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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

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Title

Exploring the pandemic: COVID-19 lockdown response levels as predictor of working memory performance and associated emotional responses

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Abstract

The unprecedented outbreak of the COVID-19 pandemic has altered the course of many lives, resulting in multiple health and social challenges. Due to the speed with which this pandemic spread, various public health 'lockdown' measures were introduced to mitigate its spread. The outcome of adherence to these measures has revealed the possible influence on individuals varying cognitive abilities. Therefore, this study aimed at exploring the predicting relationship between lockdown responses to COVID-19 restrictions and working memory performance and associated emotional responses, while looking at the socio-demographic influences of age, gender, and level of education. Participants were drawn from a secondary dataset of an international online survey study of 1634 individuals between 18 – 75 years across 49 countries. Participants' demographic questionnaires, working memory measures (free memory recall and digit span forward tasks), and hospital anxiety and depression scale were employed to collect data for analysis. A 4-way MANOVA and hierarchical multiple regression were utilised to explore the mean differences and predicting relationships between the study variables respectively. Significant differences were found in general memory performance, anxiety and depression scores across lockdown groups, but with no significant difference in working memory. The regression analysis indicated socio-demographic variables as non-predictive markers between lockdown responses and memory performance, while age and gender were significant predictors between lockdown responses and anxiety. The current study provides valuable information for interventions that may improve peoples' psychological appraisals in preparation for any new potential waves or future pandemics.

Keywords: COVID-19 lockdown, working memory, depression, anxiety, public health measures

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Chapter One Introduction

The outbreak of COVID-19 and its spread at an unprecedented speed necessitated many countries to impose strict measures to break the chains of transmission and delay its viral spread (Di Domenico et al., 2020). While various public health measures such as social distancing, hand-washing, and mask wearing, were arguably globally recommended, the enforcement of strict 'lockdown' across countries – requiring people to stay at home for extended time period – was a preventative measure differently applied internationally (Murphy et al., 2020; Wright & Caudill, 2020). As a respiratory infectious disease with severe viral spread and associated fatal clinical outcomes (Mbuvha & Marwala, 2020), the COVID-19 pandemic has led to devastating outcomes internationally, exposing people to various psychological risks and heightened levels of anxiety and depressive symptoms. These outcomes have consequently influenced individual's social engagement, decision-making, and behavioural responses to the disease spread and its strict containment measures (Heffner et al., 2021; Torales et al., 2020).

Arguments have been postulated that COVID-19 induced lockdown has resulted in psychological and social challenges, with potentially negative effects on individual attention and decision-making capacity (Bavel et al., 2020; Brooks et al., 2020). The contribution of working memory (WM, as a component of executive functioning) to interference control and task updating shows the necessity to adhere to rapidly changing rules, while continuously controlling for emotion or self-regulation (Miyake et al., 2000). Thus said, varying behavioural outcomes and responses to COVID-19 lockdown measures may potentially influence individual's cognitive abilities such as WM capacity (Fiorenzato et al., 2021; Holmes et al., 2020). Despite a recent study on the relationship between COVID-19 and WM that highlighted the pandemic's impact on individual WM performance and inhibitory deficits, leading to hospitalisation (Kira et al., 2021), there is a dearth of research on how WM capacity is associated with group responses to imposed social isolation and pandemic lockdown measures. This is especially prevalent within sub-Saharan African countries, of which South Africa is inclusive. To the best of the researcher's knowledge, no study to date has investigated in low-income, middle-income, or high-income countries how cognitive

abilities such as WM, and anxiety and depression, are associated with varying responses to COVID-19 lockdown measures. Additionally, the role of socio-demographic characteristics, such as age, gender, and educational level to pandemic lockdown responses are equally important and merit further investigations (Torales et al., 2020). For the purpose of this study, the cognitive-emotional context in this study will be defined as the integration and congruent interaction of the thoughts and meaning of charged stimuli or neural events of individuals that results in altering their emotional responses (Ochsner & Gross, 2005; Tyng et al., 2017).

The aim of this study was to explore the relationship between varying levels of responses to the novel coronavirus disease 2019 (COVID-19) lockdown measures and general memory comprehension, working memory performances, and related anxiety and depression responses of participants drawn from secondary data set of an online international survey study of 49 countries between July and September 2020. In addition to this relationship and group differences, the study also investigated whether there were predicting influences of socio-demographic variables of age, gender, and level of education on the relationship between lockdown responses, general memory comprehension, working memory performance, with associated emotional responses of anxiety and depression. While there exist many theoretical approaches to executive functioning performances (specifically working memory and general memory), and emotional responses, Baddeley's multicomponent model of working memory (Baddeley, 2012) was chosen to foreground and theoretically guide the context of this current study.

In chapter 2, a detailed literature review is presented to review empirical studies that have investigated the association between group responses to COVID-19 lockdown measures, cognitive (specifically general memory and WM) performances, and associated emotional responses, together with the theoretical framework guiding the study. Chapter 3 details the methodology used, focusing on the study design, sample and sampling strategy, measures utilised, procedures engaged, data analysis methods, and ethical considerations. The results are then fully reported in Chapter 4. Firstly, the general descriptive results of the demographic, lockdown, and cognitive-emotional variables are presented, followed by the 4-way multivariate analysis of variance (MANOVA) and

the hierarchical multiple regression results. Lastly, Chapter 5 provides a discussion of these results in relation to the reviewed literature, and outlines the study limitations and recommendations for future directions of research.

Chapter Two Literature review

The COVID-19 pandemic has led to devastating outcomes internationally within a short period of time. According to Naude and Cameron (2020), South Africa's infection rate in August 2020 rose to 622,000 confirmed cases and 14,000 fatalities. By March 2021, an estimated 2.6% of the South African population [1.53 million] was presumed as infected with the virus, while 4% of infected population resulted in fatalities (Galal, 2021). This uncertain and evolving viral pandemic has brought a massive campaign to slow down and mitigate the disease spread through various lockdown restrictions such as social isolation and physical distancing (Bavel et al., 2020; Mboera et al., 2020). However, the outcome of this pandemic has altered the course of many lives, with prolonged social distancing and systematic quarantine, leading to arguably reduced cognitive functioning, unprecedented anxiety, depression, and other mental health concerns (Fellman et al., 2020; Fiorenzato et al., 2021; Wang & Zhao, 2020).

