variance in health, the effect size of the regression was small (f^2=0.155), as it was for the mental health model (f^2=0.11) although the effect for the physical health model was small to medium (f^2=0.26). Distractibility predicted change in physical health, but with no other effects evident. This suggests that the relationship between health status and executive functioning is a nuanced one.

The advent of the biopsychosocial approach to healthcare is an attempt to respond to the knowledge that conditional interactions amongst causal agents are central to understanding how the human system operates (Engel, 1977; Froehlich and Schmitt, 2016). This thesis has been an attempt to add to the knowledge base of coronary heart disease and cardiovascular disease within this framework. The focus has been on the power of the biological (executive functioning) and the psychological (self-regulation) to explain health outcomes. By necessity, the effect size of any one contributor to multi-factorial disease progression will be limited when compared to that of the single cause and single consequence illness models, as borne out herein.

These results are interesting within the current context of health behaviour change models, which emphasize cognitive phenomena as the resources that need to be harnessed to maintain health (Badham et al, 2018). The elevation of the cognitive model - and rational thought in particular - as the central mode of health psychology (Ogden, 2012) is called in to question, as when the cognitive mechanisms that underpin constructs such as implementation intentions (Hall et al, 2014) are tested, their relationship to health outcomes is weaker than might be expected. It may be useful therefore for theorists, policy makers and practitioners to begin to incorporate aspects of subconscious motivation (e.g., emotion and motivation) into models and interventions.

Areas for Discussion: Theory, Policy, & Practice

The driving force behind the investigation of relationships between psychological variables and health is ultimately to provide knowledge that might be used to improve interventions, and subsequently patient health (Abraham & Michie, 2008; Michie et al, 2013). With this in mind, there are three areas where discussion needs to take place owing to the current results namely theory, policy, and practice. Given the sparsity of significant predictors of health in the models above, it is essential to comprehend these results within the context of the theoretical literature before interpreting them in the more specific domains of policy and clinical practice.

Theoretical Considerations - Cognitive Modelling

Cognitive modelling involves the approximation of cognitive processes to understand and predict (Lakoff, 1987). The modelling of self-control has informed the development of this study. Although currently available models do not entirely encapsulate self-control, we can look to the most recent of these to help understand this study's results.

The results cast doubt on an idea long held in Health Psychology - that reason strongly influences behaviour. Were this the case, one would expect to see greater variance in health outcomes predicted by cognitive factors. Sheeran et al (2013) criticized the Theory of Planned Behaviour for excluding unconscious impacts upon behaviour, while Conner et al (2013) pointed the lack of consideration of emotion in the TPB. Sniehotta et al (2014) suggested that the idea of reasoned action being

important to behaviour had been so disputed due to the limited predictive validity of the TPB that it was time to "retire" the theory altogether. The lack of predictive value executive functioning and self-regulation here would support this.

There is thus perhaps a case to be made to re-examine some of the ideas of the psychoanalysts, particularly conceptualising the mind as a dynamic system consisting of a series of sub-systems and drives. Whilst the relationship between psychoanalytic practice and scientific research has at times been a contentious one (Chiesa, 2010), the growth of cognitive neuroscience and the study of the biological processes that underpin cognition have begun to again conceive of the mind as having innate structures that shape the nature of impulses (Haule, 2010). For much of the twentieth century the chief adversary of these ideas is best conceptualised as the Standard Social Science Model (Barkow et al, 1995) that postulated that biology had a negligible effect upon human behaviour; that the human mind was a "blank slate" upon which culture could write (Pinker, 2003). Coupled with the ideas of rationalism (Spinoza, 1677; Kant, 1781), such a conceptualisation has no place for unconscious impulses and drives. The results of this study suggest that to rely solely on a rational conceptualisation of the mind is too simplistic.

Conceptualizing the mind as a dynamic system may aid in the interpretation of the finding that distractibility predicts physical health. Increasingly, psychobiological models emphasise the role played by biological systems other than the nervous system in emotional and cognitive phenomena (Marshall, 2015; Murphy, 2018; Hellhammer et al, 2018; Solms, 2018). Associations between cognitive and cardiovascular functioning are a particular area of interest to many (Abete et al, 2014; Crichton et al, 2014; Whedon et al, 2018). The neurovisceral integration model (Thayer and Lane, 2000; Smith et al, 2017) proposes that individual differences in vagal nerve function (as indicated by heart rate variability, HRV) plays a role in executive functioning – specifically, those with greater vagally mediated HRV perform better on executive functioning tasks (Thayer et al, 2009). Greater HRV at rest is generally indicative of better health (Joyce and Barrett, 2019), and indeed, has experimentally been shown to be associated with better executive performance (Albinet et al 2010; de Oliveira Matos et al 2020). To test the specifics of the neurovisceral integration model, You et

al (2021) investigated the relationships between HRV and CFQ subscales, finding that HRV negatively predicted Distractibility (but not Forgetfulness or False Triggering). These authors suggest that a higher resting HRV may be protective against distraction, with HRV reflecting an organism's ability to appropriately adjust sufficient mappings between input, internal states, and outcomes required to execute a given task (Benarroch, 1997; Miller and Cohen, 2001). That Distractibility alone amongst CFQ subscales is associated with health (in both You et al and the present study) suggests that the biological processes underpinning different cognitive failures may be unique to that specific factor.

Also interesting to note is that the relationship between positive health and Distractibility is inverted between the You et al study and the present results. However, the neurovisceral integration model may find support from both studies - the contrasting findings may be explained by comparing the samples used. You et al's participants were healthy, and they specifically excluded those with cardiovascular or respiratory disorders or those taking medication impacting these systems. In contrast, the present study investigated CR patients (i.e., individuals with cardiovascular disorders), many of whom would be on medication regimes. The presence of cardiovascular conditions in the present sample may disrupt the nature of the relationship between Distractibility and HRV, accounting for the significance and direction of the relationship. Even before a cardiac event, those at high risk of developing CVD differ in HRV from the general population (Hillebrand et al, 2013; Kubota et al, 2017), marking them out as a distinct subgroup.

In addition, the health of many CR patients is (and/or has been) artificially controlled through medical intervention. Many of the widely used cardiovascular interventions impact HRV, although the relationship appears to be a complex one. Nolan et al's (2008) systematic review on HRV change in coronary patients receiving secondary prevention treatment through drugs, biobehavioural treatments and exercise programmes, found that these treatments resulted in significant moderate increases in HRV. However, only one study to date examines the effect of beta-blockers (frequently prescribed for cardiovascular conditions, NICE, 2015c), which significantly increased HRV (Lampert et al., 2003), whilst anti-arrhythmic therapies are associated with a decrease in HRV (Huikuri and Stein, 2012). More work has been

carried out on the effect of statins on HRV, but a review by Millar and Floras (2014) found great inconsistency in the results across the 16 studies they reviewed on the matter. Meanwhile, coronary artery bypass grafting (CABG) surgery strongly decreases HRV immediately after surgery but it improves gradually in the subsequent months (Stein et al, 2004). The complex and potentially conflicting impact on HRV of the host of interventions experienced by those in the present study may also help explain the inverse relationship between Distractibility and HRV when compared to that of You et al.

Theoretical Considerations - BADS Sub-Tests and General Intelligence

Construct validity is a fundamental cornerstone of any field of academic investigation (Cronbach and Meehl, 1955), and it is important to ascertain whether the BADS does indeed measure executive functioning as it purports, or aspects of the *g* factor as outlined in the CHC model. If executive functioning were one construct, one would expect to observe similar relationships between its components and other phenomena. The Zoo Map and Key Search components of the BADS demonstrate significant correlations as one would expect (Table 12), but the correlations are lower than in studies with other participant groups, particularly brain injury patients (Wood and Liossi, 2006). The manner of the difference in relationships between the BADS subtests and the other psychological constructs measured are noteworthy also. Negative correlations were observed between Zoo Map errors and Self-Regulation Questionnaire constructs, and total Zoo Map scores positively correlated with Self-Regulation. All correlations were relatively small however, suggesting the measures do indeed quantify different (though related) constructs. The lack of correlation between Self-Regulation Total and Key Search suggests no overlap between the factors that Key Search measures (self-monitoring, working memory, inhibition, and mental flexibility; Miyake, et al, 2000; Wilson et al, 1996; Zelazo, 2015) and 'steps' of self-regulation denoted by Brown and Miller (1991). SRQ subscales did significantly correlate with Key Search, although correlations were weak. This is problematic for construct validity, as Impulse Control would appear to delineate inhibition, which is involved in Key Search, as both employ higher order cognitive control over baser impulses. We could therefore expect a stronger correlation than is observed. This may be due to the way the subcomponents of BADS and SRQ

constructs interrelate. Complex systems modelling that examines systems whose properties stem from non-linear interactions may provide greater insight into the nature of the relationships between these variables (Ladyman et al, 2013).

One can ask whether these results shed any light on the idea of executive functioning being a construct that can be subsumed into general intelligence. No known studies have used factor analysis to investigate how executive function as measured using the BADS maps onto the Cattell-Horn-Carroll model, although there is clear conceptual overlap between the ideas of working memory and short-term memory (Aben et al, 2012), and construct overlap between planning and fluid reasoning (Gf) has been demonstrated (Decker et al, 2007; Keith and Reynolds, 2010). As noted above, Carroll's (1993; 2003) evidence for a singular factor underpinning cognitive abilities was that subcomponents of intelligence correlate with each other at 0.8 correlation coefficient or above. This study found small correlations between the BADS subscales themselves and with self-regulation constructs. Indeed, only medium correlations were found across SRQ and CFQ constructs. The fact that BADS subscales had no relationship with health status would suggest that although general intelligence may constitute one construct under the banner "processing of mental information" (Carroll, 1993, p 10).", the relationship it has with other biopsychosocial phenomena is complex. If this is the case, and facets of information processing correlated and/or predict variance of health in different directions, one may ask what the practicality of the construct is.

Theoretical Considerations - From Executive Functioning to Self-Regulation: The Role of Emotion & Unconscious Motivation

If measures of executive functioning and self-regulation quantify the same underlying construct, one would expect to see high Pearson's correlation values between them (Field, 2009). In this current study, significant correlations between aspects of executive functioning and self-regulation do exist, but they are low (Zoo Map Total correlating at 0.156, 0.194, and 0.257 with SRQ Impulse Control, Goal Setting and Total respectively, and Key Search Total correlating at 0.133 and -0.15 with SRQ Impulse Control, Goal Setting). If the BADS constitutes an objective measure of the phenomena, the discrepancy between self-reported self-regulation may be partially

attributed to a lack of insight, potentially mimicking the Dunning-Kruger Effect (Dunning, 2011; Schlösser et al, 2013), but may also be pointing to a conceptualization of decision-making as involving factors other than cognitive phenomena.

If one utilizes the 5 Areas Model of Cognitive Behavioural Therapy (Padesky & Mooney, 1990; Garland et al, 2002; Wright et al, 2002) as a framework for conceptualizing human psychology, one can see that this paper has focused primarily upon cognitive and behavioural regulation, with some attention paid to the environment and physiology. The fact that a great deal of the variance in health status is not accounted for in the results and would therefore suggest that emotion should be incorporated into any complete theoretical conceptualization of health status.

The literature suggests the impact of emotion upon cognition could account for the lack of predictive power of cognitive functions in health in this study, due to the role emotion plays in health behaviour decision-making (Bain, 1859; Teskey, Kavaliers, & Hirst, 1984; Deroche et al., 1995; Merlo Pich et al., 1995; Peciña et al, 2006; Piazza, & Le Moal, 1996; LeDoux, 2003; Heatherton & Wagner, 2011; Wagner and Heatherton, 2015). Dolcos et al (2011) emphasized the reciprocal nature of the relationship between emotion and cognition. The importance of emotion in decision-making explains the small effect of cognition in this study, as focusing on the cognitive omits emotional aspects of behavioural control.

Theoretical Considerations - Executive Functioning, Self-Regulation, & Mental Health Status

In the relevant regression model, there are no significant relationships between mental health status and Executive Functioning/Self-Regulation. Executive functioning measures did not predict variance in Mental Health Status, and neither did SRQ and CFQ measures. The literature on self-report measures and clinical insight affords a partial explanation of this. Insight is a continuum of understanding of how an illness affects one's interactions with the world and ability to function (Markova and Berrios,

1992). Although insight allows the individual an opportunity to begin to contend with a problem (Garner, 1997; Princy et al, 2020), it also draws their attention to the space between the ideal self and the present self, which can result in low mood (Feixas et al, 2014; Montesano et a, 2020). The self-regulation measures used in this study are all self-report and ask participants to reflect upon abilities and functioning across a range of domains. Their responses may indicate an already existing awareness of a lack in current functioning, or the questioning process itself may present an opportunity for self-reflection and realisation not previously afforded (Kalton and Schuman, 1982; Brace, 2018). In either instance, clients who have experienced a decline in self-regulation (either due to CHD problems or the aging process; Von Hippel & Henry, 2011) may experience a sense of loss and subsequent distress (Endler and Kocovski 2000). To avoid this, individuals may engage in a process of denying or rationalizing away the significance of their low self-regulatory ability (Cherepanov et al, 2013), resulting in inaccurate reporting.

However, the abstract nature of the executive functioning tests may provide no opportunity to self-reflect, as an individual's performance on the task may still be opaque to them upon completion. Consequently, any low executive functioning the test indicates may not be noticed and reflected upon. In addition, knowledge of the level of executive functioning an individual is operating at may not be clear to them in their day-to-day routine, due to the difficulty in the conceptualisation of such a concept to laypersons (Neuman et al 2006). The lack of significant results in either domain lends an air of authenticity to the results.

The lack of association found between mental health and self-regulation casts doubt upon the depression-as-self-regulation-disorder theory outlined above (Strauman, 2002; Trew 2011). The dysregulation of neurological avoidance and approach systems proposed in such a model is beyond the investigative scope of this current study, but the lack of association between self-regulation and mental health suggest such a model would not be a comprehensive explanation of either phenomena (Strauman, 2002; Scholer et al, 2019).

Policy Development

It is important to outline two aspects of policy at this juncture: firstly, the nature of the policy landscape into which this study's results might realistically have an impact and secondly, an understanding of the level of evidence needed to impact policy. Interestingly, current guidelines on behavioural change in CR make no reference to healthcare professionals being required to have knowledge of individual differences in psychological variables and their impact upon health (BACPR, 2016).

Healthcare policy is made and implemented at the international, national, and local level (Bache et al, 2016) and coordination across these levels is notoriously complex (Bouckaert et al, 2016). Governance, priorities, and resources vary from locale to locale (Blank et al, 2017), and effective policy implementation will vary between domains and situations (Sabatier, 1986; Pülzl and Treib, 2017). The governance framework for CR in the UK involves the BACPR, national and local NHS policy, and SIGN AND NICE guidelines.

The nature and quantity of evidence required to result in policy change at the national level is both rigorous and extensive (Cookson, 2005). Evidence must be extracted from a host of research sources including randomized control trials and meta-analysis, whilst economic and practical factors must also be taken into consideration (NICE, 2015b). Whilst the present study could hopefully contribute to such an evidence base, it must be noted that the results of this study alone cannot be used to develop policy but must instead be viewed as one piece in the evidence puzzle that must inform such policy.

Current guidelines would benefit from more detailed incorporation of the psychological literature on individual differences in dealing with long-term conditions. The results here suggest cognitive elements are part of an array of complex factors that predict health in Phase 4 CR patients, and healthcare policymakers and providers should be aware of this. Integration of knowledge regarding an individual's cognitive (and potentially emotional) functioning into interventions would be the most obvious way in which psychological knowledge can be used.

The small amount of variance in physical health status being predicted by the cognitive factors in this model suggest that other biopsychosocial factors (as conceptualized in the 5 Areas Model; Padesky & Mooney, 1990; Garland et al, 2002) also impact health status of CR patients. The modern obesogenic environment facilitates poor health behaviours. The small impact of executive functioning and self-regulation on health status in the results suggests that asking individuals to regulate their behaviour using "Just Say No" strategies (Evans, 2002) in current environments is ineffective. Environmental changes may be the most obvious route to facilitate healthy outcomes. These can be individual environmental management interventions or societal policy to regulate the availability and accessibility of high calorific foodstuff (Robertson et al, 2018; Moore et al, 2019) and obesogenic architecture (Lipek et al, 2015; Knapp et al, 2018; Townshend and Lake, 2009).

The lack of variance in mental health status predicted by any of the cognitive factors measured may be of interest to policy makers promoting self-regulation as effective in the treatment of mental health. Many policies on depression care (APA, 2019; NICE, 2009) recommend treatment using behavioural activation – a therapeutic technique that focuses on activity scheduling using operant conditioning principles (Ekers et al, 2014; Veale, 2008). The lack of relationship between cognitive abilities and mental health outcomes in this study suggests policy should underline the importance of basing behavioural activation on behaviourist principles, rather than placing the burden of implementation of behavioural activation upon a client's cognitive capacity.

A more extensive body of literature would be required to make specific recommendations regarding the use of cognitive assessment in CR patients. SIGN (Harbour and Miller, 2001) published an outline of the levels of evidence required to make broad recommendations based upon the current literature in any domain. High quality meta-analysis of RCTs constitutes the highest level of evidence in these criteria (1^{++}), down to non-analytic studies and expert opinion at the lowest level of evidence (4). The work herein could contribute to such recommendations in future, as part of an understanding drawn from a broad range of studies. What is clear however, is that as guidelines develop, there should be increased emphasis on how individual differences impact patient health as they learn to live with the long-term implications of cardiac difficulties. The fourth edition of the BACPR Standards and Core

Components for Cardiovascular Disease Prevention and Rehabilitation and NICE guidelines on Cardiovascular Disease Prevention and Rehabilitation should begin to incorporate psychological knowledge into their documentation.

Patient-centred care was originally advocated by Balint (1972), who emphasised the importance of integrating knowledge of individual differences into care. Whilst being responsive to patient needs is now embedded in healthcare models of practice (Entwistle and Watt, 2013; Coyne et al, 2018), the medical model of healthcare still loiters (Marshall et al, 2018), particularly in times of decreasing resources (Orton et al, 2016) and there is a constant struggle for practitioners to invest the time and resources necessary to assimilate individual differences into assessment, formulation, and intervention (Stuart et al, 2008; Jonassen and Grabowski, 2012; Terry and Coffey, 2019). Whilst specific policy recommendations are beyond the scope of one study, the data adds to the growing voice in healthcare research calling for greater integration of knowledge of psychological factors into care.

Policy Development - Cultural Change

Whilst outlining policy change is relatively straight forward, change implementation requires contemplation of cultural change (Lund et el, 2016; Blank et al, 2017) as cultural shift precedes the will to develop policy (Ko et al, 2015; Coyle and Ellis, 2019). Wildavsky (1987) defined culture as:

"Support for and opposition to different ways of life" Wildavsky (1987) p. 3.

How culture influences the translation of evidence into policy and practice is of interest (Bland and Paris, 2016; Lum and Koper, 2017). The traditional assumption is that incorporating evidence-based practice is a linear process, operating at the individual practitioner level in accordance with evidence-based guidelines (Granados et al, 1997). Such an understanding is unsatisfyingly simplistic. Grimshaw et al (2004) recognised the limited evidence regarding the effectiveness of guideline implementation strategies, and recent reviews emphasize the importance of active dissemination and implementation of guidelines to ensure change (Eccles et al, 2018). Authors have stressed the often-ambiguous nature of evidence that must be

interpreted for on-the-ground implementation (Ferlie et al, 2001). The results of this study could be a case in point.

Dopson et al (2002) concluded effective organizational change requires incorporating novel information into the shared cannon of knowledge within a given context. One of the difficulties for Phase 3 and 4 CR is that whilst the BACPR governs practice, service delivery more closely resembles an informal inter-organisational network (Phelps et al, 2012; Kenett et al, 2015) consisting of local authorities, private businesses, charities, and national healthcare providers, and homogeneity between these is low (Astley et al, 2017). This makes it difficult for a coherent shared cannon of knowledge to manifest. There must also be tension for change to occur, in that the current situation must be perceived as intolerable (Gustafson et al, 2003; Hannon et al, 2017). It is not clear if this is currently the case with Phase 3 and 4 practitioners or patients. A properly formulated plan to change practice should take cognizance of these issues.

Practice Development

Bearing in mind the above-mentioned theoretical considerations and the nuances of policy change, attention now turns to clinical practice, and how these results relate to patient care. The results cast doubt upon the idea that an understanding of the role higher order cognitive functioning plays in health post-cardiac event will facilitate much change. However, the lack of association between variables may be instructive. Integrating new knowledge into practice is paramount to the successful improvement of healthcare services (Tricco et al, 2011; Straus et al, 2013; Harvey and Kitson, 2015) as the CR community has demonstrated in the past (Thow, 2009; BACPR 2017).

Given that the results suggest only distractibility is negatively predictive of Physical Health Status, this presents difficulties for making practical recommendations. Small significant correlations do exist between SF-12 measures and some aspects of BADS, SRQ, and CFQ measures (see Table 10). There is an attraction in coherent and powerful explanatory theories, but this must always be balanced by the terrible

complexity of the real world. This study shows that an explanatory theory of health which suggests cognitive power alone can be used to improve health is inadequate. Therefore, any practical recommendations must be restrained. However, if the significant correlations are taken as a starting point (though not implying causation), it may be possible to consider ways in which knowledge of individual differences can be considered in practice. Given the significant correlations but lack of a predictive model, the ways these results can contribute to practice are threefold:

1. Alterations can be made to existing interventions to accommodate for cognitive functioning
2. Alternative interventions that improve cognitive functioning can be developed and incorporated into practice.
3. The minimal role that higher order cognition plays in health outcomes can be acknowledged and circumvented.

Of these, the third is perhaps the most contentious but also the most powerful, based upon the lack of predictive power in the models above.

Practice Development - Accommodation for Cognitive Functioning: Tailoring Interventions

Healthcare practitioners employed in CR have a wide range of skills and need to be aware of a host of biological, psychological, and social factors when working with clients (Supervia et al, 2019). However, rarely does an understanding of patients' specific cognitive ability feature in rehabilitation programme tailoring (BACPR, 2017). Indeed, theory is underutilized in the development of health behavioural interventions (Prestwich et al, 2014), though theory-based interventions are more likely to be successful (Gourlan et al, 2016). Since the results of this study show correlations between cognitive ability and health status, accommodating for poor cognitive ability could potentially improve individual health outcomes.