COVID-19 lockdown responses and cognitive performance

The necessary implementation of social distancing and lockdown restriction measures during recent pandemic were geared towards reduced infection rate of COVID-19 within the population (Aleman & Sommer, 2020; Stiegler & Bouchard, 2020). Although, these measures were pivotal to stop the spread of COVID-19 pandemic, as well as to reduce mortality rate with respect to this viral disease before widespread vaccination was rolled out, they have however resulted in differing individual conformity responses to social isolation and 'stay at home' pandemic rules (Luchetti et al., 2020). In some instances, general responses to these lockdown measures have been met with considerable popular resistance because of immense socio-inequities and general lived poverty levels of the people, especially in sub-Saharan Africa, where unequal access to basic social services persists (Isbell, 2020). Imposed social isolation during COVID-19 lockdown has brought varying effects to psychological and social milieu, and consequently, citizens' responses have shown a mix of adherence and resistance to COVID-19 pandemic lockdown rules (Ilesanmi et al., 2020; Sailer et al., 2020).

Outcomes of some recently recognised psychological responses to COVID-19 lockdown measures have shown the effect of individual behavioural changes on their differing compliance levels to pandemic social restrictions, arising from resulting social stereotypes and cultural norms (Bavel et al., 2020; Bavel et al., 2022; Duffy & Allington, 2020). The initial psychological responses to COVID-19 lockdown measures is assumed as generally reflected by increased levels of emotional response such as anxiety and depression. However, these responses could also influence people's differing ability to correctly appraise strategies to self-regulate, which could be linked to the decision-making processes within the cognitive structures of individual's executive functioning capacity, specifically working memory (Brooks et al., 2020; Kira et al., 2021).

Conceptualised as a distinct component of the executive function elements, working memory (WM) is defined as a multicomponent system responsible for active maintenance and manipulation of transitory information of individual behaviours in the face of ongoing decision-making processing or distraction (Conway, 2014; Diamond, 2013). In view of this, the concept of WM therefore postulates a system within executive functioning components that is made up of elements responsible for moderating, manipulating, and updating storages and processes within the cognitive control system (Miyake et al., 2000). To correctly understand the elements and operationalisation of WM, the multicomponent model of Baddeley and Hitch (1974; Baddeley, 2012) gives expression on the 'fractionisation' of WM (Repovs & Baddeley, 2006) on individual and interrelated functions of each components.

As elucidated by Del Missier and colleagues (2012), associations between WM and decision-making competence are evident when emotion-based judgements are executed under higher or lower cognitive loads. They further highlighted that increased WM capacity leads to less probability judgement and efficient decision-making choice, whereas decreased WM performance may put pressure on individual cognitive load, resulting in low decision-making competence. The operationalisation of this association highlighted the assumption that semantic response (a type of memory response that consists of factual information and meaningful knowledge properties) plays a fundamental role in background knowledge decision-making processes, while past experiences

involve influences of episodic memory (a memory system involved in conscious awareness and recollection of events and personal experiences; Del Missier et al., 2013). This means that association between WM and decision-making processes may likely influence the outcome of individual psychological or behavioural responses arising from new semantic frameworks and episodic content retrieval that are linked to social isolation during COVID-19 imposed lockdown measures (Almeria et al., 2020; Ritchie et al., 2020).

Theoretical framework of working memory and emotion

Executive function is assumed to be comprised of a set of cognitive processes that are responsible for manipulating individual thoughts and behaviour towards attaining requisite goals and objectives (Miyake et al., 2000). The understanding of executive function does give a baseline insight into models and meaning of the elements that make up the structure of working memory. The multicomponent model of Baddeley (Baddeley, 2000, 2003) gives expression to these working memory elements, which are considered as distinct, but interrelated in the specific operations (Soliman, 2014).

According to the multicomponent model (Baddeley, 2007; Repovs & Baddeley, 2006), WM comprises of the central executive, considered as the most complex element of WM, responsible for managing and updating attentional focus of the storage and process systems. It is also recognised as the virtual homunculus of WM, capable of manipulating and functioning into other subcomponents of WM (Baddeley, 2012; Repovs & Baddeley, 2006). Other three components include the phonological loop – a storage system responsible for storing and maintaining verbal and auditory tasks; the visuospatial sketchpad – responsible for storing and updating visual and spatial information; and episodic buffer – responsible for multi-dimensional coding and binding of information within the central executive into long term memory (Baddeley, 2007, 2012; Repovs & Baddeley, 2006). All these are considered as separate components, having strongly correlated, inter-related functions toward the goals and properties of WM (Cockcroft et al., 2019). This framework

further elaborates on the hypothesis of relational influence between WM and the construct of emotion.

Emotion is a broad construct that encompasses "affective, cognitive, behavioural, expressive and physiological changes …triggered by external stimuli and associated with the combination of feeling and motivation" (Tyng et al., 2017, p. 3). Amongst several primary emotional states, *fear*, *anxiety*, and *depression* have received wider study because of their importance to clinical practices, and more accessible evidence-based reports (Baddeley, 2013). For the purpose of this study, 'anxiety' is defined as a mental and physiological state of human emotional dimension that is characterised by feelings of tension, worry, and arousal of stressful circumstances and negative outcomes (Levitt, 2016; Moran, 2016). Baddeley's (2007) revised multicomponent model provides understanding of the processes of human reasoning and decision making, in which emotion plays an integral part (Damasio, 1999). This framework further accounts for influences between emotions and WM, and establishes an assumption that human cognition, including memory, are affected and/or modulated by emotion (Phelps, 2004; Tyng et al., 2017).

Within the revised multicomponent framework, the emotional state of anxiety fits appropriately within the central executive component, as it operates principally to influence cognitive processes of attentional control element by biasing response toward threat-related stimuli (Baddeley, 2013; Moran, 2016). This therefore supports the assumption that influence on WM is elicited when attention is engaged at both perceptual and overt levels of anxiety and fear (Baddeley, 2013). A study was conducted to explore the theoretical understanding of the mechanisms underlying the association between motivation and academic achievements. The outcome of the study showed that the motivational role of emotion is primarily and directly linked to heightened measures of memory performance and outcomes in learning (Seli et al., 2016). In addition to this finding, Pessoa (2009) also argues that the influence of emotion within executive functions elicits a direct association that incorporates a link with WM capacity that generates differing unfolding behavioural responses.

Accounting for the emotional influence of depression within the multicomponent WM model requires a broader multicomponent model enhancement, namely the *hedonic detection system* (Baddeley, 2007). Depression is known to be a psychological and mental disorder that presents with specific mood alterations, negative self-concept, and regressive thoughts that are characterised with self-punitive negative agitations (Beck & Alford, 2009). The hedonic detection system however attempts to establish individual's capability of making the optimum choice when faced with positive and negative outcomes (Baddeley et al., 2012). Because of the de-energised nature of depression, and its internally-focused and negatively ruminating concepts, which mostly impact the long-term memory of the cognitive structure of the brain (Baddeley, 2007, 2013), the *hedonic detection system* therefore consists of temporary storage and processing mechanisms capacitated to manipulate various hedonic information, which consequently interact with WM storage and processes (Baddeley et al., 2012).

The hedonic detection system is viewed as including both biological and environmental influences that are responsible and sensitive to the genetic components of depression. Its operationalisation is represented within the episodic buffer component of WM, being amplified/minimised by central executive processing (Baddeley, 2007, 2013). To further ascertain the distinctiveness of emotion's characteristics and influence within working memory storage components (Berggren et al., 2017; Hur et al., 2017), the *semantic activation model* (Collins & Loftus, 1975) posits high interrelatedness of emotional words, which enhances its better recall process than other abstract or neutral words. This could explain why emotional words are more image-represented than abstract words (although less represented than concrete words) because of their semantic relatedness, thereby making it possible to influence attentional processes and episodic content of WM capacity (Altarriba & Bauer, 2004; Moran, 2016).

Association between COVID-19 lockdown responses and WM performance

The COVID-19 imposed social restrictions may exacerbate the presence of anxiety and depression with potential direct implications for WM performance (Fellman et al., 2020; Fiorenzato

et al., 2021; Huang et al., 2020), as various studies have confirmed the heightened impact of the pandemic on affects, leading to increased anxiety and depression (Choi et al., 2020; Hyland et al., 2020). With this current situation, imposed pandemic lockdown measures such as social isolation may necessitate or interact with people's response towards negative psychological feelings of loneliness, anger and confusion, resulting in impacts on decision making that may produce risky situations (Brooks et al., 2020). In view of this, differing social contexts such as culture, social stereotypes, conspiracy theories, and political polarisation, could play a significant role on people's perceptions and conformity responses toward the 'stay at home' confinement implemented during the COVID-19 pandemic (Bavel et al., 2020; Bavel et al., 2022; Isbell, 2020).

As a result of recognised psychological responses during the novel coronavirus pandemic, a large national online survey examined the perceived decline in cognitive performance including WM amongst 1215 participants when compared with their baseline memory abilities before lockdown (Fiorenzato et al., 2021). The result of the survey showed evidence of severe changes to cognitive functions involving attentional and memory abilities, including significant increases in anxiety and depression during imposed lockdown restrictions. In addition to this, responses to lockdown restrictions in women and younger people (18-25 and 26-45 year-old groups) showed difficulties in activities involving executive function abilities such as attention and concentration. A recent study on the association between individual response to COVID-19 lockdown measures (social distancing compliance) and WM performance showed that the outcome of individual differences to lockdown compliance highlighted a direct effect on their ability to analyse the cost-benefit profiles of lockdown compliance rules. This thereby resulting in psychological responses of show of less adherence and responses, and possible disregard for social distancing rules (Xie et al., 2020). In view of this, it can be argued that individual behavioural responses during the lockdown restrictions may possibly be affected by their differing WM processing capacity, bearing critical influence on their subjective compliance level, or disregard for imposed social isolation and distancing measures.

In line with the above outcomes, a longitudinal representative sample study in Scotland investigated the association between COVID-19 lockdown social restrictions and cognitive performance across five timepoints during the pandemic lockdown in March 2020. The outcome of the study showed that both short-term and long-term social isolation, and reduced social contact during the pandemic, negatively impacted participants' cognitive functions, especially in the areas of attentional capacity, working memory performance, and decision making, resulting in poor response towards adherence and compliance to pandemic restriction measures (Ingram et al., 2021). This result therefore suggests that continued COVID-19 lockdown and social restriction rules could exacerbate individual's negative and maladaptive responses to adherence and compliance measures, resulting from the detrimental effect of the prolonged restrictions on their levels of cognitive responses and functions.

Additionally, while there is a growing body of literature on the psychological impact of COVID-19 lockdown measures (Brooks et al., 2020; Grover et al., 2020; Rossi et al., 2020), there is limited evidence-based research and systematic study on how cognitive abilities influence responses to COVID-19 lockdown rules. In an online survey study conducted to evaluate the general behavioural responses of Bangladeshi people to COVID-19 lockdown measures, it was highlighted that although a good number of citizens complied with the rules principally to prevent COVID-19 infection, the majority of study respondents showed a neutral attitude towards lockdown rules (Rahman et al., 2021). Furthermore, a larger study in Germany amongst 14 433 participants showed individual and group responses to government-imposed lockdown rules, highlighting a mixture of compliance and negative reactions to mobility restrictions and physical/social isolation rules respectively (Gollwitzer et al., 2020). Gollwitzer and colleagues further noted that public reactions to different lockdown scenarios during COVID-19 stay-at-home restriction highlighted a show of negative endorsement and indifference that led to reduced compliance, or risk of non-compliance with certain lockdown scenarios such as intensified lockdown extension.