The contrast between the present data and population norms should also be considered when conceiving of how healthcare practitioners should perceive cardiovascular

patients. The discovery that CR attendees executive functioning is borderline impaired comes as a surprise. Whilst this result is tentative (given the nature of the study's design) a decline in cognitive functioning compared to healthy populations is concerning. Such a presentation is expected in brain injured patients (Wilson et al, 1997), but not commonly noted in the cardiovascular research, policy, or treatment literature (Buja and Butany, 2022). Taken with the pattern across the self-reported measures, the narrative makes for interesting reading. The present subjects believed their self-regulation was not impaired, with self-reported cognitive failures measuring slightly higher than normative date, and self-regulation being reported within the normal range. This suggest a disconnect between actual cognitive functioning and perception. This could be problematic for adaptation, as positive clinical outcomes are associated with appropriate insight into problems (Minakov and Grechaniy, 2013). The relationship could be a causal one - executive functioning deficits are associated with a lack of insight (McGlynn and Schacter, 1989), particularly within mental health populations (Harwood et al, 2005; Copstick et al, 2022; Goldstein et al, 2009; Simon et al, 2009) possibly a result of compromised frontal lobe functioning (Lysaker et al, 1998; Port et al, 2002). The literature on clinical insight has traditionally focused on unawareness of mental health issues in psychosis (Kraepelin, 1919), dementia (Zanetti et al, 1999) or brain injury (Copstick et al, 2022), and research on acceptance and denial in chronic illness populations may have some relevance here (Telford et al, 2006; Williams and Lynn 2010; Ko et al, 2021), but clinicians should be made aware that patients may not only suffer from impaired self-monitoring, goal formulation, and executing plans, but this may be compounded by a lack of awareness. Work on increasing the insight clients have into their abilities (such as helping patients re-evaluate their experiences and specific misinterpretations; Beck et al, 2004) may therefore be a necessary first step prior to any rehabilitation that requires self-regulation.

Behaviour change consists of a motivational and a volitional phase, and social cognition models traditionally do not address the volitional phase (Luszczynska and Schwarzer, 2005) where self-regulatory phenomena would most likely be involved (Zec, 1995; Ernst and Paulus, 2005). This is unfortunate, as the adoption and maintenance of health behaviours is predicted by "volition processes" (Schwarzer, 2008). This study is one of the few that investigates these volitional processes

specifically. The results suggest Phase 4 CR patients should be treated as those in the adoption or maintenance phases of health behaviours and aided in appropriate planning of their day-to-day health behaviour strategies.

Both exercise adherence and healthy eating require the ability to independently formulate and implement plans regarding meal choices, preparation, exercise scheduling, and social coordination. The ability to manage one's schedule and plan exercise is more predictive of exercise behaviour than exercise self-efficacy or intention (Rodgers et al, 2002; Rodgers and Sullivan, 2001; Schwarzer et al, 2008). The significant correlations between physical health status and SRQ score in this study resonates with this. Removing the complexity of planning to incorporate physical exercise into everyday life could result in better health outcomes - CR programmes that facilitate this may be useful in increasing exercise and subsequent physical health. The use of technological solutions in scheduling and planning may be one way to do this, as would more clinical hours for individual planning sessions with clients.

The tailoring of mental health interventions would also seem pertinent. Whilst the mental health regression model did not predict variance, the significant correlation between mental health status and SRQ could prove instructive. This echoes the literature that points to cognitive impairment being associated with depression (Snyder, 2013; Rock et al, 2014), particularly in older adults (Butters et al, 2004; Boone et al, 1995; Lichtenberg et al, 1995). The non-causational nature of correlations draws attention to the utility of implementing change techniques that focus on improving self-regulation (such as behavioural activation) to improve CR patients' mental health.

Practice Development: Accommodation for Cognitive Functioning - Incorporating Behaviour Change Techniques

Various behaviour change techniques could be used to offset the health problems correlated with cognitive functioning in CR patients. Abraham and Michie's work on codifying behavioural change techniques (BCTs) quantified and defined interventions to aid the reporting, scientific study, and practical implementation of these (Abraham

and Michie, 2008; Michie et al, 2011; 2013). Working through Michie et al's 2013 taxonomy, Action Planning (1.4) could be used to generate detailed plans of behavioural performance, with Problem Solving (2.1) used to identify behavioural barriers and solutions. Feedback on Behaviour (2.2) could be utilized after implementation to evaluate performance. Patient and clinician could then Review Behaviour Goals (1.5) to ensure continued health improvement.

Of particular interest in the taxonomy is the recommendation of Distraction (12.4) as a technique to avoid unhealthy behaviour triggers. The physical health increase predicted by Distractibility in the model above could be explained using this prism. An unexpected consequence of distractibility could be that individuals fail to notice unhealthy cues (such as food marketing) resulting in them making less of the unhealthy choices typically facilitated by an obesogenic environment. Practitioners could incorporate Distraction (12.4) as a technique more often, to improve physical health of CR patients. This points to the use of more of what Michie et al's taxonomy designate "Antecedent" techniques, such as the avoidance and reducing of exposure to unhealthy behavioural cues.

Indeed, the lack of predictive value of the other cognitive functions measured suggest that cognitive interventions may be less successful than emotional and environmental ones. As well as cognitive interventions, Abraham and Michie's taxonomy includes emotional and environmental interventions (such as environmental restructuring and emotional control training). The inclusion and development of such interventions in the arsenal of allied health professionals and patients may be a fruitful avenue for improving CR health outcomes.

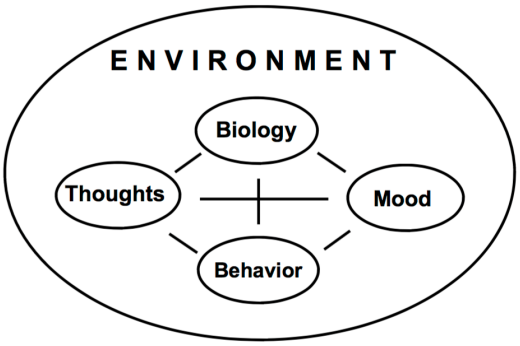
Accommodation for Cognitive Functioning: Formulation & Intervention Using Behaviour Change Techniques

Identifying the point at which self-regulation is most vulnerable to failure may help patients regulate their health behaviour. Formulation models are useful to help conceptualize individual clinical issues to aid understanding (Johnstone and Dallos, 2013; Bruch and Bond, 1998; Persons, 1989; Greenberger & Padesky 1995; Tarrier, 2006). Used in Cognitive Behavioural Therapy (CBT), they provide a:

"Hypothesis about the nature of the psychological difficulties underlying the problems the patient has identified" Persons (1989), p. 37

Organizing self-regulation and its role in health status using the Five Areas Model of Cognitive Behavioural Therapy (Padesky & Mooney, 1990; Greenberger & Padesky 1995; Garland et al, 2002) will serve this in the following section to describe how the current result may be incorporated into practice. Conceptualizing difficulties using CBT formulation strategies has been shown to be effective in dealing with a variety of problems (Taylor and Montgomery, 2007; Dobson & Dobson, 2009; Berking et al, 2010; Berking and Lukas, 2015; Helm et al, 2018) and may be useful here to articulate potential interventions to compensate for executive functioning and self-regulation difficulties. The model presents the relevant domains of a psychological problem in the following manner:

FIGURE 9 The Five Areas Model of Cognitive Behavioural Therapy



Each of the four domains that constitute the individual actor (biology, cognition, affect, and behaviour) exist within the framework of the physical world (the environment) in which the individual abides. Each domain interacts with - and is interacted upon by – each of the other domains (Kuyken et al, 2009). The lack of variance in physical health status predicted by the measures (all cognitive factors) in this study suggest that the unaccounted-for variance in health outcomes resides within remaining domains. Self-regulation and CR interventions can be understood within this framework.

Many self-regulation failures occur when the individual is experiencing negative emotion (Heatherton & Wagner, 2011; Wagner and Heatherton, 2015). When in emotional distress, seeking comfort through alcohol (Witkiewitz & Villarroel, 2009), drugs (Sinha, 2007), tobacco (Magid et al, 2009; McKee et al, 2010), or food (Heatherton et al, 1991; Macht, 2008; Haedt-Matt & Keel 2011) is common (Heatherton, 2011). The literature showing correlations between unhealthy behaviours and negative affect is myriad (Wagner and Heatherton, 2015). This may be the mechanism by which there is a demonstrated inverse relationship in the above results between self-regulation and physical health. As well as negative mood increasing eating amongst dieters (Frost et al, 1982; Heatherton, et al, 1998), episodes of prolonged depression are associated with weight gain (Sinha, 2007; Todd, 2004).

More generally, studies have demonstrated associations between negative affect and preference for immediate over delayed gratification (Mischel et al, 1973; Schwarz & Pollack, 1977; Seeman & Schwarz, 1974; Knapp & Clark, 1991; Tice et al., 2001). This may help explain the positive correlation between physical health and SRQ score. synergism exists between emotional and cognitive states, and negative affect constricts the scope of attention (Friedman & Förster, 2010; Clore et al., 2001; Gasper & Clore, 2002) making individuals pay more attention to immediate and superficial situational features (Keinan, 1987) and less likely to consider future consequences of decisions (Wegener & Petty, 1994). Animal studies suggest that the increased food consumption seen in rats exposed to prolonged stress (Piazza & Le Moal, 1996; Teskey et al, 1984) may be due to stress-induced secretion of glucocorticoids (McEwen et al, 2015; Sapolsky, 2015) which sensitizes the mesolimbic dopamine system to overconsumption by making food and food related cues take on greater reward value (Deroche et al., 1995; Merlo Pich et al., 1995; Peciña et al, 2006; Sinha, 2018). Stress may impact CR patient's self-regulation similarly in like manner. However, it appears that stress in a general sense does not result in decreased eating self-regulation, but food consumption increases when self-perception is impacted by stress (Wagner & Heatherton, 2015) for example, to escape the self-awareness of the negative self-view that dieters typically have of themselves (Heatherton & Baumeister, 1991; Miller & Downey, 1999, Leehr et al, 2015). Self-regulation failure may therefore occur when emotional states overwhelm cognitive control in particular ways.

Interventions that alleviate negative affect and help individuals deal with increased self-awareness may therefore be useful in aiding self-regulation. Having memory aids at hand that increase the cognisance of reward for self-regulation and remind the individual of their progress towards an anticipated long-term goal could improve positive emotion experienced and thus increase self-regulation (Wagner & Heatherton, 2015). At assessment, individuals beginning CR could set goals and create memory aids as an intervention, to facilitate self-regulation as they embark upon rehabilitation. In addition, avoidance as motivation is one of the oldest biological systems evolutionarily speaking (Kenrick and Shiota, 2008; Elliot 2013), and can be utilized in behaviour change. Anticipating regret and feelings of moral obligation (which can both be construed as avoidance motives) increase the likelihood that intentions will be enacted (Abraham & Sheeran, 2004; Conner et al., 2006; Godin et al., 2014) and teaching this as a strategy in CR could be beneficial. Similar interventions are outlined in Michie et al's (2013) BCT Taxonomy (specifically, Monitoring of Emotional Consequences, Anticipated Regret, and Information About Emotional Consequences).

Heatherton and Baumeister (1991) suggested that binge-eating is motivated by a desire to escape self-awareness, where individuals holding negative views of the self (particularly in relation to physical appearance) eat to avoid negative affect by focusing on the immediacy of the situation and ignoring long-term outcomes of present actions. If this model is accurate (although it has been proposed that the purpose of self-awareness may be to enable self-regulation, Carver & Scheier, 1981), it may also explain the correlation between physical health and SRQ score in the results. Interventions would be required to focus upon altering the view of self and improving self-perception, increasing self-awareness and tolerance of the negative affect fueling avoidance (outlined in Michie et al's BCT Taxonomy under Self-Belief interventions). Also, psycho-education sessions on these relationships between cognition, emotion, and health behaviours maybe useful to include in CR. The observed positive correlation between SRQ score and Physical Health in these results would suggest any intervention that could help increase awareness of the unconscious mechanisms impacting health behaviours and may help increase self-regulation.

Self-regulatory failures are common when minor indulgences snowball (Baumeister & Heatherton, 1996) e.g., restrained eaters overindulge after a small failure to adhere to dietary goals (Herman and Mack, 1975; Martin and Tesser, 2014). This seems to be cognitive in nature, where the belief that one's diet is broken results in a deficit of control (Knight & Boland, 1989; Martin and Tesser, 2014) and could be reflected in the inverse relationship between physical health and some aspects of cognitive failures displayed above. Self-Licensing is an intervention whereby an individual allows themselves a justified indulgence, resulting in lowering of feelings of conflict, and self-regulatory efforts can be beneficially directed (Inzlicht & Schmeichel, 2012; Coelho Do Vale et al, 2016; Prinsen et al, 2018). Incorporating this into CR practice could make long-term goals more likely to be achieved.

Progress-monitoring interventions which make executive control explicit by encouraging regular monitoring of progress could also be utilized in CR to increase the conversion of intention into action (Harkin et al, 2016). One such, well evidenced, tool is 'if-then' plans, which involve identifying goal opportunities, obstacles, and ways to respond (Gollwitzer, 1999, 2014). Such plans improve goal achievement and behavioural change more than merely stipulating goals (Gollwitzer & Sheeran, 2006), and help overcome distractions by creating associations between obstacles and responses (Wieber et al, 2015). This could at least partially be responsible for the relationship between health status and goal setting. This bypasses the need for executive functioning at the time of the opportunity and could help compensate for the negative impact that cognitive failures have on physical health that these results indicate (Parks-Stamm et al, 2007; Hallam et al, 2015). Wyer et al (2001c) found that a Theory of Planned Behaviour based letter sent to MI patients increased the likelihood of initial CR attendance, but did not affect compliance rates, with intervention and controls both attending the same number of sessions. This suggests there is some utility in discourse that specifically uses theory-based statements and targets CR attendance by making explicit the normally implicit executive process. Hunter (2014; 2015) evaluated artificial intelligence models that engage in persuasive dialogue with persons making behaviour change choices that could be used in CR. The recent diffusion of artificially intelligent systems (i.e., Apple's Siri, or Amazon's Alexa; López et al, 2017) into everyday use means that a delivery system for such

persuasive argumentation is already in place if this line of enquiry proves successful. The building of such systems would be enhanced by incorporating the general research on reasoned argument in behaviour change (Rollnick & Miller, 1995), and that of individual differences highlighted here.

One problem emerging from the results is the lack of variance in health outcomes predicted by the cognitive factors measured. As discussed above, exposure to overwhelming environmental cues can be a factor in self-regulatory failure (Drummond et al, 1990; Li et al, 2015; Martin-Fardon and Weiss 2017; Pitchers et al, 2018; Payne et al, 2006; Tang et al, 2012). That the above results found a decrease in physical health with an increase in SRQ Distractibility may also point to the role of environmental cues. Often, people are not aware of such cues, as cognitive activation can be implicit (De Ridder and Lensvelt-Mulders, 2018). Conceptualization of such unconscious drivers exists within PRIME Theory (labelled as automatic motivation) although a clearer formulation of cognitive activation (alongside the areas of emotion, habitual and instinctive systems) within this system would present an opportunity to build a platform to better understand unconscious cognitive activation into the pantheon of existing theoretical paradigms. Using some of the extensive research into the role of environmental cues in excessive consumption of food may help develop appropriate CR interventions. Hofmann et al (2008) discussed the role environment can play in the outcome of conflict between reflective and impulsive processing. In the reflective-impulsive model (Strack & Deutsch, 2004), impulsive behaviours are triggered when perceptual input activates associative clusters stored within long-term memory. These associative clusters are activated swiftly by perceptual input from the environment. The lack of predictive power of higher order cognitive factors in this study adds further weight to this model and points to the importance of ensuring subconscious control is made as simple as possible for patients. Neuroimaging studies have suggested that when in emotional distress, reward cues may seem more rewarding (Wagner et al, 2012), and point to the overriding power of emotion over cognition. Raising an individual's awareness and structuring their regular environment in such a way as to minimize cues could therefore be fruitful in minimizing the risk of self-regulatory failure. In their BCT Taxonomy, Michie et al (2013) collated similar interventions under the title of Restructuring the Physical

Environment (12.1) to facilitate performance on desired behaviour. This could be incorporated into CR programmes to compensate for the lack of cognitive impact upon health.

To appropriately restructure the physical environment, one must understand more about the ways environmental cues may cause self-regulation failure. Theories note that environmental cues can activate positive hedonic cognitions regarding temptation (Hofmann et al, 2010; Papies et al, 2008); for example, abstinent smoker's report positive thoughts about smoking upon exposure to smoking cues (Sayette & Hufford, 1997; Sayette et al., 2001; Sherman et al., 2003). Salient tempting cues are more likely to capture the attention also; for example, smokers are more likely to orientate their gaze towards smoking cues when presented amongst other cues (Lochbuehler et al, 2011). The cognitive-neuroscience literature on cue reactivity suggests that conditioned associations between tempting cues and rewarding substances are built up through a long period of exposure, and subsequent exposure to these cues activates motor schemas for consuming the item (Tiffany, 1990). Indeed, smokers show increased representation of and attention to smoking-related motor actions than control subjects (Wagner et al, 2011; Yalachkov et al, 2009). In addition, dieters show increased approach behaviour towards food than controls (Seibt et al, 2007; Veenstra & de Jong, 2010), as do smokers towards cigarettes (Bradley et al, 2003; Mogg et al., 2003; Mogg et al, 2005). Again, such mechanisms may account for some of the variance in health outcomes not accounted for by the model used in this study. Unhealthy behaviours are typically exemplified by immediate benefits and delayed costs, whilst the converse is typical of healthy behaviours. Interventions that focus on cultivating the immediate benefits of positive health behaviours (such as the feelings of enjoyment associated with exercise or mindfully savoring the taste of healthy food) may be a way to use emotional cues to change behaviour in CR patients and improve health outcomes.

The lack of variance in health outcomes predicted by cognitive factors in this study illustrates how powerful environmental cues may capture attention, evoke pleasurable cognitions and override opposing goals. Given the ever-present availability of high

calorie food and alcohol in modern society, and the pervasive advertising thereof (Popkin et al, 2016; Lillard et al, 2016), those with poor executive functioning and self-regulation are often required to navigate an environment for which they may not be equipped (Spence et al, 2016). The specifics of the environment each patient regularly navigates should be incorporated into assessment to formulate the best way for patients to navigate this environment and minimize their exposure to environmental cues (Kober & Mell, 2015). Michie et al's (2013) BCT Taxonomy articulates Avoidance/Reducing Exposure to Cues for the Behaviour (12.3) to help clients avoid exposure to specific behavioural cues. Distraction (12.4) may also be a useful technique when navigating cues where reducing exposure is not practical. Again, these ideas could be used in the individual tailoring of CR interventions for patients.

Overall, self-regulation is a limited resource susceptible to fatigue and the small correlations between health and some cognitive measures here suggests that areas other than cognitive are important in regulating health. The 5 Areas Model (Padesky & Mooney, 1990; Garland et al, 2002) can be used to develop interventions that may improve self-regulation and health. Strategies to enhance emotional, thought, or environmental regulation and social skills training may be useful intervention tools to increase self-regulation and subsequent health status.

Practice Development - Accommodation for Cognitive Functioning: Optimizing Education Sessions

Traditionally, didactic instruction is the most used method of communicating information within educational environments (Nie et al, 2013). The effectiveness of didactic teaching has been questioned (Evans et al, 1989; Roche et al, 1996; Nie et al, 2014), and retention of information from such settings is poor for highly successful learners (Madan et al, 1998) as well as those with poor executive functioning (Ozonoff et al, 1991; McMahon et al, 2013). In addition, didactic teaching is not as effective a method of behaviour change as other methods (Cornuz et al, 2002). The use of such teaching methods and subsequent poor knowledge may be partly responsible for the relationship between physical health and Zoo Map score noted

above (see Table 10). Phase 3 CR classes are required to incorporate teaching sessions that give information on health behaviour change, but guidance with regards the way training and teaching is to be carried out is limited (BACPR, 2016; BACPR, 2017). Educational content is specified in the BACPR guidelines, and sessions are required to address smoking cessation, healthy eating, body composition, physical activity/exercise, and medical risk management, but the focus of the guidelines seems to be content, rather than the method of delivery (BACPR 2017). While didactic instruction may be an important component of teaching sessions, consideration should be given to alternative evidence-based teaching methodologies. Imitative Learning is one of the primary ways humans learn (Bandura, 1977) and aids learning across an array of healthcare situations (Bartholomew et al, 2019; Leventhal, 2019), as has the use of successful role models (i.e., "buddying" Webb et al, 2010; Clark et al, 2012). Such mentoring systems should be encouraged in CR to encourage self-regulation and positive health.

Stuart et al, (2004) highlighted the lack of awareness of evidence-based teaching practice amongst behavioural healthcare providers, and more recent work on the skills and knowledge required for successful patient education for CHD makes no mention of teaching theory (Svavarsdóttir et al, 2016). This needs to be addressed, as educational research continually underlines the importance of education delivery method as being fundamental to retention of content (Goldberg et al, 2006; Chen and Jones, 2007; Hardiman et al, 2014; Czaja & Sharit, 2016; Shatto et al, 2017) and implementation of change (Greenwald, 1968; Eldredge et al, 2016; Reis et al, 2016; Petty et al, 2018). The results of this study indicate that it would be pertinent for CR educators to have knowledge of their patients cognitive (and potentially emotional and social) functioning, as to do so would inform them as to how best to educate and strategize with clients about lifestyle and behaviour change. However, before the cognitive needs of the individual are taken into consideration, a rudimentary understanding of effective teaching would be a useful beginning. Within current scholarship, there seems to be a disconnect between the teaching literature and that of health behaviour change, despite the clear conceptual overlap. Highlighting the significant correlation between cognitive features and health outcomes may help to bridge the gap between these two scholarly fields. There is a developing literature on teaching techniques that demonstrate improved learning, and the results of this study

suggest that the adoption of these into CR education sessions in a formal and systematised manner could be a useful way to begin to contend with the role executive functioning plays in patient health outcomes.

Paradigm shifts in educational session delivery are complex and require organizational level policy change (Daun, 2018; see the policy review above). However, some simple teaching techniques could be implemented in sessions to aid those who are low on Self-Regulation. Revisiting information after initial learning aids recall (Craik, 1983; Brandimonte et al, 2014), and goal orientated content delivery increases information retention (Kyndt et al, 2016), as does using a multisensory teaching approach where visual, kinetic, tactile, and auditory techniques are combined (Jasmine and Connolly, 2015). Some very simple techniques such as note taking (Kiewra, 1987; Good and Lavigne, 2017) and using story narrative to illustrate arguments (Hall Pistorio et al, 2017) also aid learning. Given the correlations in the results between of concurrent decreased in cognition and health, such techniques would help scaffold patients' learning and mitigate against cognitive failure.

Practice Development: Accommodation for Cognitive Functioning - Utilizing Alternative Teaching Paradigms

The size of both Phase 3 and 4 CR classes may lend themselves to the implementation of teaching techniques developed for small groups. Collaborative learning is one such technique, where learners work in pairs or small groups to achieve shared goals (Dillenbourg, 1999). Because the above correlations between Zoo Map score and physical health suggest that improved planning is correlated with improved physical health, interventions that share the goal structing burden amongst peers may prove to be a way to facilitate better outcomes for patients. Of particular interest in CR is the idea of using collaborative learning to explore participants' intentions to implement rehabilitation-related information (Barkley et al, 2014). Collaborative learning could be used as a means of developing peer support (Shen et al, 2004; Cuthbertson et al, 2018) and exploring social norms regarding behaviour change (Ajzen & Madden, 1986). Collaborative learning can also take place using long-term "learning communities", where learners are grouped together over a longer time span to support each other (Gabelnick et al, 1990; West and Williams, 2017). CR attendees could be

molded into such communities to support each other as they wrestle with incorporating behaviour change into everyday life. This may provide those with poor executive functioning an additional source of ideas, feedback, and encouragement, accommodating for their executive functioning status. The lack of relationship that goal setting has with physical health in this study suggests that current methods of goal implementation are not effective and forging such communities may help reverse the trend.