Socio-demographic factors and the association between COVID-19 pandemic and WM performance

Socio-demographic factors such as age, gender, and level of education could presumably play pivotal roles when investigating the association between lockdown responses, cognitive performance, and emotional responses. Age and gender differences have been postulated as noticeable influencing risk factors on COVID-19 infections and outcomes (Goujon et al., 2020). Goujon and colleagues showed a higher prevalence of COVID-19 amongst adult males (55-80 years) compared to women (15-55 and ≧80 years), while the proportion of fatalities were also reportedly higher among men of all age groups than women. Similarly, a study from 10 European countries confirmed a higher prevalence among working age women than working age men, owing to higher involvement in healthcare-related occupation (Sobotka et al., 2020). Furthermore, a general higher prevalence of COVID-19 has been recorded in adult men than women, as a result of general behavioural pattern and negative genetic disposition (Agrawal et al., 2021).

Consequently, due to the association between higher WM performance deficits, emotional responses (such as depression and anxiety), and COVID-19 infections and outcomes in a recent study (Kira et al., 2021), it is hypothesised in the current study that age and gender differences may predict this association because of their existing relationship with cognitive performance – WM and general memory (Hyde, 2016; Weiss et al., 2003), where males held gender stereotype of outperforming females on visuospatial tasks, and females exhibited better verbal tasks performance than males. In the same view, the existing relationship of age with emotional responses, where older adults exhibited lower anxiety response to daily life stress exposure compared to younger adults (Scott et al., 2013; Streubel & Kunzmann, 2011) may also argue for the assumption of age predicting the association between COVID-19 lockdown outcomes and emotional responses such as anxiety and depression.

Furthermore, there are diverse studies that have posited and sketched the potential relationship between WM performance and education (Conway, 2014; Pickering, 2006; Pickering & Gathercole, 2004). In essence, the role of education in cognitive development is fundamentally

underpinned by WM processes and adaptation that predicts individual levels of performance and attainment (Gonzalez et al., 2020). In the same manner, because of the association of emotion with cognitive functions and processes (Tyng et al., 2017), emotion is viewed as an important foundational component for learning, educational adaptation, and development (Cowan, 2014). To understand the effect of educational level on prevailing COVID-19 pandemic compliance and emotional responses, a study by Xie and colleagues (2020) found that education was not a significant predictor of the pandemic outbreak and people's responses to social distancing measures. Similarly, the result of Fellman et al. (2020) also reported a non-significant association between COVID-19 cognitive-emotional responses and differing level of education amongst 201 participants from five countries.

These results were also consistent with outcomes from previous pandemics such as severe acute respiratory syndrome (SARS), where level of education was not associated with SARS pandemic outcomes and emotional symptoms of post-traumatic stress disorder (PTSD) and depression (Hawryluck et al., 2004). However, in another study exploring the association of socio-economic variables and COVID-19 related infections and fatalities amongst over 34,000 participants drawn from 401 administrative districts and counties in Germany, the results showed that level of education had a significant negative effect (at the district level) on COVID-19 pandemic prevalence. This therefore suggests that people with higher level of education within those districts had less COVID-19 prevalence and outcomes (Ehlert, 2021). Taken together, the literature suggests that education may have a buffering effect on the relationship between COVID-19 pandemic related group responses and outcomes and cognitive-emotional performances. In view of the above outcomes, predicting influence of the above socio-demographic determinants may exacerbate or buffer COVID-19 prevalence and cognitive performance and emotional responses (Naidu, 2020).

The influence of COVID-19 outbreak, especially with reference to people's psychological and behavioural responses to the pandemic lockdown measures, have generated hypotheses about potential influence on individual cognitive capacity and emotional responses. Recent studies have

posited the association between COVID-19 pandemic and WM capabilities (Kira et al., 2021). However, to the best of the researcher's knowledge, no study to date has investigated if individual's baseline cognitive ability, specifically such as general memory (Gruenewald & Lockhead, 1980; a measure of cognition responsible for storage processes and retrieving known set or category of information from the short-term and long-term memory components) and working memory capacity, and associated emotional responses, are related with varying responses to COVID-19 lockdown measures.

Larger online survey study and lockdown groups

This study is nested within a larger international online survey study across 49 nations that investigated various factors that act as determinants of adherence and poor coping in response to COVID-19 lockdown measures. Additionally, the study also explored various cognitive-emotional processes underlying differing responses to the pandemic measures (Van Belle et al., 2021). The online cluster study was originally conducted as a cross-sectional study in the United Kingdom (UK) in the wake of the pandemic waves resulting into the imposed strict lockdown measures. The study eventually progressed internationally to other continents of the world who were experiencing similar lockdown and social restriction measures during the COVID-19 pandemic.

In the international online study, three group responses to COVID-19 lockdown measures were identified amongst 2309 respondents. This was consistent with previous similar online cluster analysis conducted in the UK that showed different ways people respond in compliance or resistance to various lockdown measures resulting from COVID-19 outbreak (Duffy & Allington, 2020).

The UK online survey study conducted by Duffy and Allington (2020) analysed how participants were grouped together according to their risk similarities, and dimensions of their lockdown response data relating to adherence, behaviours, perceptions, and leadership trust in certain lockdown response measures. In the same manner, the creation of lockdown response variable in this current study was adopted in line with same online survey study through a *k*-means

cluster analysis. The larger international online study that the current study was part of, performed an exploratory factor analysis on the 54 lockdown questions or items that assessed participants' beliefs, attitudes, and behaviours around COVID-19 pandemic characteristics and government-imposed lockdown measures (Van Belle et al., 2021). In order to reduce the robustness of the *k*-means clustering, the principal component analysis (PCA) was utilised on the lockdown-related questionnaires of the entire sample participants, which were answered on a 5-point Likert scale covering statements such as adherence to lockdown instructions; self-medication approach; beliefs around COVID-19; participant's well-being during the pandemic lockdown; individual's non-pandemic health behaviours; belief and perception about the future; level of trust in government ; and the use of social media during the lockdown.

Cluster analysis was further performed using varimax rotation and Kaiser's criterion normalisation and extraction, with analysis of eigenvalue greater than 1 (Field, 2009). The outcome of the analysis reported plotted *"k"* within 30 iterations for 2, 3, and 6 factors, whereby the cluster analysis of k =3 was chosen as the optimal cluster division for maintaining meaningful population size within the cluster, as well as in alignment with the previous online survey study (Duffy & Allington, 2020; Van Belle et al., 2021). The creation of three clusters in the larger international study was informed by the strength of the factor loading in the PCA, and as such, the created three clusters were named 'general population' (cluster 1), 'extreme responders' (cluster 2), and 'sufferers' (cluster 3). In this current study, identification of the COVID-19 lockdown group response was based on the larger international study's cluster composition. The cluster grouping in the current study (slightly modified as 'comply group', 'sufferer group' and 'defiant group') therefore showed how each grouping characteristics inform the cognitive (specifically general memory and working memory), emotional, and neural processes underlying psychological responses to COVID-19 lockdown rules.

Research aims, questions and hypotheses

The aim of this study was to investigate the association between cognitive performance (general memory and WM) with its associated emotional responses, and the three group responses to COVID-19 lockdown measures (comply, sufferer, and defiant groups), while looking at the moderating influences of the socio-demographic characteristics of age, gender, and level of education. Therefore, the main and secondary research questions guiding this study are:

1. Is there a significant difference in the association between the cognitive contents of general memory and WM performance within the three 'lockdown groups'?
2. Is there a significant difference in the association between the subsequent emotional responses of anxiety and depression within the three 'lockdown groups'?
3. Do socio-demographic factors – specifically age, gender, and level of education – predict the association between group responses to COVID-19 lockdown measures, general memory comprehension, WM, and anxiety and depression?

In light of the above theoretical and literature reviews, existing evidence supports the following hypotheses:

Hypothesis 1: Significant differences will be found within the association between cognitive contents of general memory and WM performances across the 'lockdown group' responses.

Hypothesis 2: Significant differences will be found within the association between the subsequent emotional responses – specifically anxiety and depression – across the 'lockdown group' responses.

Hypothesis 3: Socio-demographic factors – specifically age, gender, and level of education – will predict the association between group responses to COVID-19 lockdown measures, general memory comprehension, WM performance, and anxiety and depression.

Chapter Three Methodology

Research Design

The design for the study assumed a positivist and quantitative research approach to data collection and analysis. Quantitative research describes characteristics of the current objective state of a phenomenon, and an observable context that can be generalised to a population (Leedy & Ormrod, 2015; Salkind, 2018). The study adopted an exploratory, non-experimental, cross-sectional design. Using this form of design within this study afforded the possibility of controlling for other variables to get a robust effect of the relationship between the construct/phenomenon (Bordens & Abbott, 2018). The use of a cross-sectional study further assisted in explicating the different mean levels within the independent variables when compared with one another. This design approach was also considered a good cost-effective measure of collecting data within a single time frame (Leedy & Ormond, 2015).

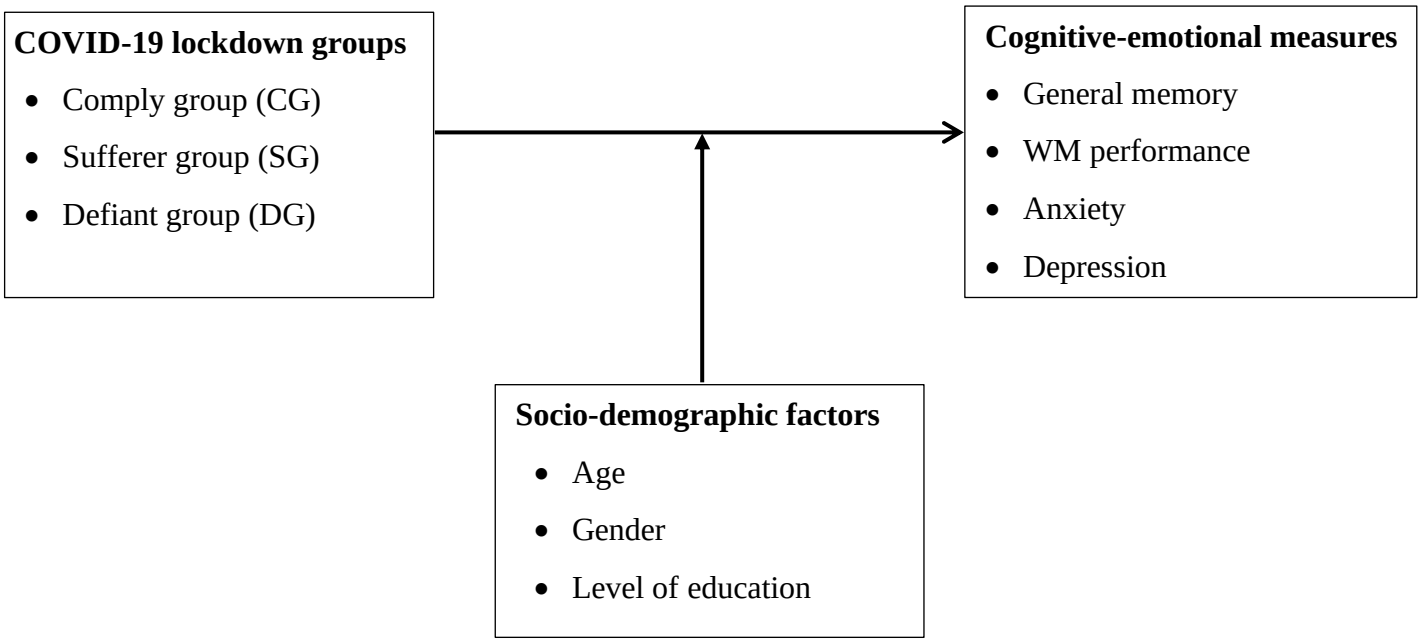
The detailed variables of interest in this study comprised of COVID-19 lockdown groups, which were analogous to the conformity groups of the larger international online study (see sample and sampling strategy section for details). This conformity response group was the focal independent variable in the study, comprising of three different levels namely the ‘comply group’, ‘sufferer group’, and ‘defiant group’ as elaborated below. Other independent variables, which were also moderating variables, were the socio-demographic factors of age, gender, and level of education. Both age and gender were dichotomised as binary variables, where age comprised of ‘younger adults’ with age range of 18 – 25 years, and ‘older adults’ were categorised from 26 – 75 years. The categorisation of age group was consistent with the cognitive assumption that brain maturation, capacity for good judgement, and moderation of correct behaviour and decision making fully develops between age 23-25years (Arian et al., 2013). This therefore informed the concept of capping younger adults at 25 years to understand the perceived cognitive differences that might be discovered between the two age-groups categorisation (Kogan, 1979).