Active learning is a teaching strategy that engages the student in the learning process more than other methods (Bonwell, & Eison, 1991). In this paradigm, merely listening to didactic teaching is not enough: problem solving, reading, writing, and discussion are all instrumental in achieving learning (Bloom et al, 1956). Learners sit less (Baepler et al, 2014) and engagement is enhanced through negotiated, purposive goals and reflection upon situational specifics to establish links between learning and practical application (Barnes, 1989; Shinde et al, 2017). The lack of relationship observed between physical health and goal setting may be due to goals being set without negotiation (i.e., smoking cessation may be assumed as a goal by both health professionals and the individual themselves, rather than one that is negotiated), which may result in reduced motivation and poor health behaviour management. Active learning shares conceptual similarities with working memory training (designed to improve executive functioning – see below), where capacity to process novel information and direct attention to goal-related stimuli is cultivated (Shipstead et al, 2015). There exists literature that supports the principles behind active learning (Bonwell and Eison, 1991; Prince, 2004; Barkley and Major, 2018) and learners prefer active learning to traditional didactic methods (Knowles, 1990; Tsang and Harris, 2016; Gordy et al, 2018), although research tends to focus on formal students in education establishments rather than patients in healthcare settings (Michael, 2006; Makopoulou, 2018). Standen et al (2018) suggested various techniques for teaching self-regulation and eating, including using stories to illustrate points regarding diet, and devising an implementation intention plan. Devising an implementation intention plan where the individual negotiates with themselves may be necessary to establish the desired relationship between physical health and goal setting.

There is a dearth of the use of such methods in the psychoeducational components of many CR programmes (Ski et al, 2016; Piepoli et al, 2014). However, active learning requires learners to perform "higher-order thinking" involving analysis, synthesis, and evaluation (Braxton et al, 2000; Renkl et al, 2002; Freeman et al, 2014), which are indeed the very skills that executive functioning affords and those that a handful of the above results suggest are significantly correlated with physical and mental health. The circular nature of the problem thus presents itself. It may therefore be useful to turn to perhaps a more radical strategy: that of improving self-regulation and executive functioning.

Practice Development: Improving Self-Regulation and Executive Functioning

Given the very small variance in cognitive structures associated health, and the sparse and weak correlations demonstrated, it must be noted that even if largescale changes in cognitive performance were achievable, the above results suggest this would result in minimal health gains for CR patients. However, even small gains in overall health status can have a significant impact at the individual level, and therefore any avenue that offers the potential for increased health should be explored.

Traditionally, adult cognitive functions were viewed as static, cemented by biological disposition and early development (Gross, 2016). However, early neuroscientists developed the concept of neuroplasticity (Konorski, 1948; Buonomando & Merzenich, 1998) whilst labouring against academic dogma (Doidge, 2007), referring to the brain's ability to remodel and change in response to new situations (Demarin et al, 2014). The idea that neural networks are not fixed is a hopeful one for Cardiac Rehabilitation, as it suggests that executive functioning training could result in more positive health outcomes, albeit moderately.

The case has been made that some executive functions may be trainable, and training may result in improved self-regulation (Jaeggi et al, 2008; Hofmann et al, 2012). Such training might be useful if cognitive improvements transcend the practiced task into everyday cognitive functioning (Thorndike, 1906; Barnett & Ceci, 2002).

Evidence suggests some tasks may improve executive functioning. Diamond and Ling (2016) found at least one peer-reviewed paper supporting the effectiveness of various activities in improving executive functioning: computerized training, games, aerobics, resistance training, martial arts, yoga, and mindfulness. It is beyond the scope of this thesis to provide a comprehensive review of each, but a summary of the conclusions arising from the literature on the different methods and the significance for CR is in order.

Early work found associations between memory training and neurological changes. Olsen et al (2004) found that 5-week practice on working memory tasks increased brain activity in the middle frontal gyrus and the superior and inferior parietal cortices. Klingberg's (2010) review of memory training literature observed effects of working memory training on frontal and parietal cortex activity, the basal ganglia, and dopamine receptor density. Shipstead et al's (2012) review found evidence that working memory training effects extended to general fluid intelligence and attentional control. The results of the present study suggest that if working memory training does generalize in this manner, the incorporation of such training could help improve physical health as there is conceptual overlap between working memory and executive functioning (Panesi and Morra, 2016; Gottwald et al, 2016; Kane and Engle 2002), although the evidence is not strong enough at this point to culminate in policy change recommendations (Friedman and Miyake 2017; Lehto, 1996).

The commercially popular phenomena of "brain training" (a term which has entered the public lexicon as synonymous with any intervention where cognitive tasks are translated into computerised games, then marketed as tools to maintain and increase cognitive ability, Owen et al, 2010) became an area of interest in the last two decades (Ball et al, 2002; Green & Bavelier, 2003; Fuyuno, 2007) as a plethora of commercial companies claimed their products were based on neuroscience research (Lumosity, 2020a) and could help one "improve memory, increase focus, and feel sharper" (Lumosity, 2020b). As our results show positive correlations between physical health and BADS planning and strategizing, such claims are promising as (should they prove true), these tools could be utilized to increase the strength of cognitive functioning in CR patients. However, as early as 2014 there was descent from the academic community regarding such claims (Max Planck Institute, 2014) and in 2016 the US

Federal Trade Commission charged Lumos Labs with "deceptive advertising" (Federal Trade Commission, 2016a, 2016b) concerning some of the claims made regarding product efficacy.

If there is merit in using such training, they could be used in CR to improve patient's cognitive abilities and potentially their health. Simons et al's (2016) review on generalizing gains made on brain training tasks to performance on other tasks or daily functioning found limited evidence for the transfer of improvement made on training tasks to even closely related tasks, and scant evidence that training improved performance on distantly related tasks or everyday cognitive functioning. In a meta-analysis, Bediou et al, (2018) found that commercially available video games had limited impact upon cognition. Practice on brain training games appears to improve performance on the same game, but gains do not generalize to other cognitively demanding tasks (Oei and Patterson, 2014; 2015, Morrison and Chein 2011; Kable et al, 2017). This suggests that the adoption of such training into CR would be of little or no benefit.

Simons et al (2016) also noted that the mechanisms by which brain training gains are made are rarely defined by studies claiming improvements. Along with many other practice regimes, brain training relies on the vertical transfer of learning: the ability to solve similar problems using previously acquired knowledge (Seel et al, 2017). The evidence suggests that it is difficult to achieve such vertical transfer through brain training (Simons et al, 2016; Bediou et al, 2018; Sala et al 2018). Given that healthcare practitioners are not only interested in the impact of cognitive training on executive functioning, but the subsequent impact of executive functioning upon health (a further causal step away from cognitive training), one would wish to see a large effect of brain training on cognitive functioning to have a clear rationale for implementing training in CR in the hope of increasing actual health. Any plans to utilize brain training as a standard aspect of healthcare rehabilitation programmes would therefore seem to be premature at this stage.

One lesson from the more general cognitive training literature is that training enhances performance of practiced tasks or nigh identical tasks, but improvements do not easily generalise (Diamond and Ling, 2016; Noack et al, 2009; Stine-Morrow &

Basak, 2011). For example, working memory training enhances working memory and may produce a reduction in inattentiveness in daily living (Diamond and Ling, 2016) but has no effect on self-control, creativity, flexibility, general attention (Nutlet et al, 2011; Harrison et al, 2013; Melby-Lervåg and Hulme, 2013; Spencer-Smith and Klinfberg, 2015). Given the correlation between impulse control and health in the results above, a training task which taught how to resist impulsive eating could be the most practicable way to implement learning. Any claims made for the benefits of training would have to be specific about which exact training affected which exact cognitive skill.

Despite this, with regards health behaviours, Houben et al (2011) found working memory training effected impulsive alcohol consumption in hazardous drinkers. Houben and Jansen, (2011) found that training to strengthen food-related inhibition reduced chocolate consumption, while Veling et al, (2011) found the same training reduced impulsive eating. Such patterns of change would suggest that developing appropriate interventions requires specifying what aspects of cognition and/or emotion might impact upon the precise health behaviours practitioners are looking to improve, and then to develop specific interventions designed to have a very particular effect. It may be that individual assessment of patients would be required to ascertain the exact role specific individual differences are playing in their health behaviours, and then interventions tailored accordingly. This would be particularly true if interventions were being implemented to impact Distractibility as the above results show an inverse relationship between health status and Distractibility, and therefore decreasing distraction might be counterproductive. However, before the implementation of such procedures into practice, the results presented above would have to be replicated in disparate samples to cement the findings.

Rather than the repetition of abstract, nonrepresentational tasks being used to develop task performance with the hope of vertical transfer, improving cognitive functioning (if possible at all) requires consistent practice in trying to tackle domain-related challenges in complex environments where such challenges are present (Diamond and Ling, 2016; Ericsson, 2006; Ericsson & Charness, 1994; Ericsson et al, 1993; Grossmann et al., 2012; Rohwedder & Willis, 2010; Schooler & Mulatu, 2001; Schooler et al, 1999, 2004; Simonton, 2000; Staudinger, 1996; Staudinger & Baltes,

1996; Stern, 2009). This means that within Cardiac Rehabilitation, the practice of specific skills regarding resisting food temptation and practice in engaging in exercise are most likely to be effective, and the relationships (and lack thereof) in the data above support this.

The literature on the benefits of physical activity on cognitive functioning and how this informs the results above is equally nuanced. Aerobic exercise with no cognitive component (such as running on a treadmill) does not improve cognitive functioning (Smiley-Oyen et al, 2018; Krafft et al 2014; Smith et al 2010; Angevaren et al, 2008) but exercise that includes cognitive work such as planning, problem-solving, working memory, concentration, or inhibitory control can benefit executive functioning (Williams, and Lord, 1997; Moreau et al, 2015; Oswald et al, 2006). This is interesting to consider when pondering the nature of CR classes, where exercise is prescriptive and typically specifically designed to not involve cognitive load, but merely copying the movements of an instructor (Dingwall et al, 2006; Thow, 2009). It would suggest that the relationship between physical and cognitive fitness can be circular (although the above results suggest the relationship is minimal) and incorporating elements of cognitive work into classes could potentially result in a virtuous circle effect. Given the relationships demonstrated in this study between cognitive failures, SRQ and physical health, exercise that includes cognitive work could potentially be used to develop these cognitive skills, and such improvement could result in better health status.

Investigation into increasing self-regulatory capacity has been completed in the hope that self-regulation training would result in greater self-regulatory success (Heatherton & Wagner, 2011). Baumeister and Heatherton's (1996) model stipulates that self-regulation is a finite resource that can be exhausted, but capacity can be increased through training and practice. Training typically focuses upon engaging in small acts of daily self-control (e.g., maintaining good posture; Muraven et al, 1999) or (in terms of health behaviour change) engaging in easier self-control tasks (such as healthy eating) before beginning difficult ones (such as smoking cessation; Gailliot et al, 2007b). Indeed, recent meta-analyses show regular self-control exercise in one domain may be transferrable to others (Friese et al, 2017; Beames et al, 2017). Though publication bias may have inflated the effect sizes, these ideas do have

implications for interventions. Incorporating training on simple self-regulation tasks into CR could be a useful way to increase self-regulation on health-related lifestyle factors.

Future Research

All research projects point to the need for further investigation. Issues arising from this study are detailed below.

Future Research: Methodological Considerations

This study tracks the impact of cognitive factors upon health outcomes. It could be argued that the relationship between the two is often mediated by health behaviours (for example, the inability to plan, resulting in inadequate meal preparation routines, meaning more unhealthy snacking and lower risk of obesity). As such, modelling that includes measures of health behaviours as well as health status would be an area for further investigation (Ajzen, 1991; Norman et al, 2005). This might shed light upon how different aspects of cognitive functioning impact specific health behaviours and would afford greater insight into how to support individuals to maintain and improve health (Sharma, 2015).

Using multiple measures to investigate any psychological phenomena affords the opportunity to estimate the relative quantities of signal and noise in a study (Ansolabehere et al, 2008; Field, 2013), and while this study included several self-report measures (SRQ and CFQ), to include multiple objective measures of executive functioning unfortunately would require resources that were beyond the scope of this doctoral thesis. Future studies investigating executive functioning and health outcomes in CR would do well to include multiple measures in addition to the BADS, such as the Wisconsin Card Sorting Test (WCST; Grant and Berg, 1993) and the Cambridge Neuropsychological Test Automated Battery (CANTAB; Sahakian et al. 1988).

Replication is a cornerstone of science and differentiates science from non-science and pseudo-science (Dunlap, 1926; Collins, 1992; Popper, 2005), and one that has been absent from much of the psychological literature (Open Science Collaboration, 2015; Pashler and Harris, 2012; Simons, 2014). Given the fact that the data did not

show the relationships between cognition and health that were hypothesised, it would be useful to complete a replication study carried out to confirm the results.

Future Research: Positive Feedback

Correlational results give weight to the theory that a positive feedback loop may exist between self-regulation and mental health. Further investigation into this is required to fully understand this phenomenon. The existence of positive feedbacks may increase complexity, expedite change, or trigger multiple stable states in the underlying system (Ben-Yam, 2002; Kiel, 2009) and knowledge of this would aid our understanding of how to best develop interventions appropriately. Environmental and biological sciences use complexity modelling to investigate the properties and functions of positive feedback within systems and how they generate behaviours (Mitrophanov and Groisman, 2008; DeAngelis et al, 2012; Sheikholeslami and Razavi, 2016) and more recently complexity theory has been applied to health (Sturmberg, and Martin, 2013) and social sciences (Turner and Baker, 2019). The present study uses a traditional reductionist framework to investigate the variables defined (Westhorp, 2012), modelling the phenomena of cognitive functioning as a system consisting of subcomponents (Caws, 2015). Conceptualising cognitive functions as complex systems would provide the opportunity to investigate phenomena that characterise such systems (including feedback loops) and other properties such as emergence (Nicolis and Nicolis, 2012; Gignoux et al, 2017), adaptation (Tu and Rappel, 2018), and spontaneous order (Luban, 2020).

Future Research: Neurobiological Modelling

While this paper uses neuropsychological measures to quantify executive functioning phenomena, future research could go further by investigating the neurobiological underpinnings of self-regulation using an understanding of biological mechanisms themselves. Self-regulation appears to be associated with three areas of the prefrontal cortex: ventromedial prefrontal cortex (vMPFC) including orbitofrontal cortex, lateral prefrontal cortex, and anterior cingulate cortex (ACC; Rudorf, and Hare, 2014; Kelley et al, 2015). Damage to the vMPFC appears to result in patients being less able to regulate social, affective, or appetitive behaviors (Wagner & Heatherton 2010;

Delgado et al, 2016; Hiser & Koenigs, 2018). Participants attempting to suppress activation of reward systems show increase lateral prefrontal cortex and anterior cingulate cortex activation (Beauregard et al. 200l; Brody et al. 2007; Del Parigi et al. 2007). There is also evidence that vMPFC has a crucial role in supporting awareness in learning (O'Callaghan et al, 2018) and episodic future thinking (Bertossi et al, 2017). Incorporating feedback from others (i.e., adjusting to social norms) can be problematic for such patients. In contrast, patients displaying lateral prefrontal cortex damage can abide by social norms and inhibit inappropriate behaviour. These patients, however, struggle with planning and initiating behaviours, especially complex behaviours designed to achieve complex goals (Stuss & Benson 1986; Wagner & Heatherton 2010). They can also be disorganized and easily distracted (Nee & D'Esposito, 2016). The ACC region is associated with the ability to carry out goal directed behaviours (Cohen et al. 1999; Botvinick & Cohen 2014; Shenhav, et al, 2016), and resist temptations (Botvinick et al. 2001, Kerns et al. 2004, Paus 2001, Peterson et al. 1999). All these self-regulation-related abilities associated with the prefrontal cortex are required for anyone concerned with long-term health management, and particularly those suffering from chronic health conditions. A detailed investigation of prefrontal cortex functioning in CR patients attempting behaviour change may provide insight into the specific nature of their cortical functioning and increase understanding of the neurobiology underpinning change.

Other brain areas may also be involved in self-regulation. Studies investigating decision-making have shown that prefrontal cortex areas are associated with long-term outcomes and subcortical areas associated with short-term ones (Heuttel, 2010). Results from animal studies show that consumption of rewards or rewarding activities is accompanied by activation in both the orbitofrontal cortex (a subcomponent of the prefrontal cortex) and the mesolimbic dopamine system (Boileau et al. 2003, Carelli et al. 2000, Damsma et al. 1992, Everitt 1990, Kringelbach 2005, Schilström et al. 1998). Similar results demonstrating this duality have been shown in neuroimaging studies in humans, where reward consumption is associated with increased activity in the ventral striatum and the orbitofrontal cortex (Breiter et al. 1997, Gottfried et al. 2003, Kringelbach et al. 2003). Indeed, it appears the same brain areas can be activated by exposure to reward cues (food cues, attractive faces, etc.) as well as the reward itself (Cloutier et al, 2008; Knutson et al, 2005; Somerville et a, 2011; Van der

Laan et al, 2011). Furthermore, Lopez et al (2014) demonstrated that in relation to eating, food cue reactivity in the nucleus accumbens (part of the mesolimbic dopamine system) played a significant predictive role with regards to the strength of desire for food, eating behaviour, and amount consumed, and in contrast, activity in the inferior frontal gyrus supported resistance to temptation. This research (and the lack of health outcomes predicted by executive functioning in this study) suggest that an appropriate neurobiological approach to investigating health decision making must move beyond merely the prefrontal cortex to include other neurological phenomena, such as dopaminergic pathways. Future research on the prefrontal cortex therefore requires the modelling of the mesolimbic dopamine system also.

The tightknit relationship between regulation and emotion is hinted at here. It seems that self-regulation itself is a finite resource that can be exhausted by an array of activities, including emotional inhibition (Vohs & Heatherton, 2000), managing social impressions (Vohs et al, 2005), and thought suppression (Muraven et al, 2002). There is also evidence that those with anxiety and mood disorders have reduced connectivity between the prefrontal context and the amygdala (Johnstone et al, 2007; Kim & Whalen 2009), an additional concern for anyone suffering from a long-term physical health condition who has also experienced mental health challenges. Considering the lack of a biologically specific mechanistic model for self-regulation depletion, Gailliot & Baumeister (2007) proposed that self-regulation relies on blood glucose circulation and demonstrated that blood glucose levels are reduced by acts of self-control (Gailliot et al, 2007a; 2009; Gailliot, and Baumeister, 2018). An abiding idea is that self-regulation requires a balance between impulses and self-control (Baumeister & Heatherton, 1996; Metcalfe & Mischel, 1999; Hofmann et al, 2009a; Heatherton & Wagner 2011). Such duality seems to bear up in neuroimaging studies, as substantial evidence exists for connectivity and common activity between frontal and subcortical areas where impulses originate (Banks et al, 2007; Li and Sinha, 2007; Somerville et al, 2010). Modelling both frontal and subcortical areas must there be the way forward when developing future research into the neurobiological structures underpinning decision making.

Future Research: The Amygdala–Prefrontal–Lateral Hypothalamic System

Modelling the health of CR attendees using knowledge of how other areas of the brain interact with prefrontal cortex functions may produce a more accurate understanding of the factors impacting health behaviours. One method of investigation is to identify the areas of the brain to which the prefrontal cortex sends and receives neural projections, and to investigate the topographical organization of these connections (Martin, 2006). The prefrontal cortex sends sizeable inhibitory projections into the limbic system, (specifically the amygdala - an area implicated in negative emotion) to assert impulse control (Sapolsky, 2004; Pinard et al, 2012; Benarroch, 2015). Raised metabolism in the prefrontal cortex is associated with lower rates of activity in the amygdala (Urry et al, 2003). Conversely, the prefrontal cortex also receives projections from parts of the amygdala, possibly hinting at why strong emotions can inhibit executive functioning (Fuster, 2015; Folloni et al, 2019). The role of the amygdala and its relationship with the prefrontal cortex is not explored in this paper, and further investigation should provide more understanding of its role in motivation and volition in CR patients' health behaviours.

The hypothalamus is a brain area that regulates drive towards biological goals (i.e., autonomic function) and is complicit in the most fundamental elements of behaviour, setting the organism into motivated frames until those frames have been satiated (Dampney, 2011; Sapolsky, 2017). The hypothalamus consists of a series of impulsive uni-dimensional systems (hunger, thirst, defensive aggression, etc), each of which are only 'concerned' with the achievement of their aim (Swanson, 2000). The lack of health outcome variance predicted by cognitive factors in this study suggests close attention should be paid to these psychological systems. The interaction between the hypothalamus and more evolutionarily recent parts of the brain (such as the prefrontal cortex) aims to solve the problems of organising oneself and one's basic motivations in more complex forms of being that transcend immediate gratification (Vertes, 2006). The existence of projections between the hypothalamus and prefrontal cortex (as well as the nature of the topographical organization of these connections) is therefore of interest to Health Psychologists investigating the neurology of motivation. Interestingly, the prefrontal cortex appears to receive diffuse and numerous projections from the hypothalamus, and those descending from the

prefrontal cortex to the hypothalamus are highly specific (Rempel-Clower and Barbas, 1998), suggesting that the influence of the hypothalamus on the prefrontal cortex is greater than the reverse.

Future Research: Neurotransmitters

Knowledge of the role specific neurotransmitters' play in health behaviour would also be an area for further study. The mesolimbic pathway is a dopaminergic pathway that originates in the ventral tegmentum and passes through the nucleus accumbens before projecting into the prefrontal cortex. This pathway has been demonstrated to be involved in mediating pleasure and reward (Wise, 2006; Anstrom et al, 2009). One could assume that this dopaminergic structure would cause the prefrontal cortex to become active in response to reward. However, it has been demonstrated experimentally that dopaminergic neurons and prefrontal cortex neurons are more heavily responsive to anticipation of reward, rather than reward itself (Schultz et al, 2000; Kropotov, 2010). Indeed, activation in anticipation of reward seems to be at the core of the prefrontal cortex's function (Sapolsky, 2004). Again, this points to the need for investigations to take account of emotion more so than the model outlined in this study. Interventions such as those outlined above that increase the cognisance of reward (and therefore the anticipation thereof), are likely to increase the likelihood of compliance and change.

Dopamine receptor stimulation has also been shown to have an 'inverted-U' shaped relationship with working memory, in that too much or too little stimulation impairs working memory performance (Floresco and Phillips, 2001; Phillips et al, 2004; Sawaguchi and Goldman-Rakic, 1991; 1994; Seamans et al, 1998). Other research has shown that blocking dopamine receptors impairs shifting mental set while also impairing working memory (Mehta et al, 2004). It may would be fruitful therefore to investigate whether increasing dopamine in CR patients could therefore help to boost executive functioning and self-regulation and whether this has a subsequent impact upon health.

Areas of Expertise

At the heart of this paper are the cognitive science issues of planning and impulse control and their role in health behaviour. Concerning this issue, it is important to consider some of the cultural differences between the world of healthcare provision and academia (Gaukroger, 2008; Chemla and Keller, 2017). Academia relishes a world of complexity and perceives imperfect evidence as motive for further hypotheses and study, resulting in a more nuanced understanding of any phenomena (Dunbar and Fugelsang, 2005; Erduran, 2020). This is the origin of witticism that science comprises individuals learning more and more about less and less until they know everything about nothing (a quip traditionally attributed to Nobel Laureate Konrad Lorenz; Logan, 2018). Conversely, healthcare providers are required to traverse this world of complexity yet still provide economical, timely, and effective clinical interventions (Belar and Perry, 1992; Wolf, 2007; Mackey and Bassendowski, 2017). The current literature regarding the neuroscience of decision-making therefore does not easily translate into such interventions – an issue this paper has attempted to be cognisant of when making recommendations. There is a need for Health Psychology to begin to bridge this divide more successfully.

Limitations

A new consensus regarding the modelling of cognitive ability is emerging within the current literature, and the results of this study can and should be considered within this understanding. The lack of predictive power in the results may partially be due to the underpinning conceptualization of executive functioning, specifically the interspersion of factors being measured by executive functioning tests between the third tier of the CHC model. Were the CHC constructs with the strongest correlations with health status utilized as measures, there may be a stronger possibility of achieving significant results.

The issue of sampling the hidden population of those not in attendance at Phase 4 programs persists. Studies show that 39% of CVD patients do not attend cardiac rehab upon discharge, and a further 13% do not take part in the programme once signed up (British Heart Foundation, 2017b). Technological solutions to the problem of contacting hidden populations have been suggested (Matthews and Cramer, 2008;

Ellard-Gray et al, 2015; Tuttas, 2015) and may be a fruitful avenue for future research in phase 4 CR. In a systematic review Bonevski et al, (2014) summarized the research that describes strategies for improving representativeness. Non-probability sampling strategies (such as snowball sampling) were advocated over and above random sampling to reach hidden populations. Increasing the cognisance of CR researchers of common barriers to the recruitment of hidden populations (i.e., stigma, cultural beliefs, etc) would a be useful starting point in incorporating an understanding of these populations into the field (Ellard-Gray et al, 2015).

The population that any study attempts to address its findings towards is characterised by a wide array of features to consider. The only generic demographic characteristics this study measured were gender and age, and waist circumference was the sole health outcome predictor quantified. Measuring other variables may have helped to better describe and understand the population in question. Specifically, consideration of comorbidities, socioeconomic status, and individual differences may have provided further insight into health status. Different underlying cardiac conditions present with slightly different symptoms, and such nuances could potentially mediate or moderate the relationship between executive functioning/self-regulation and health outcomes. Socioeconomic status is also known to predict health status (Guralnik et al , 2006; Braveman and Gottlieb, 2014) and may have accounted for some of the variance left unaccounted for by each model. In addition, the psychological literature could be further surveyed to explore those differences across populations that impact CR health outcomes. The differential psychology literature investigates individual differences in behaviour and related underlying psychological processes (Chamorro-Premuzic et al , 2015), and consideration of personality, temperament, motivation, interests, and values, could have taken place to better describe and understand the population in question (Strickhouser et al, 2017) The practicalities of data collection mean that decisions must be taken regarding the balance between collecting data with maximum utility and the potential to overwhelm participants with questions, thus decreasing the likelihood of a complete questionnaire. A future replication of this study could supplement the measures used with ones that assess socioeconomic status, disease diagnoses, and individual differences. This could offer further insight into the nature of the population who experience cardiovascular disease and advance our understanding of the mechanisms underpinning health.

Ecological validity refers to the degree to which performance upon tests can be generalized to real-life settings (Sbordone, 2008). There are criticisms of psychometric tests' abilities to accurately predict how an individual behaves in their environment, particularly when scores are in the normal range (Sbordone, 2008), although the BADS has been shown to be able to distinguish between neurologically impaired and non-neurologically impaired groups. The BADS has veridical ecological validity (Norris and Tate, 2000), but no tests of verisimilitude have been carried out (Sbordone, 2008). The purpose in using tests of executive functioning is to examine the actual ability underlying the perceived ability that is reported using self-reported measures. On the outcome side of the model, self-reported health was used as the outcome measure. Ecological validity of the SF-12 has not been tested in the literature, though it is extensively used. A less biased way to measure health would be observed behaviour. Ideally, the study would have measured physical health directly using a measure such as body fat (Durnin and Womersley, 1974) or the shuttle-walking test (Keell et al, 1998) but constrictions upon resources rendered this unpractical.

The role of the CFQ subscales in the model is also interesting to note. The CFQ was specifically designed to be non-specific with regards the underlying cognitive processes it assessed, as it was conceptualized that multiple processes may be associated with lapse (Broadbent et al, 1982). Pollina et al (1992) propose that the questionnaire is composed of five factors, whilst Matthews et al (1990) name seven and Larson et al (1997) suggest a two-factor solution. To add to the confusion, some items directly measure attention lapses, whilst some measure errors that result from such lapses. The CFQ measure also seems to be associated with neuroticism (Matthews et al, 1990; Wallace, 2004) as conceptualized by Eysenck (1963). More clarity on these issues would be beneficial for studies using the CFQ to draw scientific conclusions, such as the present one.

The current study measured cognitive functioning and health status at one time, carrying out correlational and regression analysis to ascertain the relationships between these variables and found limited evidence of significant relationships between the variables. In a series of studies measuring cognitive functioning over

more than one time period, Benvenuti et al (2013; 2014) found that preoperative cognitive functioning was associated with change in behavioural capacity through the rehabilitation process in cardiac surgery patients. In Coronary Artery Bypass Graft (CABG) surgery patients, Phillips-Bute et al (2006) found an association between cognitive changes and quality of life changes over 1-year post surgery. These patients could all be considered a subcategory of outpatients, and all had come through surgical interventions, but these studies also all measured cognitive functioning and health across time. Future studies with CR patients could utilize a similar longitudinal design, perhaps measuring cognitive functioning at the beginning of the rehabilitation process and change in health status over time at the outcome measure.

One can look at the correlation coefficients to represent the magnitude of the association between the variables measured in this study (Cohen, 1992). According to traditional analysis none of the effect sizes across variables could be considered large (Cohen, 1988). Gignac and Szodorai (2016) ascertained that effect sizes of psychological variables in the published literature are typically small to medium in magnitude when considered within this traditional framework, and recommended that correlations of 0.10, 0.20, and 0.30 be respectively seen as small, typical, and large.

Conclusion

In addressing the subject of psychological and neurological conceptualization, Haier (2016) said that three rules should govern investigation: 1) No account of the brain is straightforward; 2) No single study is authoritative; 3) It takes lengthy periods of time and much sifting of conflicting and incompatible results for any scientific consensus to appear on any issue. The results of this study would appear to fit well into this description. The thesis has led to the creation and interpretation of new knowledge through original research by providing a new understanding of the way cognitive functioning may impact upon the health of cardiac patients. The design of the study springs from a critical understanding of the current state of knowledge within the field of long-term health management. A critical understanding of research methodologies was used to develop the appropriate methodology to answer the hypotheses stipulated. The results and discussion demonstrate an ability to conceptualise, design, and implement research that is at the forefront of the integration of historical disparate

areas of psychological theory and practice. In addition, the thesis has demonstrated the ability to both develop and communicate independent judgement concerning research and practice within cardiac rehabilitation. Both strengths and weaknesses of the study have been evaluated and considered in the development, implementation, and communication of the project.

The role played by cognitive factors in predicting health status of CR patients helps to explain some of the limitations of existing social cognitive models of health behaviour, including the lack of conceptualisation of neurobiological factors such as executive functioning. Although the most prominent feature of the results is the lack of variance in Physical and Mental Health predicted by cognition (save distractibility), the direction of the predictive relationship and the configuration of correlations would suggest a more complex model than that which first appears.

The role of executive functioning in health status would appear complex. One can contemplate the nature of cognition as defined and delineated in the literature, with the *g* factor seemingly emerging as a consensus regarding the existence of one factor underpinning and defining all intelligence. However, the different relationships between health outcome and some of the subcomponents of the cognitive tests deployed in modelling (particularly the correlational data and the inverse relationship between distractibility and physical health) suggests that there is still a case to be made for differentiating between cognitive phenomena and their impact upon real world variables. The sparsity of variance predicted by cognitive factors suggests that other psychosocial factors (emotion, biology, and environment) should be investigated as sources of potential variance in outcome. As more evidence like that demonstrated in this study emerges, researchers, policy makers, and practitioners alike will be required to incorporate the growing understanding of the role of cognitive variables in health into their respective disciplines.

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Appendices

Appendix 1 - Participant Information Sheet

The Impact of Executive Functioning on Phase IV Cardiac Rehabilitation Outcomes

Participant Information Sheet

What is the Study?

This study is looking at how planning and problem solving skills (also known as "executive functioning") affects the health and well being of phase IV cardiac rehabilitation attendees. We are interested in what how these skills relate to the health of phase IV cardiac rehabilitation participants. We are asking all people who attend this class to take part in this study.

Introduction

You are being invited to take part in this research. Before you decide it is important for you to understand why the research is being done and what it will involve.

Please take the time to read the following information carefully and discuss it with the class leader and the researcher if you wish. Ask us if there is anything that is not clear, or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

What is the purpose of this study?

Previous research has shown that individuals planning and problem solving can affect different aspects of health. However, there is little information on this in relation to phase IV cardiac rehabilitation participants. Our study will investigate how various aspects of planning and problem solving are related to health. This will help us understand how best to develop phase IV cardiac rehabilitation programmes for individuals in the future.

Why have I been chosen?

We are asking everyone in the class to take part.

Do I have to take part

It is up to you to decide whether or not to take part. If you decide to take part you will be able to keep a copy of this information sheet and you will be asked to complete a consent form. If you decide to take part you are still free to withdraw at any time without giving a reason. This will not affect your relationship with the class in any

way.

What do I have to do?
If you agree to take part, we will ask that you complete a questionnaire at the end of the class.

What happens if I do not wish to take part?
We will thank you for taking the time to read this information sheet, and you will not have to take any more part in the study. Participation in the study is entirely voluntary. However, if you choose to complete a questionnaire, we will be most grateful. Irrespective of your decision to take part, this will not affect your relationship will the class in any way.

What are the possible benefits of taking part?
We hope that the information we get from this study will help us to understand what effects the health of phase IV cardiac rehabilitation participants, and will help us in developing our knowledge of cardiac problems.

What happens after the study?
The information you give will be added to all the other information we get from participants. The results will be made available to you, if you should so wish.

Will my taking part in the study be kept confidential?
All information which is collected about you during the course of the study will be kept strictly confidential. Any information you provide will not be connected to your name or personal information so that you cannot be identified from it.

Are my questionnaire answers anonymous and secure?
Yes, the information you give will be kept anonymous. Data will also be securely held on a University password-sensitive computer. We will keep the data for a maximum of 5 years, so as to allow time for study to be published.

What will happen to the results of the research study?
The results will be used in a University project at the University of the West of England, with whom the study is being carried out. In addition it is hoped that the study will be written up for a report that may be submitted for publication in the academic journals, such as '*The Journal of Cardiopulmonary Rehabilitation and Prevention*', or another similar academic journal, and will be shared with other professionals who are interested in phase IV cardiac rehabilitation. It will not be possible for anyone to link anything in the report to you.

Contact for Further Information
If you require further information or have any questions at any time, please do not

hesitate to contact us.

Dougie Marks
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University of the West of England
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Julian Bath
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Thank you for taking part in this study.

Appendix 2 – Participant Consent Form

CONSENT FORM

The Impact of Executive Functioning on Cardiac Rehabilitation Outcomes

Name of Researcher: Douglas Marks – Professional Doctorate Student

Please tick box

1. I confirm that I have read and understand the information sheet for the above study. ☐

2. I understand that my participation is voluntary and that I am free to withdraw during the data collection, without giving any reason, without my rights being affected. ☐

3. I understand the content of the interviews will not be shared with anyone other than my academic supervisor. The information will be stored within a locked filing cabinet or within a password protected computer. ☐

4. I agree to take part in the above study ☐

_____	_____	_____
Name of Volunteer	Date	Signature
Dougie Marks		
Name of Investigator	Date	Signature

Thank you for your help with this research project

Appendix 3 – Participant Questionnaire

Lifestyle Questionnaire

We are interested in people's experiences of phase IV cardiac rehabilitation and their health. We would be grateful if you would help us by filling in this questionnaire. There are no right or wrong answers; we're only interested in your views, experiences and opinions. Try not to spend too much time on any question, and answer each question as honestly as possible.

ALL OF YOUR RESPONSES ARE COMPLETELY ANONYMOUS, PRIVATE AND CONFIDENTIAL.

Please tell us..

1. Your Gender: Male ☐

Female ☐

2. Your age: _____

3. Your waist size at your naval (in centimeters)

_____

SF-12

This questionnaire asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities. Please answer every question by marking one box. If you are unsure about how to answer, please give the best answer you can.

1. In general, would you say your health is:

❒	❒	❒	❒	❒
Excellent	**Very good**	**Good**	**Fair**	**Poor**

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, Limited A Lot	**Yes, Limited A Little**	**No, Not Limited At All**
2. **Moderate activities,** such as moving a table, pushing a vacuum cleaner, bowling or playing golf	❒	❒	❒
3. Climbing **several** flights of stairs	❒	❒	❒

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	Yes	**No**
4. **Accomplished less** than you would like	❒	❒
5. Were limited in the **kind** of work or other activities	❒	❒

During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	Yes	**No**
6. **Accomplished less** than you would like	❒	❒
7. Didn't do work or other activities as **carefully** as usual	❒	❒

Please turn over

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

❒	❒	❒	❒	❒
Not at all	**A little bit**	**Moderately**	**Quite a bit**	**Extremely**

These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks –

	All of the Time	**Most of the Time**	**A Good Bit of the Time**	**Some of the Time**	**A Little of the Time**	**None of the Time**
9. Have you felt calm and peaceful?	❒	❒	❒	❒	❒	❒
10. Did you have a lot of energy?	❒	❒	❒	❒	❒	❒
11. Have you felt downhearted and blue?	❒	❒	❒	❒	❒	❒

12. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

❒	❒	❒	❒	❒	❒
All of the time	**Most of the time**	**A Good Bit of the time**	**Some of the time**	**A little of the time**	**None the time**

Please turn over

Zoo Map Test Version 1
Rules

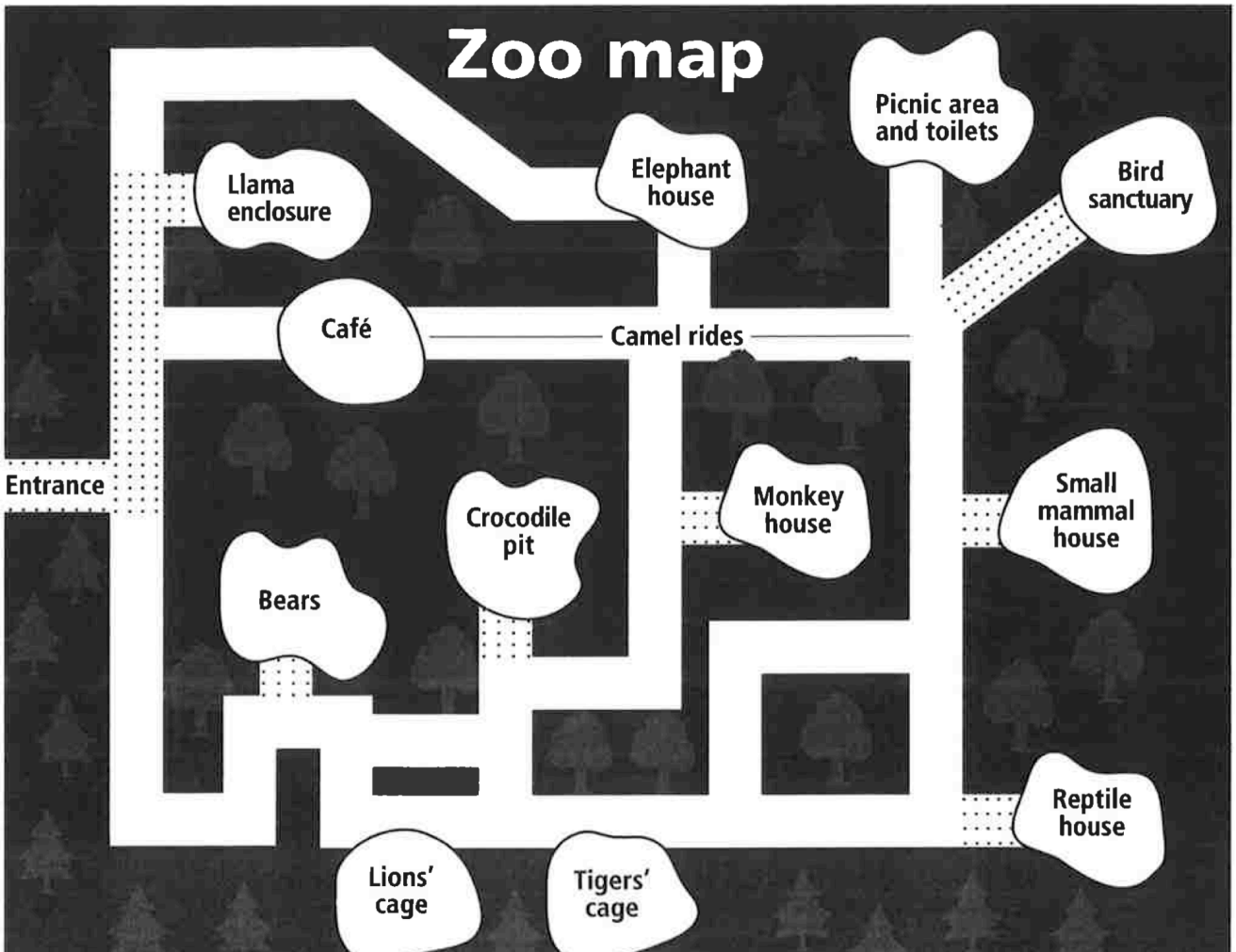
Imagine that you are going to visit a zoo.

Your task is to plan a route in order to visit the following (not necessarily in this order):

- **Elephant house**
- **Lion's cage**
- **Llama enclosure**
- the **Café**
- the **Bears**
- **Bird sanctuary.**

When planning your route the following rules must be obeyed:

- start at the **entrance** and finish with a **picnic**
- you may use the **shaded paths as many times as you like** but the **unshaded ones only once**
- you may take only **one Camel ride.**



Zoo Map Test Version 2
Rules

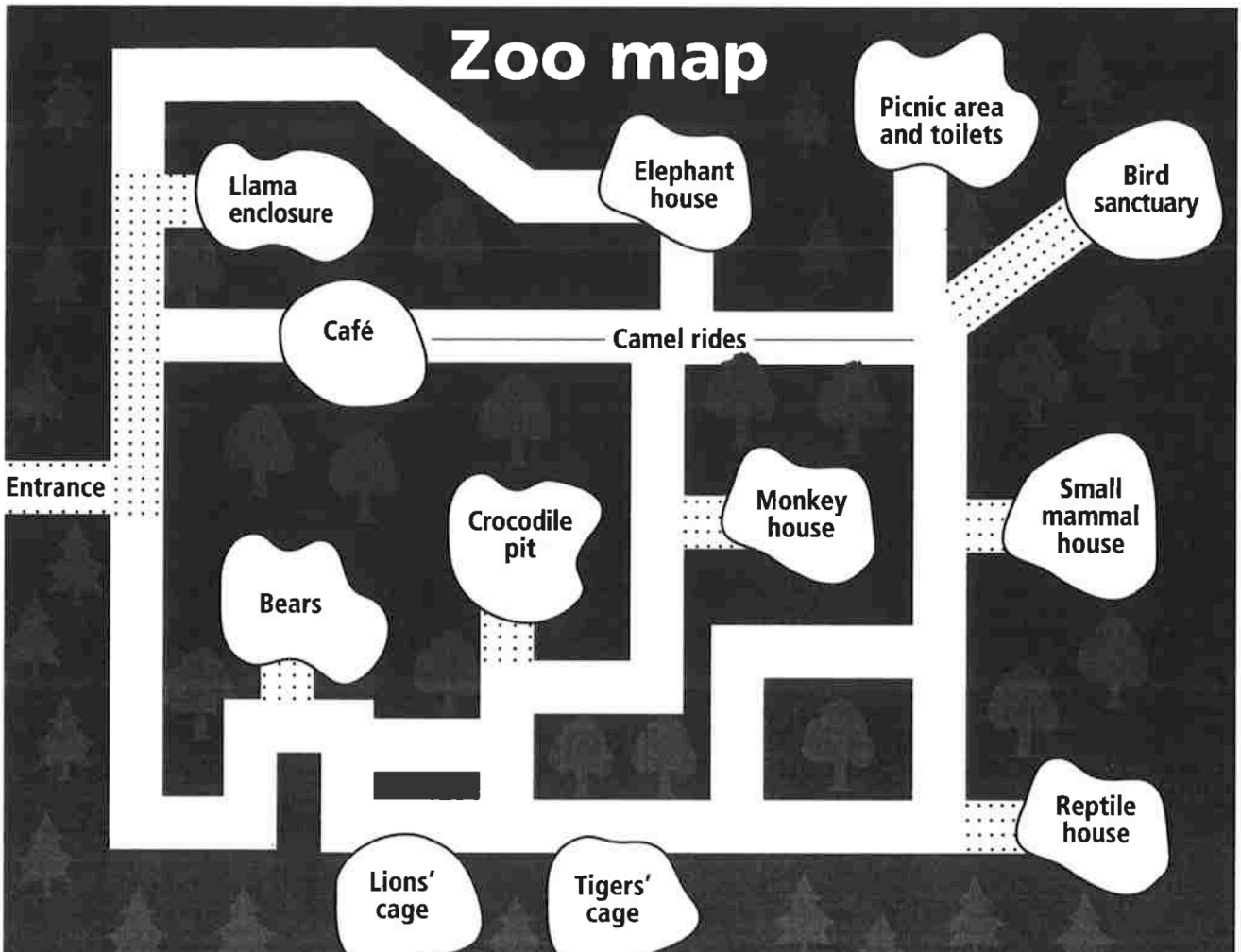
Imagine that you are going to visit a zoo.

Your task is to visit the following animals in the order indicated:

1 from the **Entrance** visit the **Llama enclosure**
2 from the **Llama enclosure** visit the **Elephant house**
3 after visiting the **Elephants** go to the **Café** for refreshments
4 from the **Café** go to see the **Bears**
5 visit the **Lions** after the **Bears**
6 from the **Lions** make your way to the **Bird sanctuary**
7 finally, finish your visit with a **picnic**.

When planning your route the following rules must be obeyed:

- start at the **entrance** and finish with a **picnic**
- you may use the **shaded paths as many times as you like** but the **unshaded ones only once**
- you may take only **one Camel ride.**



Key Search Test

Imagine that this square is a large field. Somewhere in this field you have lost your keys. You don't know exactly where you have lost them because you have been all over the field, all you know is that they are somewhere in the field.