Further to this, the broader range of older adult age categorisation was informed because of the degree of cognitive decline that may be presented amongst those aged 60years and above

(Plaasman et al., 1995), and as such, will assist in balancing up the cognitive outcome of the results among these set of two age-group category. In the same view, gender was also dichotomised as 'female' and 'male' in the study design. Level of education was however trichotomised, having three levels namely 'college/matric and below', 'undergraduate', and 'postgraduate' in order to give broader expression to participants' exposure to educational knowledge.

The dependent variables of this study were the cognitive processes of general memory comprehension and WM performance, while the emotional response variables were anxiety and depression. All the above variables were the focal observations employed to determine the study outcomes in order to answer the research questions and hypotheses enumerated earlier in the report. This study's variables and their conceptual expression are illustrated in Figure 1.

Figure 1. Conceptual Model for the Study



Sample and sampling strategy

This study is nested within an existing dataset of the larger international online survey study conducted in July 2020 (see Van Belle et al., 2021). The target sample of 1634 respondents was extracted from the total valid sample size of 2273 participants in accordance with below-mentioned inclusion and exclusion criteria. Three lockdown groups were identified based on the lockdown questionnaire data described below (see appendix A): (1) Comply Group (CG) – those that find it easier to adhere to group/society norms and stereotypes; (2) Sufferer Group (SG) – participants who carry out lockdown rules with some deviations, known to possess conflicting outlook to social norms; and (3) Defiant Group (DG) – those with a negative outlook to COVID-19 lockdown restrictions, who often respond in opposition to social norms and lockdown rules (Duffy & Allington, 2020; Van Belle et al., 2021). As part of the above inclusion criteria, target sample participants comprised adults of 18-75 years, without any psychological conditions or comorbidities, who could speak and write considerably in English.

The sample size consisted of participants across 49 countries from Africa, Asia, Europe, North America, and South America. Gender demographic of this sample represented about 56% male and 42% female, with the rest 2% reckoned as unknown, and were consequently excluded from the study analysis. In this study, 50.5% represented the younger age group (18-25 years), with 49.5% constituted as older adults (26-75 years). In terms of level of education, 73% reported qualifications higher than Grade 12 equivalent, while 26.8% were with a Grade 12 education or lower. The profile of various countries that participated in this large international online survey study is shown in Table 1.

The larger study utilised non-probability, convenience, and snowball sampling method. This sampling method enhanced people's participation, as no restrictions were imposed on referring friends and family members available and interested in becoming part of the study (Laher & Botha, 2012; Leedy & Ormond, 2015). Considering the nature of COVID-19 pandemic at the time of study, online advertisement was considered the most appropriate non-probability sampling method, which eliminated risk of infection from face-to-face sample recruitment, and strengthened

compliance with lockdown regulations and strict protocol of social distancing (Qiu et al., 2020; Xie et al., 2020). The Prolific software was used to recruit participants and collect their data for this study. It is an efficient online survey platform suitable for recruiting participants for both social science and psychological research purposes (Armstrong et al., 2021). It is considered an ethically sound research tool that prioritises the treatment of participants within any of its research subject pool, and has a user-friendly interface with other data analysis software such as Qualtrics (Palan & Schitter, 2018).

Table 1. Sample Participants by Country from Larger Survey Study

No	Name of country	Sample size
1	Albania	1
2	Angola	1
3	Australia	3
4	Bangladesh	1
5	Belgium	8
6	Brazil	3
7	Bulgaria	1
8	Canada	57
9	Chile	31
10	Czech Republic	15
11	Denmark	5
12	Estonia	13
13	Finland	10
14	France	32
15	Georgia	1
16	Germany	8
17	Greece	86
18	Hong Kong, SAR China	1
19	Hungary	45
20	India	3
21	Indonesia	2
22	Ireland	12
23	Israel	12

No	Name of country	Sample size
24	Italy	187
25	Japan	1
26	Korea (South)	1
27	Latvia	8
28	Malaysia	1
29	Mexico	123
30	Morocco	1
31	Netherlands	17
32	Nigeria	3
33	Norway	6
34	Pakistan	1
35	Poland	478
36	Portugal	307
37	Romania	1
38	Russian Federation	2
39	Slovenia	15
40	South Africa	47
41	Spain	72
42	Sri Lanka	1
43	Sweden	6
44	Switzerland	3
45	Syrian Arab Republic (Syria)	1
46	Taiwan, Republic of China	1
47	Ukraine	1
48	United Kingdom	488
49	United States of America	150

Note. $N = 2273$

Research Instruments

COVID-19 lockdown questionnaire

It is a self-administered 54-item questionnaire that assesses the attitudes, behaviours, perceptions, and beliefs around COVID-19 pandemic and lockdown restriction measures. This measure was based on the online cross-sectional study conducted in the UK on the resistance and compliant responses of respondents during the COVID-19 pandemic (Duffy & Allington, 2020; Van-Belle et al., 2021). It consists of a 5-point Likert scale response that indicate levels of agreement with statements covering adherence to official guidance, self-medication efforts (e.g. use of antibiotics or ginger tea), beliefs and perceptions around COVID-19 infection (e.g. "that coronavirus was created in a laboratory"), well-being during the lockdown, and non-COVID-19 related health behaviours (e.g. alcohol consumption, diet, etc.).