Starting from the dot, draw a line with the pen to show where you would walk to search the field to make absolutely certain that you would find your keys no matter where they were.

CFQ

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know how often these things have happened to your in the past 6 months. Please circle the appropriate number.

		Very often	Quite often	Occasionally	Very rarely	Never
1.	Do you read something and find you haven't been thinking about it and must read it again?	4	3	2	1	0
2.	Do you find you forget why you went from one part of the house to the other?	4	3	2	1	0
3.	Do you fail to notice signposts on the road?	4	3	2	1	0
4.	Do you find you confuse right and left when giving directions?	4	3	2	1	0
5.	Do you bump into people?	4	3	2	1	0
6.	Do you find you forget whether you've turned off a light or a fire or locked the door?	4	3	2	1	0
7.	Do you fail to listen to people's names when you are meeting them?	4	3	2	1	0
8.	Do you say something and realize afterwards that it might be taken as insulting?	4	3	2	1	0
9.	Do you fail to hear people speaking to you when you are doing something else?	4	3	2	1	0
10.	Do you lose your temper and regret it?	4	3	2	1	0
11.	Do you leave important letters unanswered for days?	4	3	2	1	0
12.	Do you find you forget which way to turn on a road you know well but rarely use?	4	3	2	1	0
13.	Do you fail to see what you want in a supermarket (although it's there)?	4	3	2	1	0
14.	Do you find yourself suddenly wondering whether you've used a word correctly?	4	3	2	1	0

Please continue overleaf...

		Very often	Quite often	Occasion-ally	Very rarely	Never
15.	Do you have trouble making up your mind?	4	3	2	1	0
16.	Do you find you forget appointments?	4	3	2	1	0
17.	Do you forget where you put something like a newspaper or a book?	4	3	2	1	0
18.	Do you find you accidentally throw away the thing you want and keep what you meant to throw away – as in the example of throwing away the matchbox and putting the used match in your pocket?	4	3	2	1	0
19.	Do you daydream when you ought to be listening to something?	4	3	2	1	0
20.	Do you find you forget people's names?	4	3	2	1	0
21.	Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	4	3	2	1	0
22.	Do you find you can't quite remember something although it's "on the tip of your tongue"?	4	3	2	1	0
23.	Do you find you forget what you came to the shops to buy?	4	3	2	1	0
24.	Do you drop things?	4	3	2	1	0
25.	Do you find you can't think of anything to say?	4	3	2	1	0

Please turn over

SRQ

Please answer the following questions by circling the response that best describes how you are. If you STRONGLY DISAGREE with a statement, circle ∈. If you DISAGREE circle ∉. If you are UNCERTAIN or UNSURE circle ∠. If you AGREE circle ∇, and if you STRONGLY AGREE circle ®. There are no right or wrong answers. Work quickly and don't think too long about your answers.

	Strongly Disagree		Disagree or Unsure	Uncertain	Agree	Strongly Agree
1. I usually keep track of my progress toward my goals.	1	2	3	4	5	
2. My behavior is not that different from other people's.	1	2	3	4	5	
3. Others tell me that I keep on with things too long.	1	2	3	4	5	
4. I doubt I could change even if I wanted to.	1	2	3	4	5	
5. I have trouble making up my mind about things.	1	2	3	4	5	
6. I get easily distracted from my plans.	1	2	3	4	5	
7. I reward myself for progress toward my goals.	1	2	3	4	5	
8. I don't notice the effects of my actions until it's too late.	1	2	3	4	5	
9. My behavior is similar to that of my friends.	1	2	3	4	5	
10. It's hard for me to see anything helpful about changing my ways.	1	2	3	4	5	
11. I am able to accomplish goals I set for myself.	1	2	3	4	5	
12. I put off making decisions.	1	2	3	4	5	
13. I have so many plans that it's hard for me to focus on any one of them.	1	2	3	4	5	
14. I change the way I do things when I see a problem with how things are going.	1	2	3	4	5	
15. It's hard for me to notice when I've Ahad enough@ (alcohol, food, sweets).	1	2	3	4	5	
16. I think a lot about what other people think of me.	1	2	3	4	5	
17. I am willing to consider other ways of doing things.	1	2	3	4	5	
18. If I wanted to change, I am confident that I could do it.	1	2	3	4	5	
19. When it comes to deciding about a change, I feel overwhelmed by the choices.	1	2	3	4	5	
20. I have trouble following through with things once I've made up my mind to do something.	1	2	3	4	5	

Please turn over

Strongly Disagree Disagree or Unsure Uncertain Agree Strongly Agree

	Strongly Disagree		Disagree or Unsure		Uncertain Agree	Strongly Agree
21. I don't seem to learn from my mistakes.	1	2	3	4	5	
22. I'm usually careful not to overdo it when working, eating, drinking.	1	2	3	4	5	
23. I tend to compare myself with other people.	1	2	3	4	5	
24. I enjoy a routine, and like things to stay the same.	1	2	3	4	5	
25. I have sought out advice or information about changing.	1	2	3	4	5	
26. I can come up with lots of ways to change, but it's hard for me to decide which one to use.	1	2	3	4	5	
27. I can stick to a plan that's working well.	1	2	3	4	5	
28. I usually only have to make a mistake one time in order to learn from it.	1	2	3	4	5	
29. I don't learn well from punishment.	1	2	3	4	5	
30. I have personal standards, and try to live up to them.	1	2	3	4	5	
31. I am set in my ways.	1	2	3	4	5	
32. As soon as I see a problem or challenge, I start looking for possible solutions.	1	2	3	4	5	
33. I have a hard time setting goals for myself.	1	2	3	4	5	
34. I have a lot of willpower.	1	2	3	4	5	
35. When I'm trying to change something, I pay a lot of attention to how I'm doing.	1	2	3	4	5	
36. I usually judge what I'm doing by the consequences of my actions.	1	2	3	4	5	
37. I don't care if I'm different from most people.	1	2	3	4	5	
38. As soon as I see things aren't going right I want to do something about it.	1	2	3	4	5	
39. There is usually more than one way to accomplish something.	1	2	3	4	5	
40. I have trouble making plans to help me reach my goals.	1	2	3	4	5	
41. I am able to resist temptation.	1	2	3	4	5	
42. I set goals for myself and keep track of my progress.	1	2	3	4	5	
43. Most of the time I don't pay attention to what I'm doing.	1	2	3	4	5	
44. I try to be like people around me.	1	2	3	4	5	

Strongly Disagree Disagree or Unsure Uncertain Agree Strongly Agree

Please turn over

	Strongly Disagree		Disagree or Unsure		Uncertain Agree	Strongly Agree
45. I tend to keep doing the same thing, even when it doesn't work.	1	2	3	4	5	
46. I can usually find several different possibilities when I want to change something.	1	2	3	4	5	
47. Once I have a goal, I can usually plan how to reach it.	1	2	3	4	5	
48. I have rules that I stick by no matter what.	1	2	3	4	5	
49. If I make a resolution to change something, I pay a lot of attention to how I'm doing.	1	2	3	4	5	
50. Often I don't notice what I'm doing until someone calls it to my attention.	1	2	3	4	5	
51. I think a lot about how I'm doing.	1	2	3	4	5	
52. Usually I see the need to change before others do.	1	2	3	4	5	
53. I'm good at finding different ways to get what I want.	1	2	3	4	5	
54. I usually think before I act.	1	2	3	4	5	
55. Little problems or distractions throw me off course.	1	2	3	4	5	
56. I feel bad when I don't meet my goals.	1	2	3	4	5	
57. I learn from my mistakes.	1	2	3	4	5	
58. I know how I want to be.	1	2	3	4	5	
59. It bothers me when things aren't the way I want them.	1	2	3	4	5	
60. I call in others for help when I need it.	1	2	3	4	5	
61. Before making a decision, I consider what is likely to happen if I do one thing or another.	1	2	3	4	5	
62. I give up quickly.	1	2	3	4	5	
63. I usually decide to change and hope for the best.	1	2	3	4	5	
	Strongly Disagree		Disagree or Unsure		Uncertain Agree	Strongly Agree

Thank you for your participation

Appendix 4 - BADS Key Search Scoring

8 Summary

We have reported and described the BADS, a new test to assess everyday problems arising from the DES. In the development of the BADS we have been influenced by two theoretical models. The first is the working memory model (Baddeley & Hitch, 1974) with its hypothetical construct of a central executive (CE). This CE can be conceived as an overall controller, organiser, planner and allocator of resources. Baddeley, Logie, Bressi, Della Sala and Spinnler (1986) and Hartman, Wilson and Pickering (1992) suggest that the CE is defective in patients with Alzheimer's disease and severe traumatic brain injury. The second model influencing the development of the BADS is the Attentional Control System proposed by Shallice (1982). This model comprises two attentional mechanisms – a contention scheduling system responsible for the more routine aspects of attention, and a supervisory attentional system which is responsible for higher level, more demanding attentional tasks. Patients with the DES may have few problems with tasks involving the contention scheduling system, but typically have great difficulty with tasks involving supervisory attentional systems.

We have also been influenced by the development of ecologically valid assessment tools that map onto real-life behaviours. Forerunners of the BADS include *The Rivermead Behavioural Memory Test* (Wilson, Cockburn & Baddeley, 1985); the *Communicative Abilities in Daily Living* (Holland, 1980); the *Behavioural Inattention Test* (Wilson, Cockburn & Halligan, 1989) and the *Test of Everyday Attention* (Robertson, Ward, Ridgeway & Nimmo-Smith, 1994).

The BADS should prove useful to clinical psychologists, neuropsychologists and other therapists involved in the assessment of people with brain injury. It will assist them in identifying whether or not a patient has executive deficits likely to interfere with everyday life, and it will help them determine whether their clients have a general impairment of executive functioning or a specific kind of executive disorder. The BADS would also appear to be useful for the assessment of executive functioning in schizophrenia, as a small study (Evans, McKenna, Chua & Wilson, submitted) suggests that people with schizophrenia perform very similarly to people with brain injury.

Finally, the BADS might prove to be useful in neuropsychological and psychiatric rehabilitation. Because the BADS provides a tool for picking up subtle difficulties in planning and organisation, particularly in those people who appear to be cognitively well preserved and functioning well in structured situations, it might prove to be particularly useful in assessing and preparing patients for moves from hospital care into more independent living situations. We look forward to further research using the BADS for planning and evaluating rehabilitation.

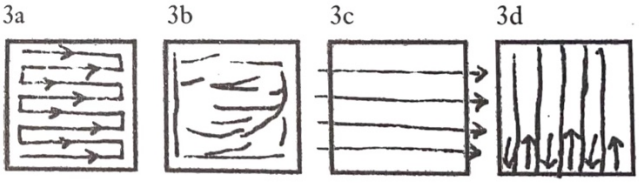
9 Appendices

9.1 Appendix 1: Scoring the Key Search Test

1 Entering the field
Entering at either of the bottom corners is the most efficient strategy, so entering within 10 mm of either bottom corner gains 3 marks. Entering at any other point along the base gains 2 marks. Entering anywhere else scores 1.

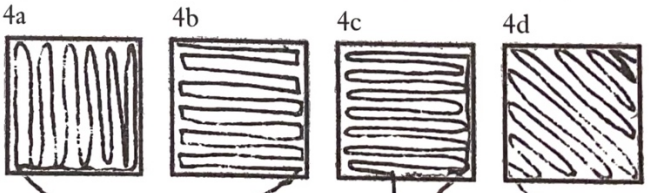
2 Finishing the search
The instructions do not specify that a subject has to leave the field. Finishing within 10 mm of any corner (as in 4a, 4b, 4d and 4e below) gains 3 marks, finishing anywhere else along the base (as in 4c and 6i e) scores 2 and finishing anywhere else (as in 5a, 5c, 6i j and 6iii d) scores 1.

3 Continuous line
This mark should be awarded even if a subject has lifted the pen off the paper as long as s/he has either replaced the pen at the same point or joined the line up as when parallel lines are drawn left to right across the square and the ends are then joined vertically as in 3a below. The mark is not awarded when a subject takes the pen off the paper and replaces it at a different point as in 3b or 3c but *is* given if the lines go to the field edges as in 3d where the subject clearly has the solution.



Score: 1 0 0 1

4 Parallel
If all the lines have the same basic orientation this would be awarded the mark regardless of the shape of the line 'ends' thus the first four drawings below score 1, the fifth 0. If a line at right angles to the basic pattern is simply a means of getting to the nearest corner as in 4c or exiting at the point of entry as in 4a, the mark is still awarded.



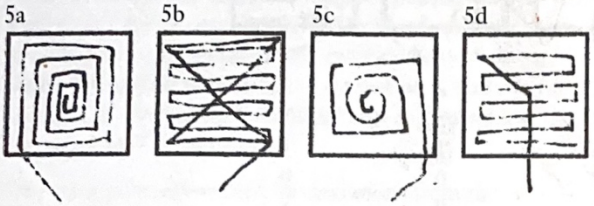
Score: 1 1 1 1

4e

Score: 0

5 Vertical and/or horizontal lines

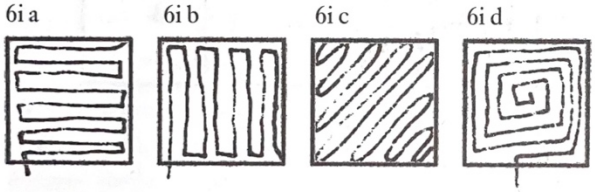
This point is awarded if *all* the lines are vertical and/or horizontal, thus 4a, 4b, and 4c could be given this mark as would 5a below, but 4d and 4e would not, nor would 5b, 5c or 5d below.



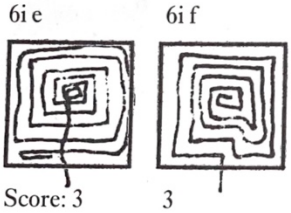
Score: 1 0 0 0

6i Predetermined patterns

The predetermined patterns are horizontal as in 6i a, vertical as in 6i b, diagonal as in 6i c, concentric out-to-in as in 6i d, and concentric in-to-out as in 6i e. Concentric patterns with minor differences as in 6i f would still be scored as predetermined. Patterns 6i a and 6i b, being the most efficient [see text] score 5, the diagonal and concentric patterns score 3.

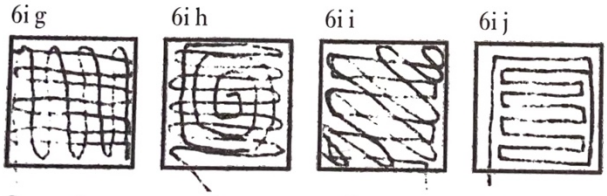


Score: 5 5 3 3



Score: 3 3

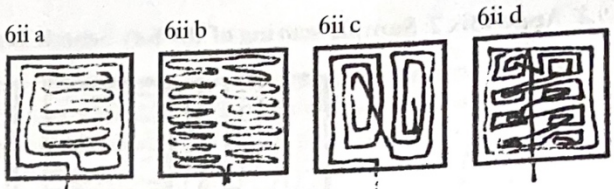
Note that occasionally subjects repeat the same pattern at right angles to the first as in 6i g or superimpose two predetermined patterns as in 6i h and 6i i or begin/end by walking right round the field boundary as in 6i j. These are still awarded the 5 marks for the ideal predetermined pattern (but would fail to gain the mark(s) for being all parallel and/or vertical/horizontal).



Score: 5 5 5 5

6ii

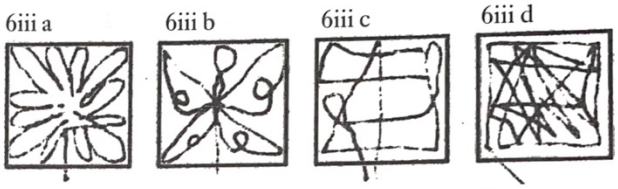
If subjects combine 2 predetermined patterns, as in 6ii a, or duplicate a pattern in the same orientation, as in 6ii b – 6ii d, this is scored as using more than one predetermined pattern and given only 2 marks.



Score: 2 2 2 2

6iii Systematic but inefficient search patterns

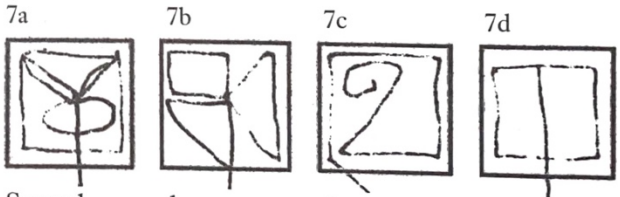
One mark is given for any search pattern which is clearly pre-planned or deliberate as in 6iii a and b even though that plan would be inefficient, unsuccessful or impossible to implement. 6iii c and d are clearly done 'on the fly' and get no mark.



Score: 1 1 0 0

7 Attempting to cover all the ground

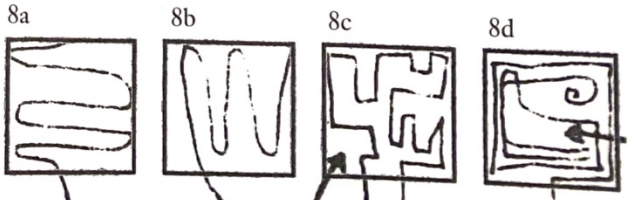
This is included to discriminate between those subjects who have obviously tried to search the whole field but whose strategy would either be impossible to implement in a real field or would be unsuccessful, as in 7a and 7b below, and those subjects who even if they *say* they have searched the whole field clearly haven't as in 7c and 7d. The first two drawings would get 1 mark for 7 but 0 for 8 (finding the keys) whereas the second two drawings would get no mark for either the search or finding the keys.



Score: 1 1 0 0

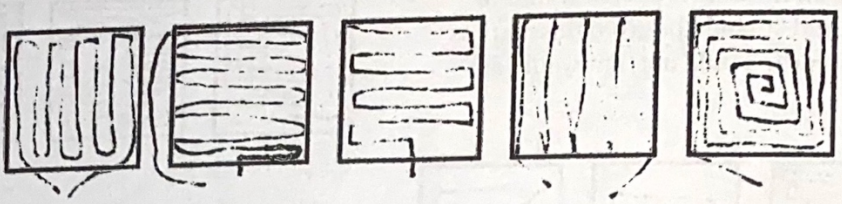
8 Finding the keys

The question being addressed here is whether the strategy is likely to be successful. Clearly all the drawings above, with the exception of those in 6iii and 7 have a high chance of being successful. Equally, search patterns like those in 8a and 8b, though carelessly drawn, would be successful if carefully implemented, and should be awarded the mark. Drawings like 8c and 8d, however, though more carefully drawn, would not be given the mark since the spaces indicated by the arrows are greater than in any other part of the drawing.

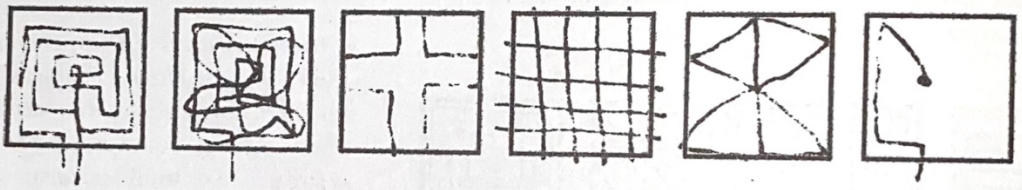


Score: 1 1 0 0

9.2 Appendix 2: Sample scoring of the Key Search Test



1 enter	3	2	2	3	3
2 finish	3	3	3	3	1
3 continuous	1	1	1	1	1
4 parallel	1	1	1	0	0
5 vert/horiz	1	1	1	0	1
6 patterns	5	5	5	3	3
7 all ground	1	1	1	1	1
8 find keys	1	1	0	1	1
Total	**16**	**15**	**14**	**12**	**11**



1 enter	2	2	2	1	2	2
2 finish	2	1	2	1	1	1
3 continuous	1	1	1	0	1	1
4 parallel	0	0	0	0	0	0
5 vert/horiz	1	0	1	1	0	0
6 patterns	3	2	0	0	0	0
7 all ground	1	1	1	1	1	0
8 find keys	1	1	0	1	0	0
Total	**11**	**8**	**7**	**5**	**5**	**4**

Appendix 5 - The University of the West of England's Faculty Research Ethics Committee (FREC) Ethical Approval

RE: FREC Application Form

LT

Leigh Taylor <Leigh.Taylor@uwe.ac.uk>

Thu 29/06, 22:17

Douglas Marks; Julian Bath (Staff - SOLS)

Reply all

Inbox

> You replied on 17/07/2017 02:40.

Hi Dougie

Many thanks for your email responding to your conditions. I can now confirm that you have full ethical approval.