Other responses include beliefs about the future, and trust in government (e.g. "I believe the government acted too slowly to control the spread of the virus"), and the use of social media during the lockdown (e.g. "I check social media for information or updates about coronavirus"). The outcome of the questionnaire responses was utilised to cluster respondents into groups based on participants' similarity responses on compliance to lockdown rules. The cluster grouping in the current study (slightly modified as 'comply group', 'sufferer group' and 'defiant group') therefore showed how each grouping characteristics inform the cognitive, emotional, and neural processes underlying psychological responses to COVID-19 lockdown rules.

Demographic questionnaire

A self-administered demographic questionnaire was added at the start of the survey. It comprised some information relating to age, gender, level of education, and participants' country of residence, including their regional/continental groupings (see appendix B). Additional information contains level of socio-economic status (SES), which was a combination of social and economic support received by citizens from government during COVID-19 pandemic, and provision of foreign aid from other countries to support such initiative. These factors were each measured from 0

and 100, where the SES factor (considered in this study as 'geopolitical factors') were measured by binary factor scores namely national coronavirus response factors (NCRF), and social security factors (SSF). Each of the binary factor scores were further summed up and averaged as a fraction of one (1) in order to capture the extent by which the various degree of government responses directed to mitigate COVID-19 pandemic influenced the social and economic welfare of their citizens. The outcome of the scores was assumed to show the differing results of citizens' responses to government policies such as stringent COVID-19 lockdown measures.

Both NCRF and SSF incorporates the Oxford COVID-19 government response tracker (OxCGRT), which consists of various systematic government response indicators, as well as other human rights compositions and values (Hale et al., 2021). The NCRF compose of OxCGRT scores for government response, and lockdown stringency (including containment and health policies) with a maximum score of 0.5 representing very strong, stringent government response to pandemic. The SSF incorporate the human rights scale that measures the protection of citizen's physical integrity, the human development index that measures the context of citizen's life expectancy and gross national income, as well as the OxCGRT scores for economic support to citizens during the COVID-19 pandemic. The maximum score of 0.8 represent high social security for citizens by their government during the pandemic, while the minimum score shows the opposite (Hale et al., 2021). These measures were adapted from the larger international online survey study that the current study was nested with (see Van Belle et al., 2021).

Cognitive/Memory assessments: Free memory recall test (FMRT) and digit span forward (DSF)

As a standardised cognitive test, the free memory recall test (FMRT) measure participants' general memory performance by recalling previously memorised and constrained statements, especially unrelated or coupled textual words containing elements of concreteness, emotionality, and neutrality (Gruenewald & Lockhead, 1980; Brewer et al., 2010). The use of FMRT for online survey study was developed by the principal investigator of the larger international survey study. Although, it has not been standardised as valid psychometric instrument, its adaptation follows the

structure, processes, and norms of the original validated free recall tasks (Christian et al., 1978; Rubin & Friendly, 1986). The FMRT consists of 30 selected words within the passage (see appendix C), made available to participants for recall after overt rehearsal of the passage, including bold texts (Pollio et al., 1968; Rubin & Friendly, 1986). Texts to be recalled are assumed to represent various categories of concrete, abstract, neutral, and emotional words, and reflects level of words to test memory recall performance (Altarriba & Bauer, 2004).

Scoring FRMT tasks ranges from 0 to 30, indicating each correctly recalled words equal one gained point. Appropriateness of FMRT is largely due to its usability between 16 and 90 years (within age-bracket of the study sample), as well as correlation with Weschler Adult Intelligent Scale (WAIS-IV; Coalson & Raiford, 2008) and California Verbal Learning Test (CVLT-II; Delis et al., 2000) as valid memory performance assessment (Yamagishi et al., 2012). Although the adapted measure may not have been standardised for the dataset utilised in this study, it followed and utilised the original validated FMRT that has been established to possess strong internal consistency reliability of .71 amongst the study of 36 undergraduate students (Rubin, 1980).

The digit span forward (DSF) assessment is a component of adapted online memory test of the traditional digit span task, aimed at assessing measures of WM, particularly the phonological attentional capacity (Griffin & Heffernan, 1983; Rosenthal et al., 2006; Schofield & Ashman, 1986). Because of its implication with verbal WM as epitomised in Baddeley's (2000) multicomponent model, DSF is primarily managed by phonological loop in order to measure memory performance of increasing task of repeated number-strings (Wilde et al., 2004). The DSF is suitable for memory performance measurement of individuals within 16-85 years (Coalson & Raiford, 2008; Ostrosky-Solis & Lozano, 2006), and as such, a fitting instrument for this study sample. However, the adapted online DSF (Cambridge Brain Science, 2011) has not been standardised for countries outside of the UK-based population, where the larger survey study was originally designed before it was sent out internationally. Also, its psychometry properties were not accessible at the writing of this study.