Kind regards

Leigh

Leigh Taylor (Mrs)
Team Leader
Research Information and Governance
Research Administration
Research, Business & Innovation
North Avon House, Ground floor
University of the West of England
Bristol, BS16 1QY

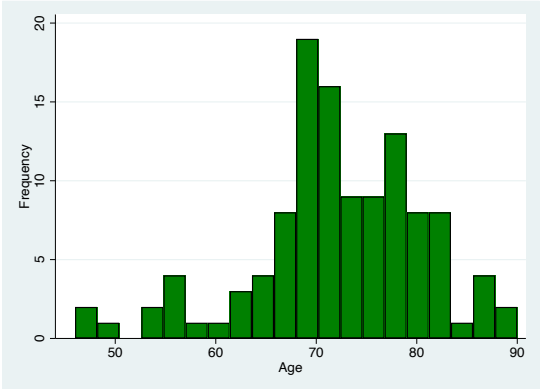
Leigh.Taylor@uwe.ac.uk
Tel: 0117 328 1170

http://rbi.uwe.ac.uk/resadmin.asp

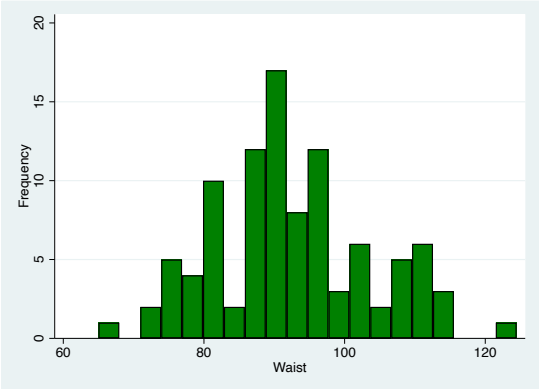
Appendix 6 – Frequency Distributions for Predictor and Criterion Variables

Predictor Variables Histograms

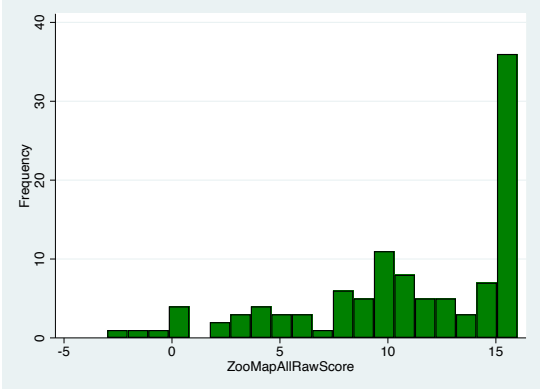
Age



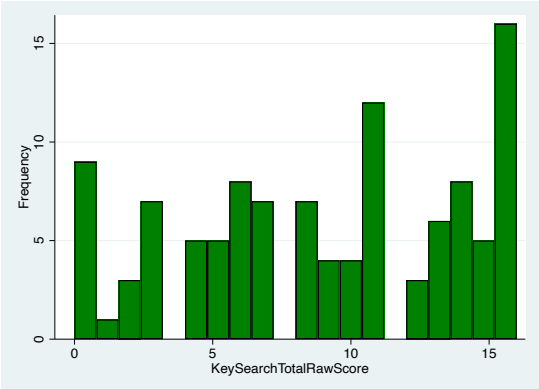
Waist



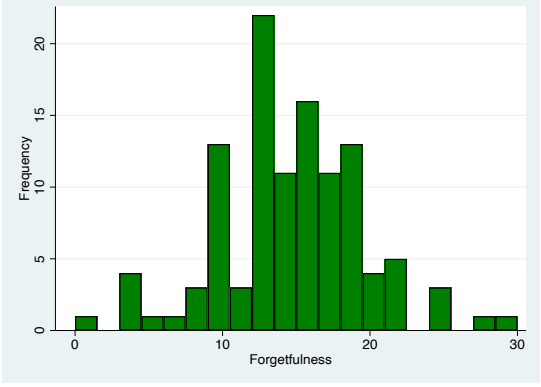
BADS Zoo Map (Total Raw Score)



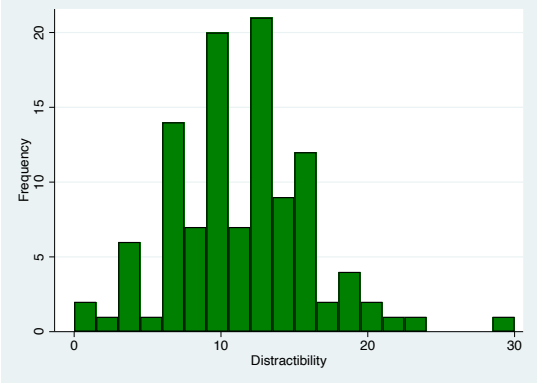
BADS Key Search (Total Raw Score)



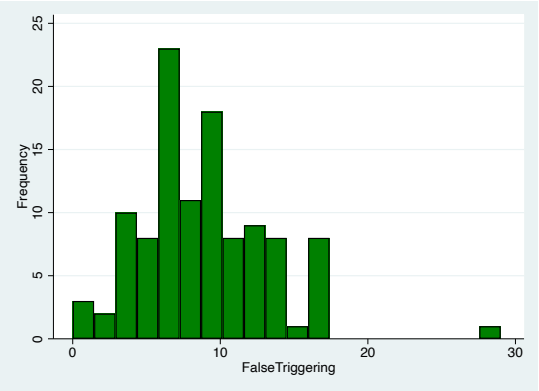
CFQ Forgetfulness



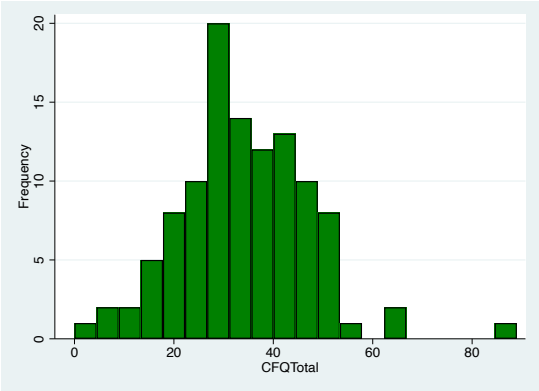
CFQ Distractibility



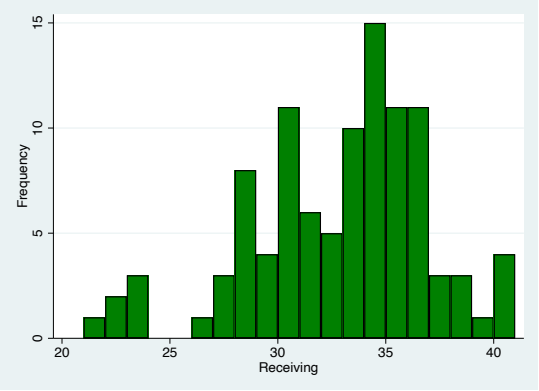
CFQ False Triggering



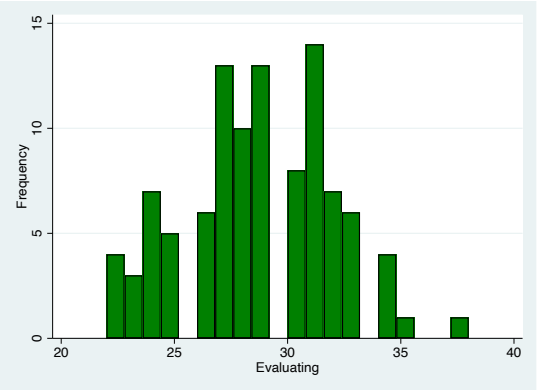
CFQ Total



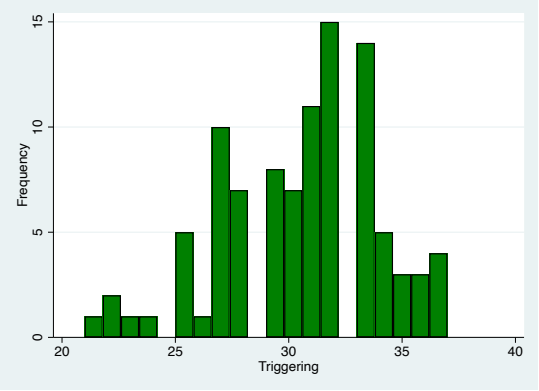
SRQ Receiving



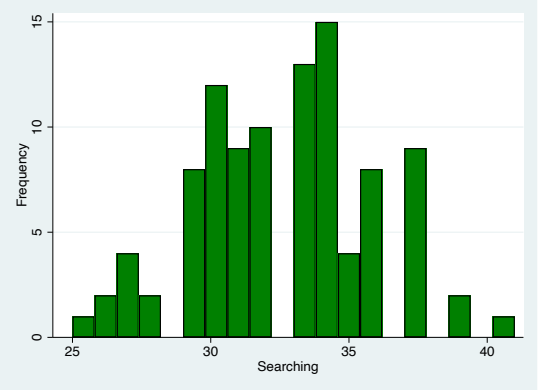
SRQ Evaluating



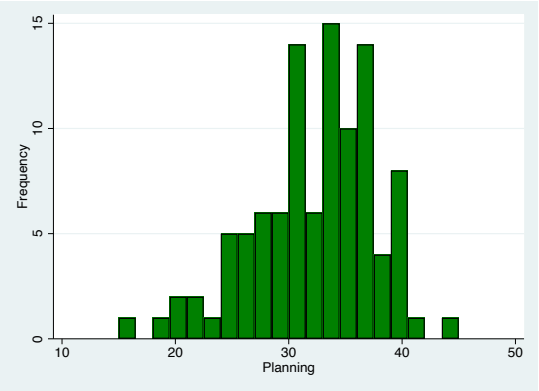
SRQ Triggering



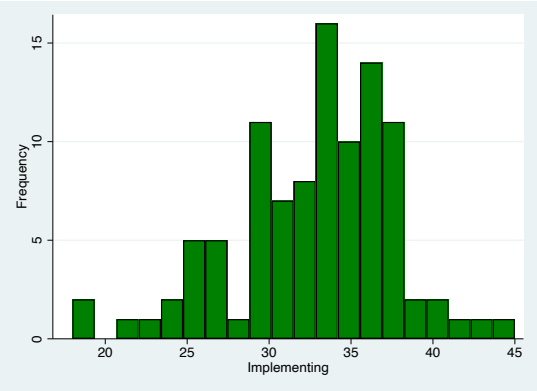
SRQ Searching



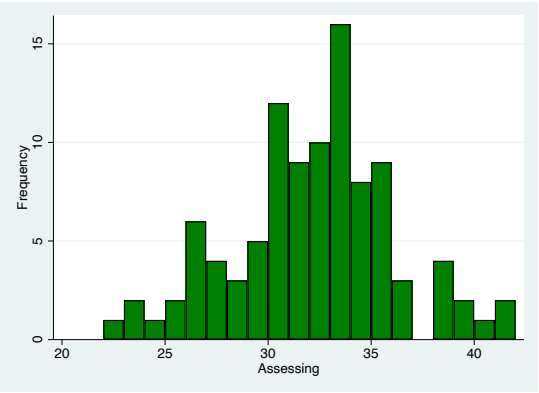
SRQ Planning



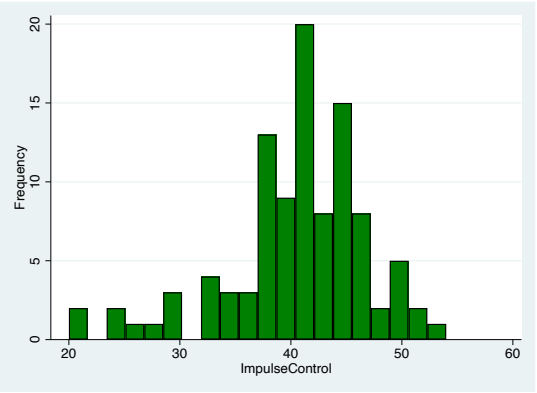
SRQ Implementing



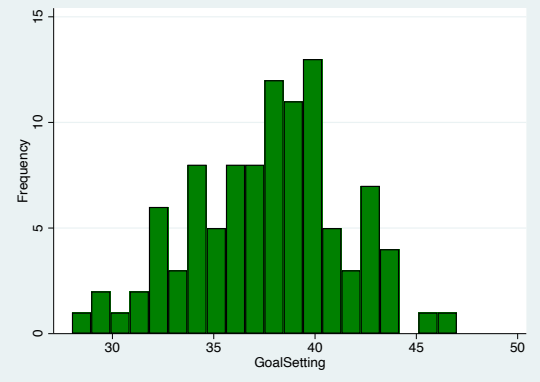
SRQ Assessing



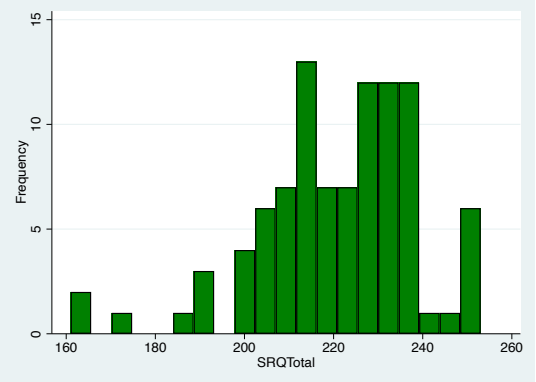
SRQ Impulse Control



SRQ Goal Setting

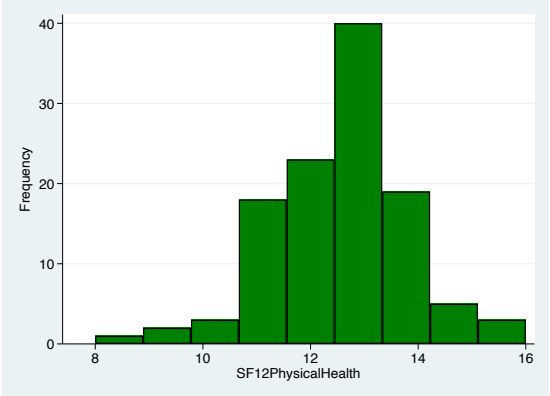


SRQ Total

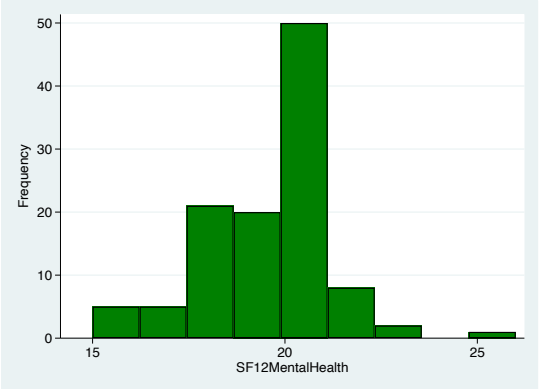


Criterion Variables Histograms

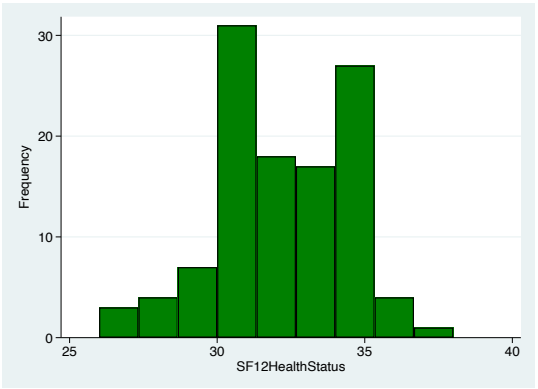
SF-12 Physical Health



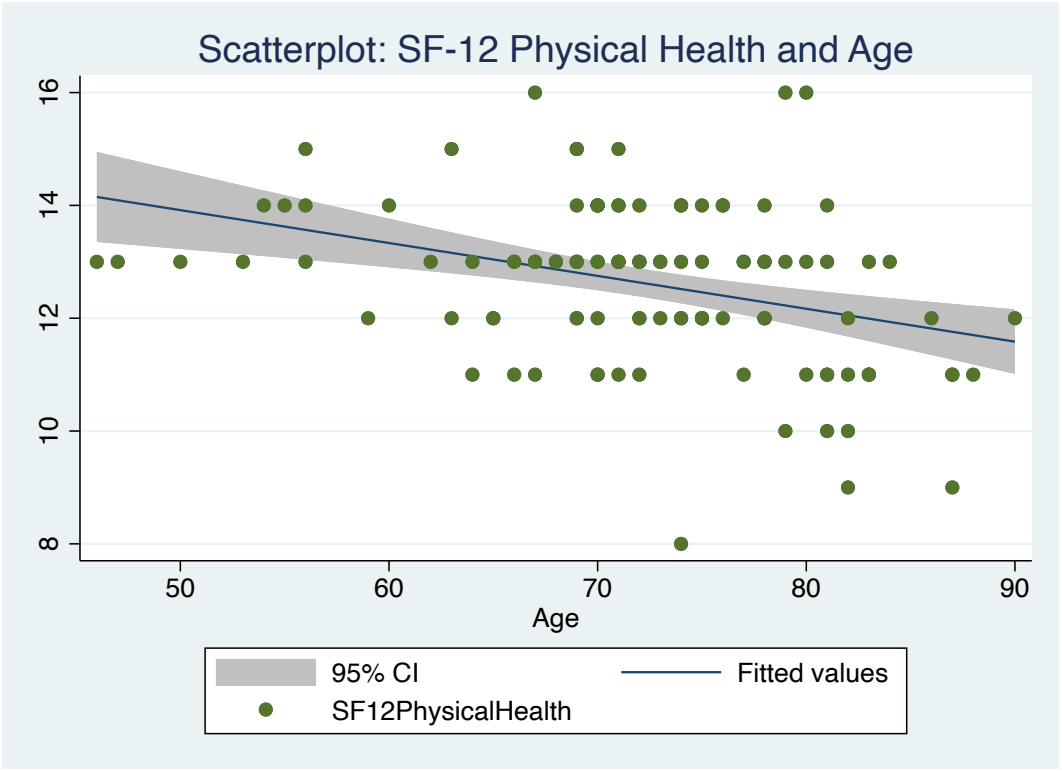
SF-12 Mental Health

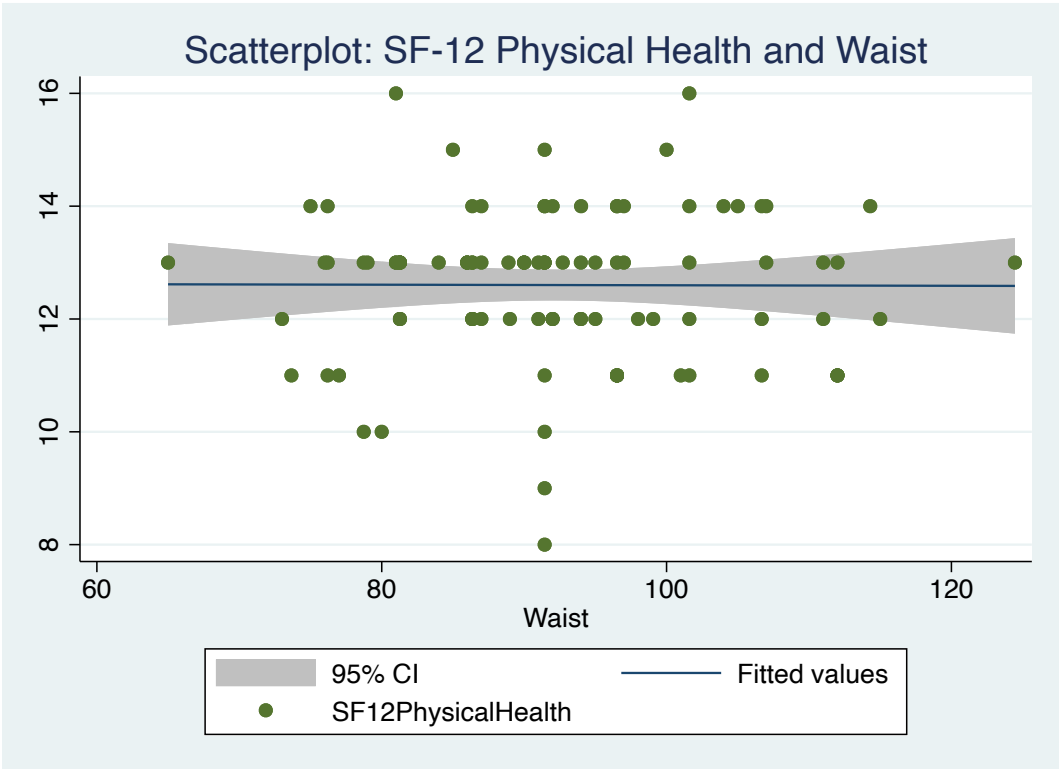


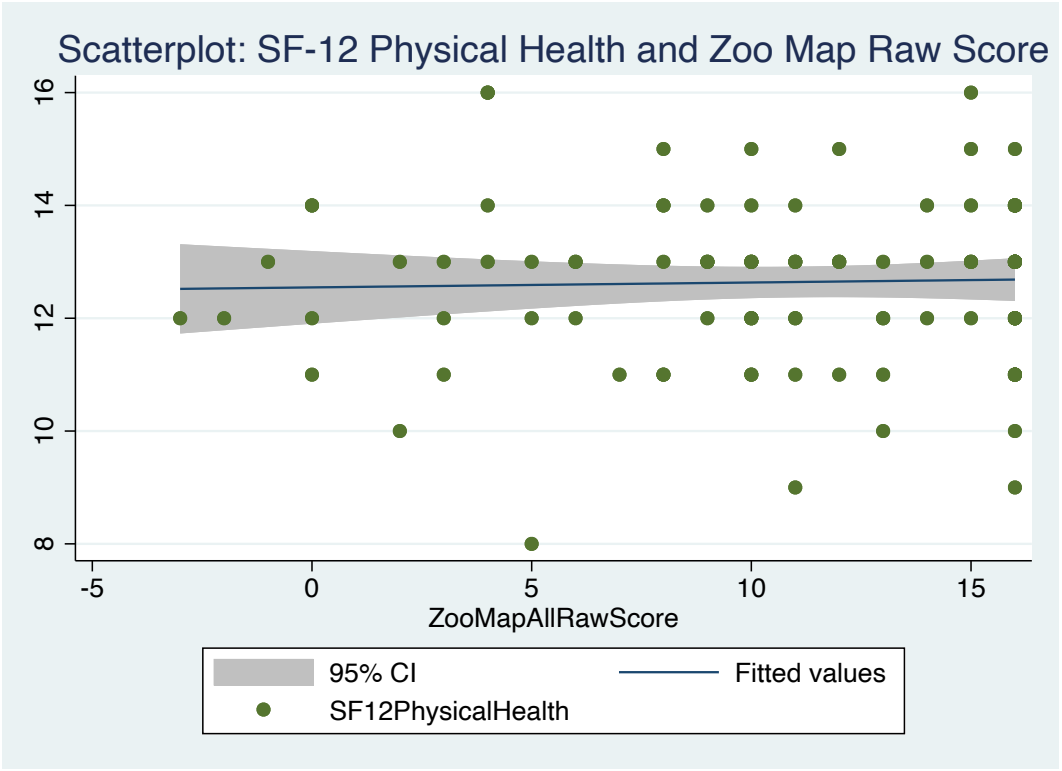
SF-12 Health Status



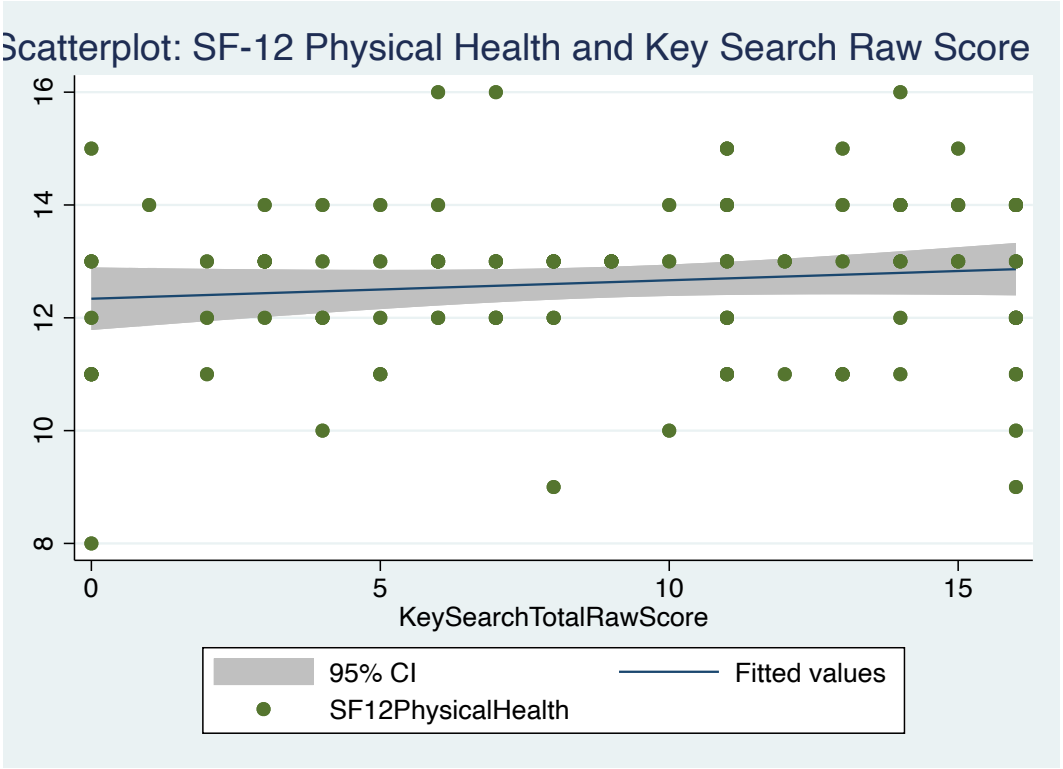
Appendix 7 - Scatterplots to Demonstrate Linearity

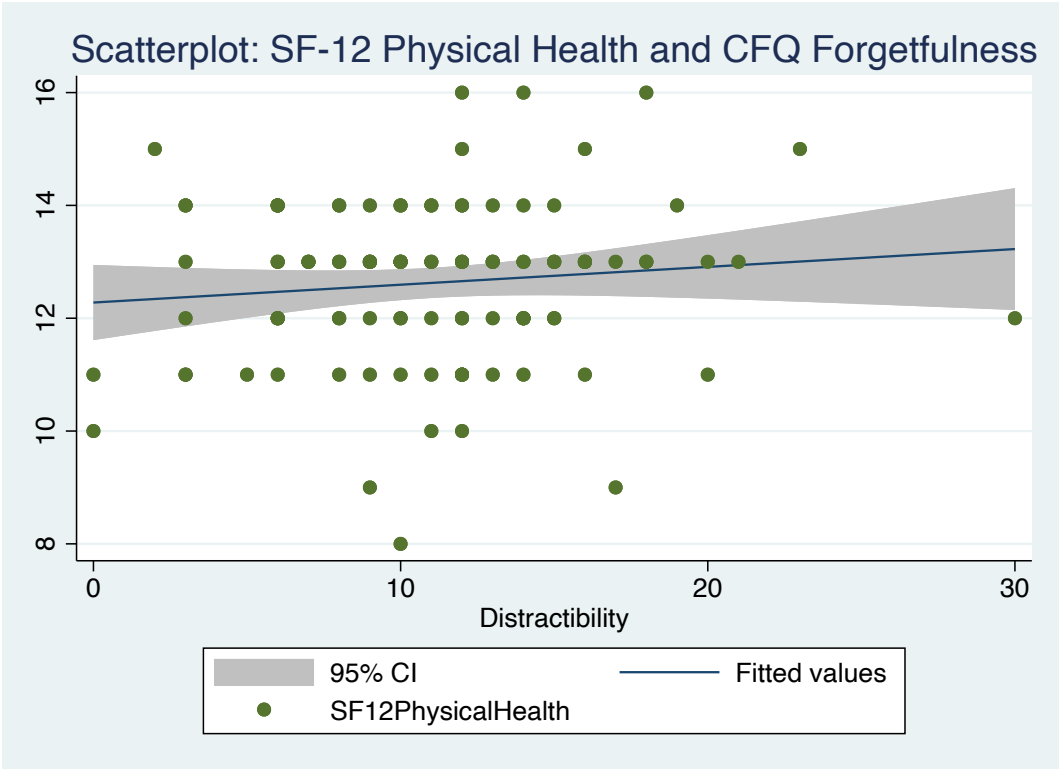

Scatterplot: SF-12 Physical Health and Age
16
14
12
10
8
50
60
70
80
90
Age
95% CI
Fitted values
SF12PhysicalHealth

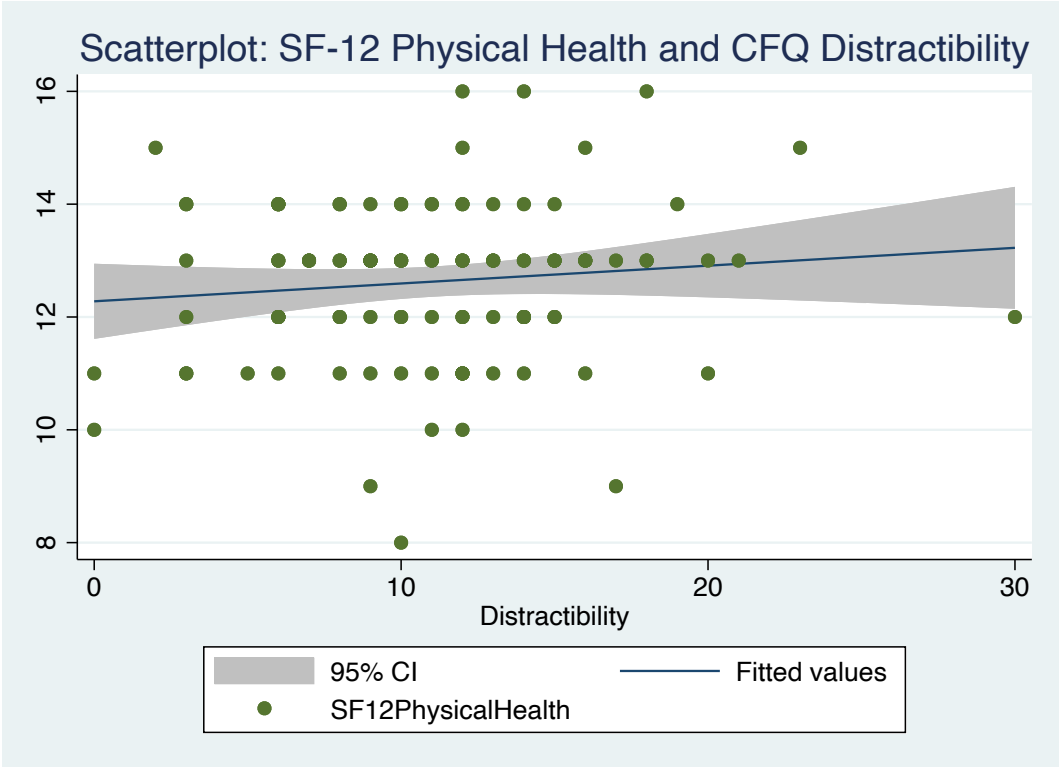

Scatterplot: SF-12 Physical Health and Waist
16
14
12
10
8
60
80
100
120
Waist
95% CI
Fitted values
SF12PhysicalHealth

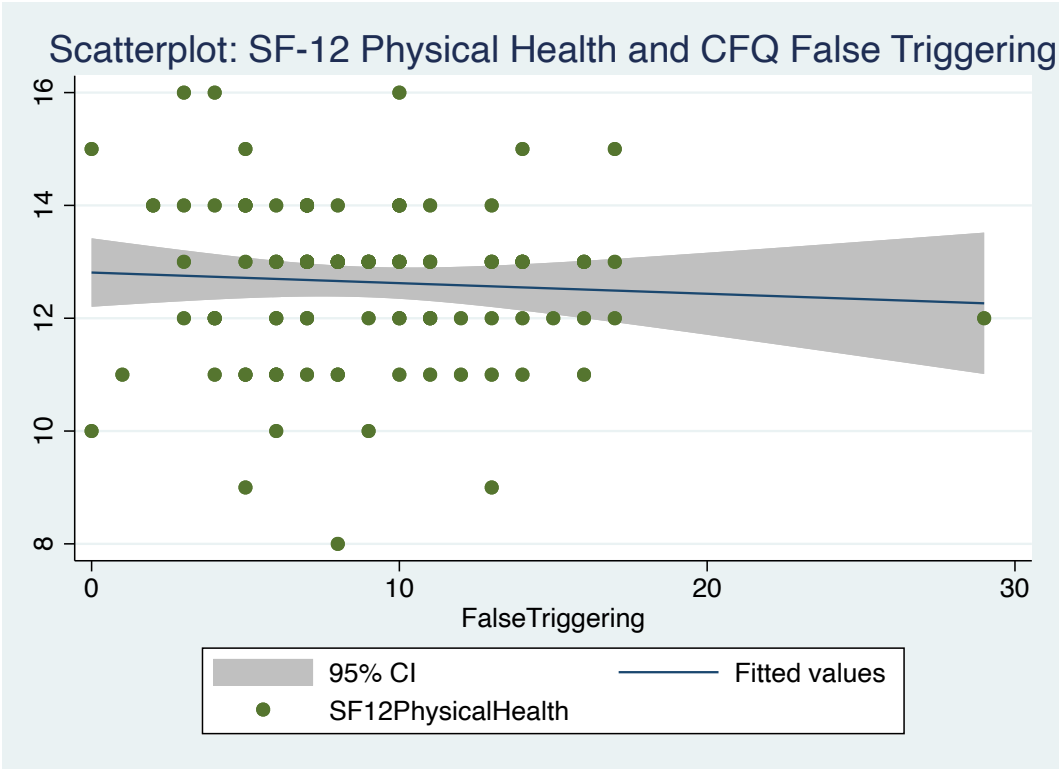


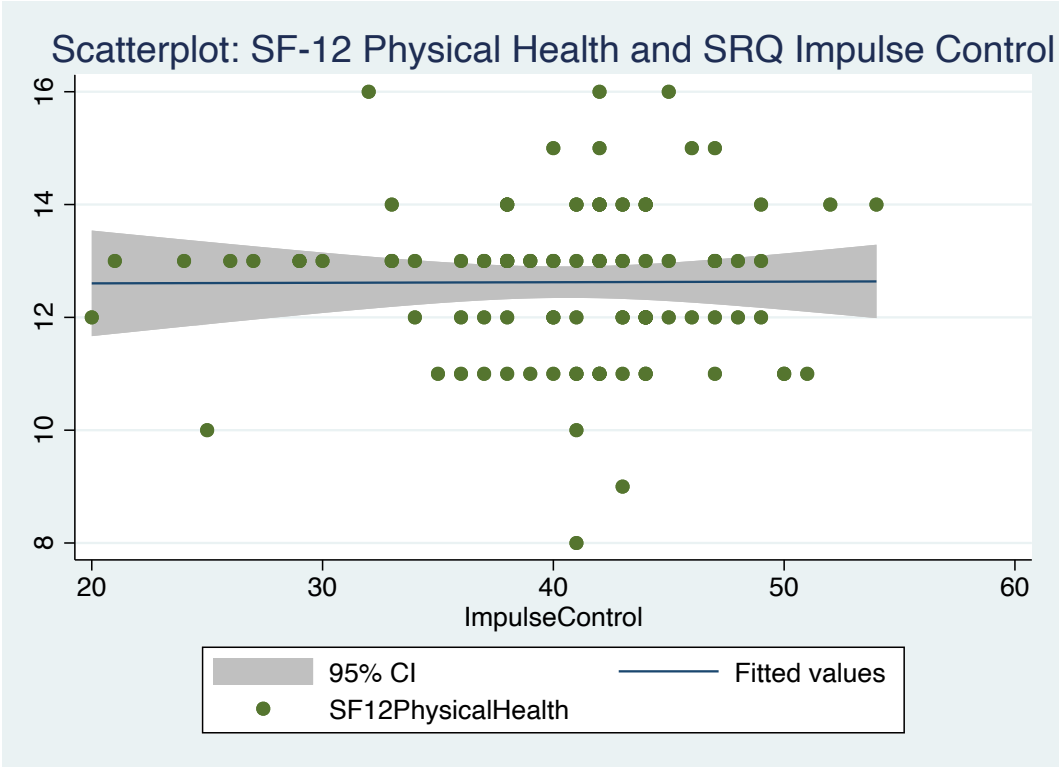
Scatterplot Physical Health and Key Search Raw Score

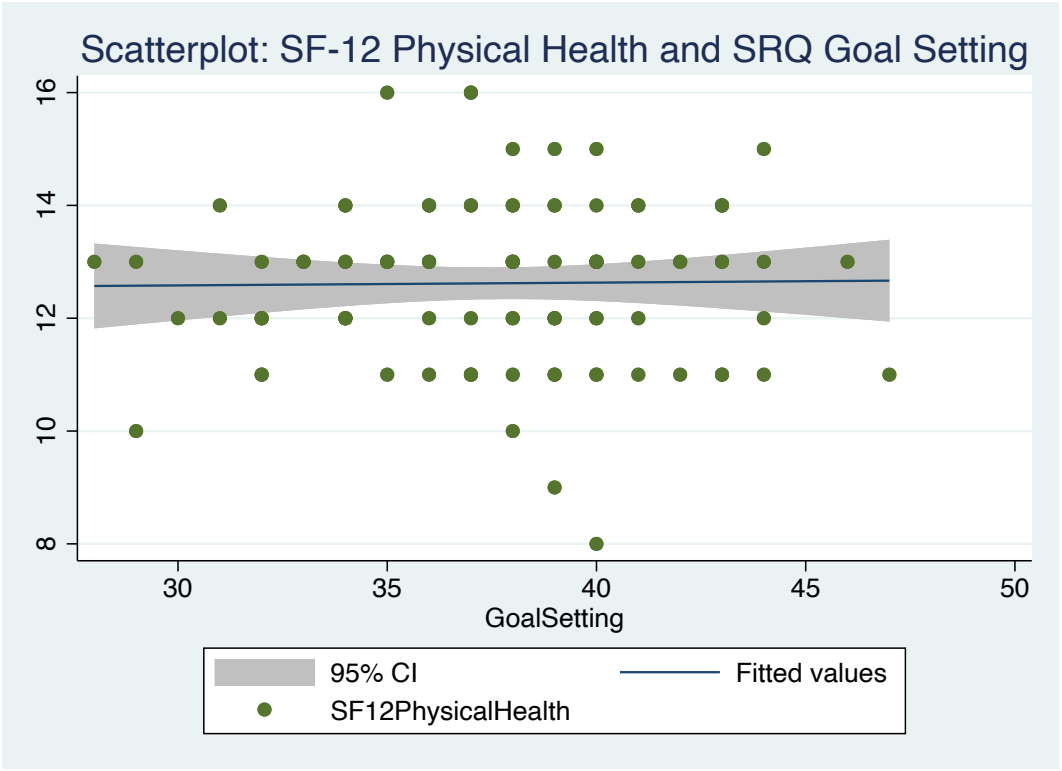


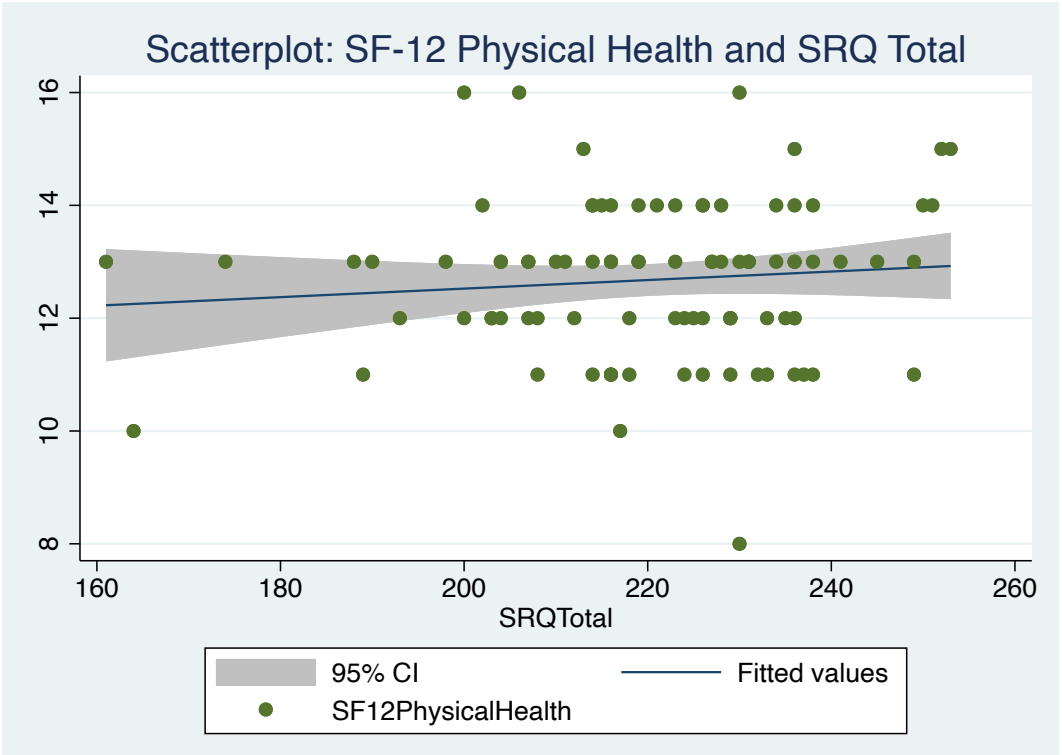

Scatterplot: SF-12 Physical Health and CFQ Forgetfulness
16
14
12
10
8
0
10
20
30
Distractibility
95% CI
Fitted values
SF12PhysicalHealth

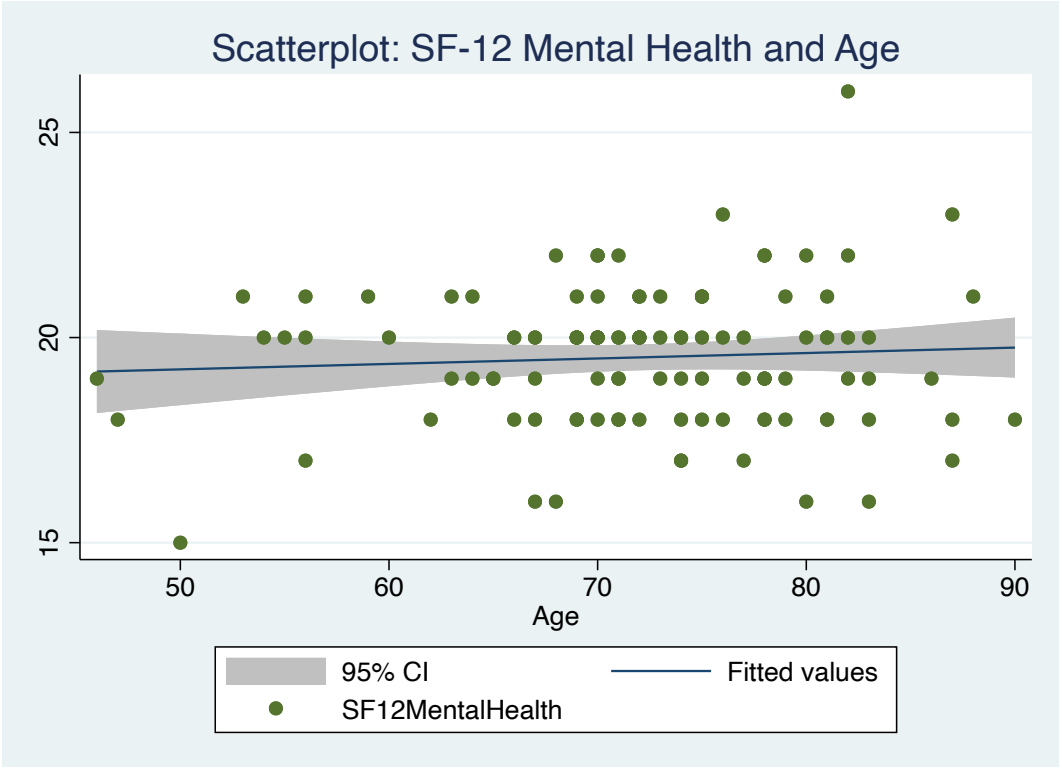

Scatterplot: SF-12 Physical Health and CFQ Distractibility
16
14
12
10
8
0
10
20
30
Distractibility
95% CI
Fitted values
SF12PhysicalHealth

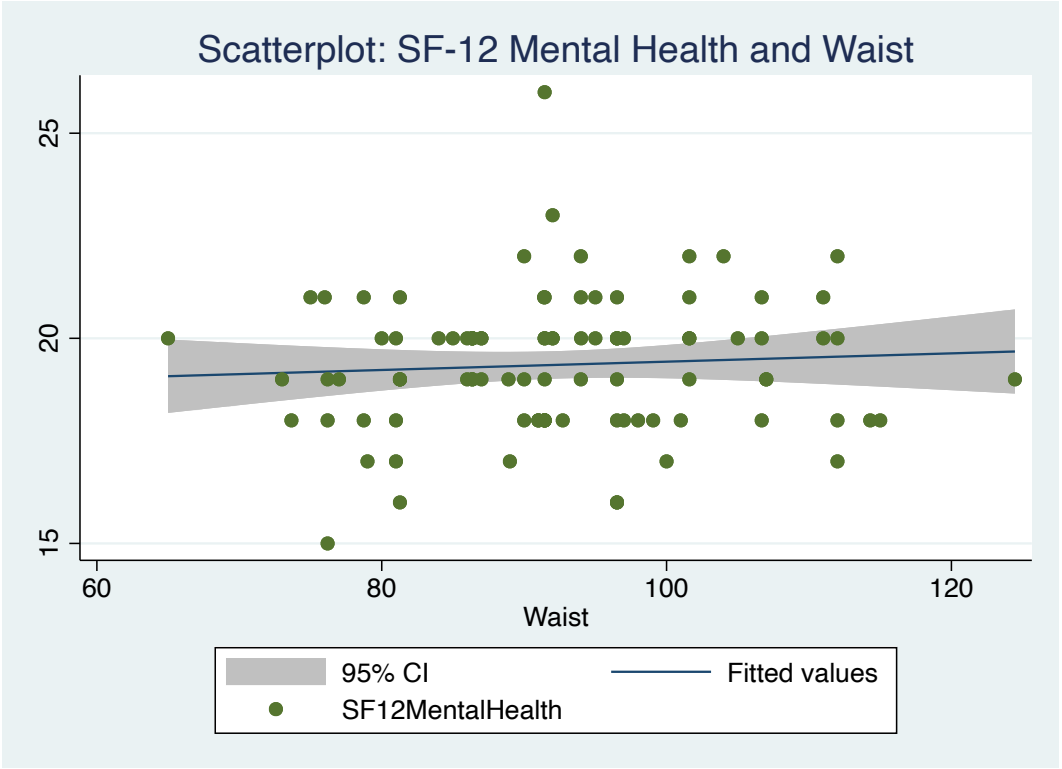

Scatterplot: SF-12 Physical Health and CFQ False Triggering
16
14
12
10
8
0
10
20
30
FalseTriggering
95% CI
Fitted values
SF12PhysicalHealth

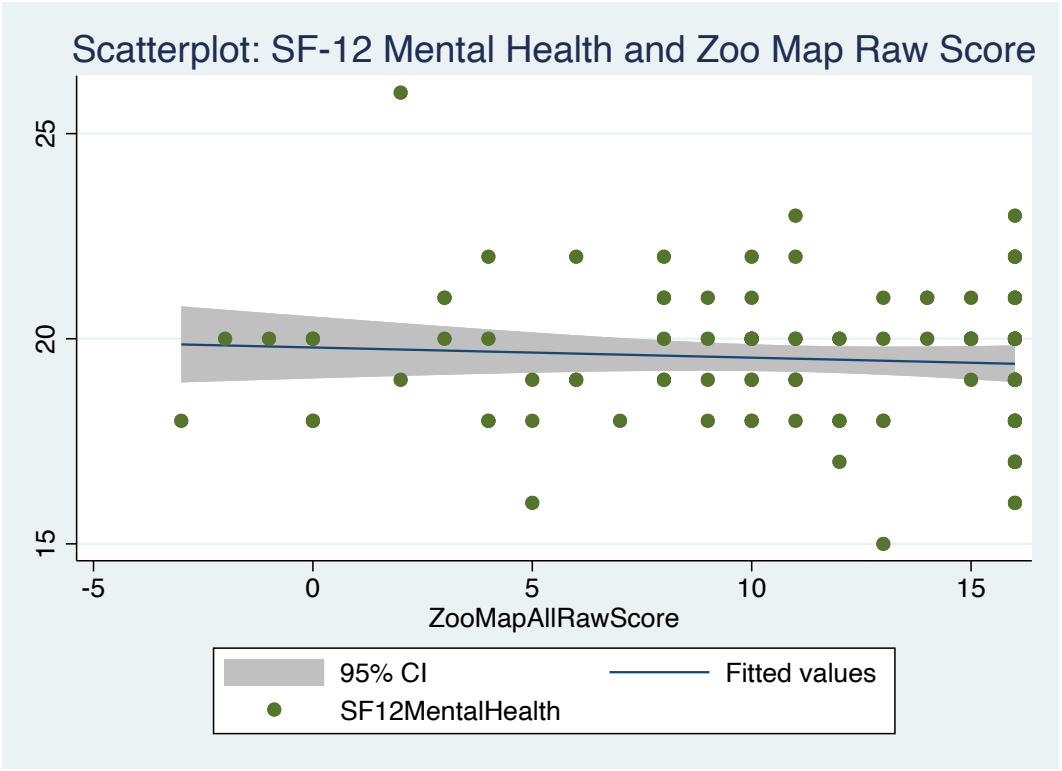

Scatterplot: SF-12 Physical Health and SRQ Impulse Control
16
14
12
10
8
20
30
40
50
60
ImpulseControl
95% CI
Fitted values
SF12PhysicalHealth

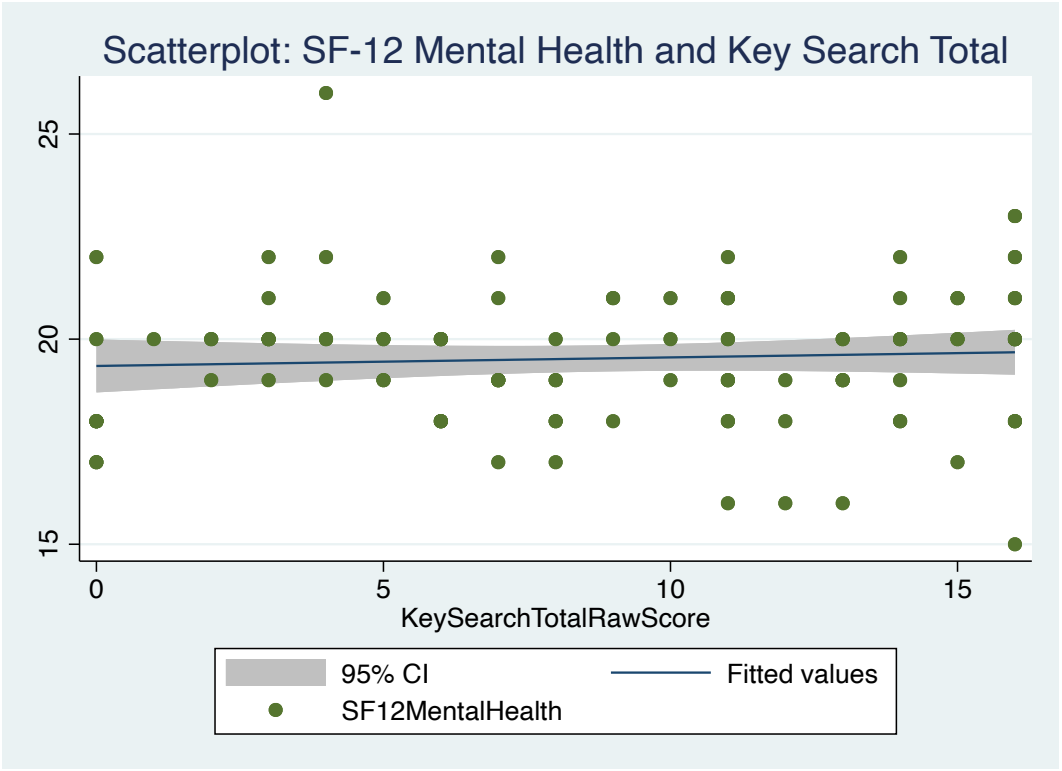

Scatterplot: SF-12 Physical Health and SRQ Goal Setting
16
14
12
10
8
30
35
40
45
50
GoalSetting
95% CI
Fitted values
SF12PhysicalHealth

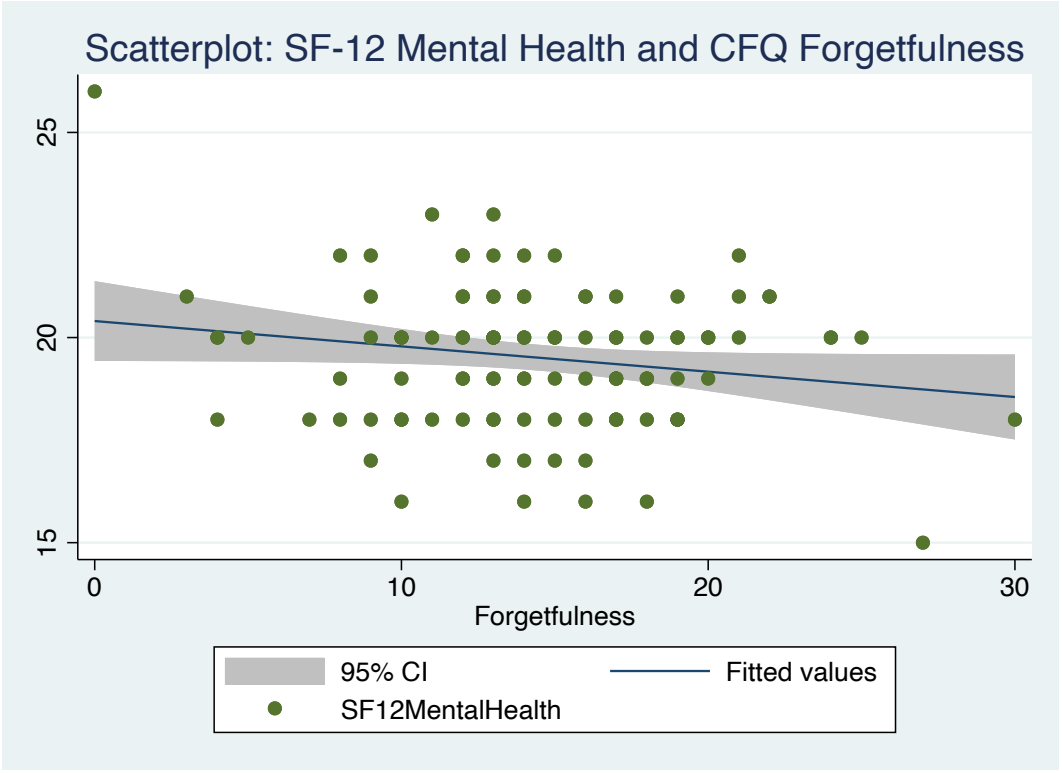

Scatterplot: SF-12 Physical Health and SRQ Total
16
14
12
10
8
160
180
200
220
240
260
SRQTotal
95% CI
Fitted values
SF12PhysicalHealth

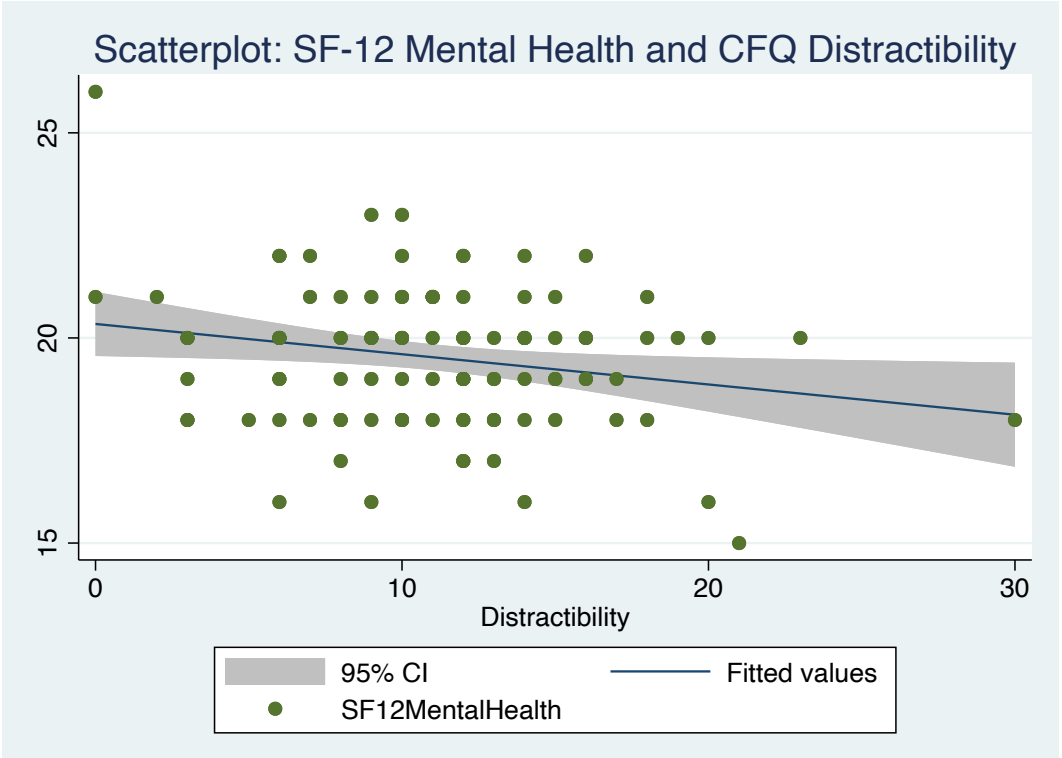

Scatterplot: SF-12 Mental Health and Age
25
20
15
50
60
70
80
90
Age
95% CI
Fitted values
SF12MentalHealth

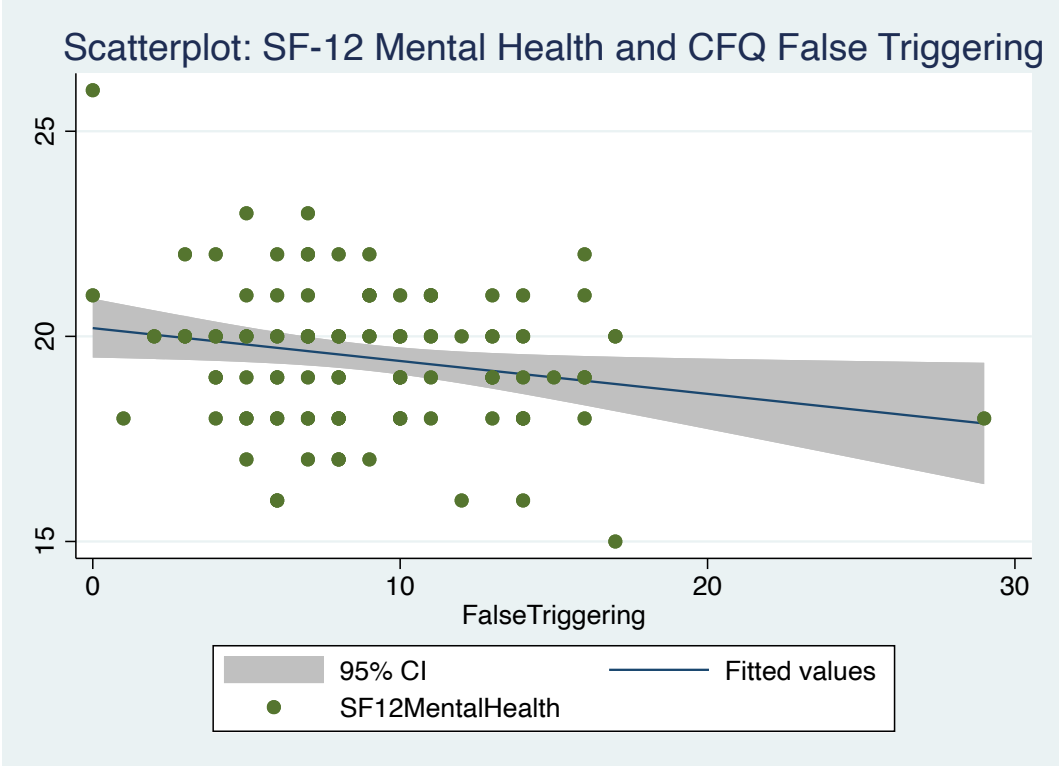

Scatterplot: SF-12 Mental Health and Waist
25
20
15
60
80
100
120
Waist
95% CI
Fitted values
SF12MentalHealth

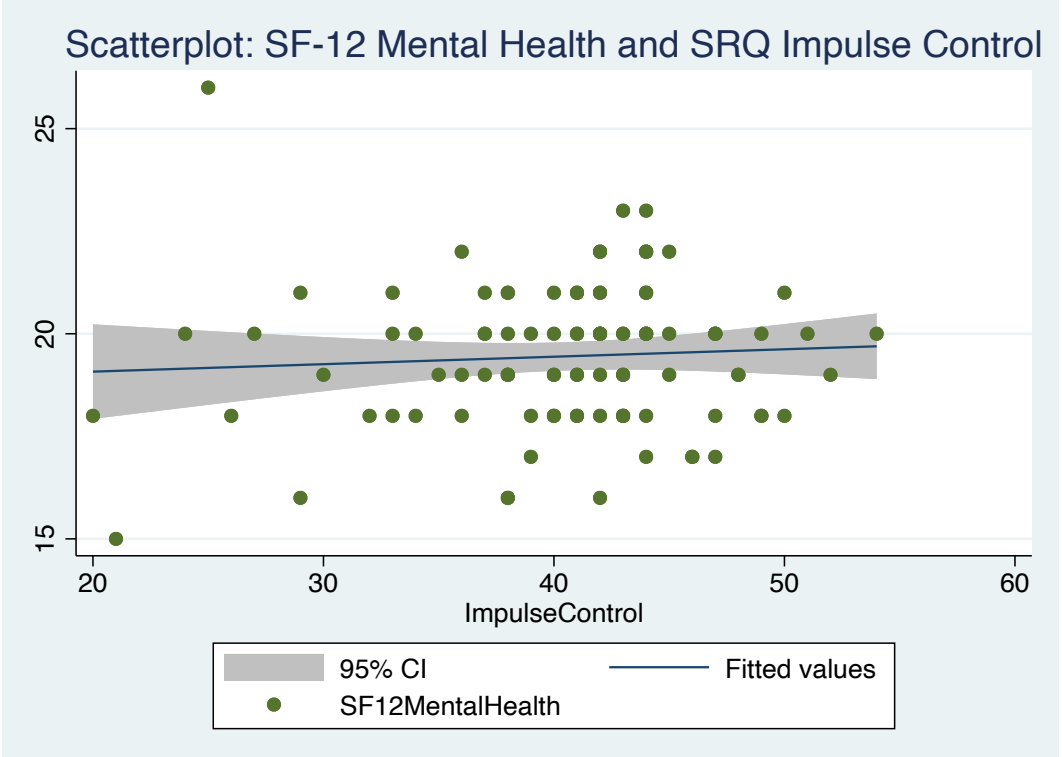

Scatterplot: SF-12 Mental Health and Zoo Map Raw Score
25
20
15
-5
0
5
10
15
ZooMapAllRawScore
95% CI
Fitted values
SF12MentalHealth

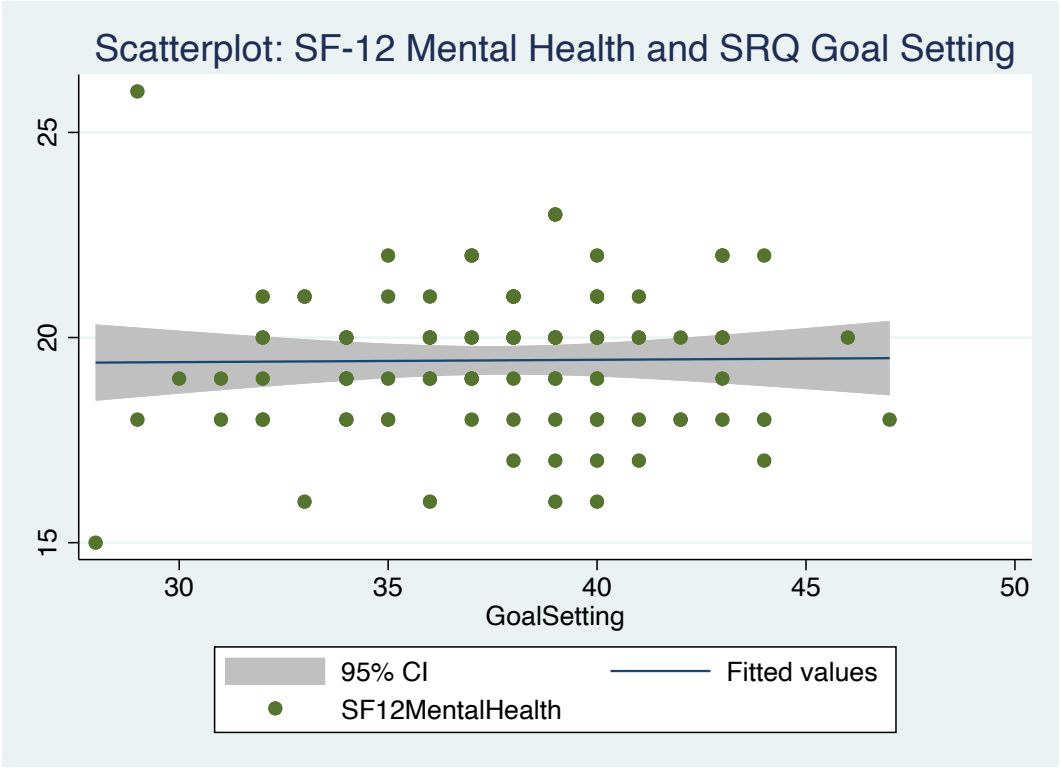

Scatterplot: SF-12 Mental Health and Key Search Total
25
20
15
0
5
10
15
KeySearchTotalRawScore
95% CI
Fitted values
SF12MentalHealth


Scatterplot: SF-12 Mental Health and CFQ Forgetfulness
25
20
15
0
10
20
30
Forgetfulness
95% CI
Fitted values
SF12MentalHealth


Scatterplot: SF-12 Mental Health and CFQ Distractibility
25
20
15
0
10
20
30
Distractibility
95% CI
Fitted values
SF12MentalHealth


Scatterplot: SF-12 Mental Health and CFQ False Triggering
25
20
15
0
10
20
30
FalseTriggering
95% CI
Fitted values
SF12MentalHealth


Scatterplot: SF-12 Mental Health and SRQ Impulse Control
25
20
15
20
30
40
50
60
ImpulseControl
95% CI
Fitted values
SF12MentalHealth


Scatterplot: SF-12 Mental Health and SRQ Goal Setting
25
20
15
30
35
40
45
50
GoalSetting
95% CI
Fitted values
SF12MentalHealth

Appendix 8 – Means, Standard Deviations, and T-Tests for Variables Not Utilized in the Inferential Analysis - Total Sample and Gender

Variable	Total M (SD)	Male M (SD)	Female M (SD)	t (df)	p-value
Zoo Map Version 1 Sequence Score	5.60 (2.62)	**5.88 (2.49) ****	**5.19 (2.75) ****	**2.65 (417)**	**0.009**
Zoo Map Version 1 Errors	1.56 (2.32)	**0.81 (1.63) ****	**2.70 (2.69) ****	**-8.95 (417)**	**<0.000**
Zoo Map Version 1 Raw Score	4.02 (4.10)	**5.07 (3.45) ****	**2.47 (4.44) ****	**6.743 (417)**	**<0.000**
Zoo Map Version 2 Sequence Score	6.94 (2.52)	**6.94 (2.52) ****	**7.88 (0.85) ****	**-4.677 (418)**	**<0.000**
Zoo Map Version 2 Errors	0.32 (0.90)	0.25 (0.81)	0.41 (1.02)	-1.778 (418)	0.076
Zoo Map Version 2 Raw Score	6.99 (2.20)	**6.68 (2.60) ****	**7.46 (1.30) ****	**6.743 (417)**	**<0.000**
Zoo Map Profile Score	2.64 (1.09)	2.68 (1.03)	2.59 (1.16)	0.791 (418)	0.429
Key Search Profile Score	1.85 (1.54)	1.79 (1.61)	1.99 (1.40)	-1.088 (418)	0.277
CFQ Total	35.15 (13.27)	34.98 (13.59)	35.39 (12.83)	-0.312 (407)	0.756
SRQ Receiving	32.38 (4.02)	**31.98 (3.9) ***	**32.99 (32.29) ***	**-2.29 (340)**	**0.023**
SRQ Evaluating	29.3 (3.64)	29.43 (3.34)	29.13 (28.44)	0.747 (330)	0.456
SRQ Triggering	29.58 (3.61)	**29.96 (3.02) ***	**29.05 (4.29) ***	**2.206 (316)**	**0.028**
SRQ Searching	32.03 (3)	31.86 (3.22)	32.28 (2.65)	-1.248 (3280	0.213
SRQ Planning	30.97 (5.27)	**31.56 (4.77) ***	**30.13 (5.83) ***	**2.438 (330)**	**0.015**
SRQ Implementing	32.89 (4.54)	**33.54 (3.53) ****	**32 (5.53) ****	**3.017 (319)**	**0.003**
SRQ Assessing	30.66 (3.64)	**31.32 (3.72) ****	**29.74 (3.31) ****	**3.935 (318)**	**0.0001**
SRQ Total	218.73 (16.77)	**221.56 (14.11) ****	**215.12 (19.1) ****	**3.386 (202)**	**0.0008**
SF-12 Physical Functioning	4.41 (1.32)	4.43 (1.42)	4.38 (1.16)	0.401 (462)	0.689
SF-12 Role-Physical	3.26 (0.92)	**3.39 (0.86) ****	**3.06 (0.96) ****	**3.856 (462)**	**0.0001**
SF-12 Bodily Pain	1.92 (0.91)	1.85 (0.94)	2.01 (0.85)	-1.881 (462)	0.061
SF-12 General Health	2.91 (0.84)	2.90 (0.93)	2.93 (0.68)	-0.276 (462)	0.782
SF-12 Vitality	3.32 (1.25)	**3.08 (1.2) ****	**3.63 (1.25) ****	**-4.683 (440)**	**<0.000**
SF-12 Social Functioning	4.99 (0.96)	**5.01 (0.83) ****	**4.84 (1.04) ****	**2.902 (451)**	**0.004**
SF-12 Role Emotional	3.66 (0.67)	**3.73 (0.64) ***	**3.57 (0.7) ***	**2.459 (462)**	**0.014**
SF-12 Mental Health	7.84 (0.39)	7.87 (0.86)	7.8 (0.06)	0.963 (440)	0.336
SF-12 Physical Component Summary (PCS-12)	43.12 (9.91)	43.65 (10.3)	42.35 (9.29)	1.389 (462)	0.165
SF-12 Mental Component Summary (MCS-12)	54.0 (8.23)	**55.69 (7.93) ****	**51.6 (8.06) ****	**5.428 (462)**	**<0.000**

*Significant difference, $p<0.05$
**Significant difference, $p<0.01$