The original DSF comprises of random digit strings presented at an increasing length to test-taker from 3 to 10 rings, to be repeated to the examiner in the same correct sequence. This measure (DSF) consist of 8 items, with each item scored at an additional increasing rate, depending on whether examinee repeats the string correctly or not. Each string repeated correctly gain an extra score from previously repeated strings. Maximum individual score ranges from 0 to 36, where 0 reflect lack of correctly repeating any strings, and 36 means respondent correctly repeats all 8 items in sequential order. The original DSF has internal consistency reliability of 0.89, where reliability coefficient with other memory assessment is averaged at 0.87 (Coalson & Raiford, 2008; Paula et al., 2015). The online DSF utilised in this study is adapted and standardised as a measure of online WM performance (Sternin et al., 2019). It consists of 8 increasing different letters strings that are shown to participants sequentially, and are required to type back in the same order it was shown in the blank space provided online (see appendix D). These letter string begins with 3 letters up to 10 letters. Participants will be shown a combination of alphabetic letters for few seconds, and thereafter requested to type the same letters in sequential order, until the task – containing 8 levels of increasing letter strings – is completed. Each letter written correctly equates to 1 mark and subsequent corrected string equates additional mark higher than previously correct strings, with the available scores ranging from 0 to 36.

Hospital anxiety and depression scale

Hospital anxiety and depression scale (HADS) is a self-assessment mood scale questionnaire designed to assess symptoms of anxiety and depression within non-psychiatric hospital settings (Bjelland et al., 2002; Zigmond & Snaith, 1983; see appendix E). It is constructed to measure and provide reliable information to clinicians while assessing patients' symptoms and severity level conditions, thus providing them with necessary mental health advice (Snaith, 2003; Stern, 2014). The suitability of HADS for individuals within 16-65 years and older (Herrmann, 1997; Zigmond & Snaith, 1983), and its ability to effectively measure levels of symptom severity in anxiety and depression, fits appropriately with the multicomponent model in addressing measures

of emotional reactions associated with WM and attentional performances (Baddeley, 2007; Bjelland et al., 2002).

The original HADS questionnaire comprises of two different anxiety and depression subscales, each having 7 items (closed-format questionnaires) with 4-point likert-scale response (0-3). The analysis of HADS shows possible score range from 0-21 for each subscale (Snaith, 2003). Because the test is simple and user-friendly, questionnaire can be completed between 2-5 minutes, with each subscale scores ranging from 0-7 as normal range; 8-10 as mild range; 11-14 as moderate range; while 15-21 reckoned as severe range of probable manifestation of anxiety and/or depression (Snaith, 2003; Stern, 2014). The original HADS subscales are considered a justifiable measures of severity, with reliability measures of .83 to .93 for anxiety and .74 to .90 for depression (Bjelland et al., 2002; Golden et al., 2007).

Furthermore, HADS have stable and very good concurrent validity of .67 and .75 with other related questionnaires (Bjelland et al., 2002). As a psychometric instrument written in English, HADS has been translated into other languages because of its relativeness, robust reliability/validity measures, and its utility within community and healthcare settings (Bjelland et al., 2002; Snaith, 2003; Stern, 2014). The online version of HADS used in this study was adapted from the original questionnaire, and its psychometric properties were also adapted for this study; however, a study has shown that internal consistency reliability of paper-based HADS and online-based were similar (Cronly et al., 2018). Here, the Cronbach's reliability alpha for HADS anxiety was 0.89 for paper-based and 0.84 for online sample, while for HADS depression, Cronbach's alpha level was 0.87 for online sample and 0.88 for paper-based.

Procedure

The larger international survey was conducted between July and September 2020, amid various COVID-19 lockdown measures in many countries around the world. It was originally intended for UK study, but was then distributed widely, with a total of 49 countries represented, including South Africa. Qualtrics and Prolific (Henshaw & McKenzie, 2019; Palan & Schitter,

2018) online survey platforms were utilised to collect participants' data. As an incentive, all participants who completed the survey were entered into a prize draw of £100 amazon voucher to be won, included as part of the debrief information (see appendix F). The tests related to this current study took an average of 60 minutes to complete, as they could be done at interval times and days within a week time-period to finish the survey.

In identifying the target sample for this study, the larger survey dataset was searched, using the COVID-19 experiences questionnaires (see appendix A), in order to correctly allocate participants into the three specified groups (CG, SG, and DG) based on their assumed similar behavioural responses to pandemic lockdown measures. Test administration was conducted via online survey, starting with demographic questionnaires, followed by COVID-19 experience questionnaires, and cognitive measurements (FRMT and DSF) to assess participants' general and working memory performances respectively, while HADS task was administered last. The larger online survey study collected a total number of 2518 respondents, where those that did not complete the survey were excluded from the analysis. Having considered the inclusion and exclusion criteria of the total sample, the data was however reduced to 2309 respondents. Using this pre-prepared dataset, the current study thereafter imported the dataset into SPSS for further statistical analyses.

Data Analysis

The IBM SPSS version 27 (IBM Corp., 2020) was utilised to statistically analyse this study dataset. Below are the steps taken to analyse and report the data of this study:

Descriptive statistics of study variables

As a first step, descriptive statistics were employed to describe general characteristics of the dataset for the study. Categorical data such as the demographic variables of age, gender, level of education, etc. were analysed using frequencies and percentages, while measures of central tendency (means and standard deviation) was the analyses used for numeric data (Salkind, 2018). Also, measures of variability (Leedy & Ormrod, 2015) were used to analyse general memory comprehension, WM capacity, and emotional components of anxiety and depression (FRMT, DSF,

and HADS), as they were considered as interval or scale data. Various parametric assumptions for all statistical analyses above were considered and met before analyses were done. Assumptions for Pearson's correlation was checked with the measurements for all outcome variables to be interval or scale, and evidence of linear relationship between those variables was confirmed. The assumptions for normality were analysed and met by central limit theorem, and the use of QQ and PP plots, as well as variables' skewness and kurtosis measures between the range of -1 to +1, and -3 to +3 respectively. Absence of multicollinearity was assumed through the Bartlett's test of sphericity which recorded a significant level; while presence of homogeneity of variance was verified by using Levene's test; and ensure the extreme outliers were statistically removed using the combination of Cook's distance (variables greater than 1 removed), and Mahalanobis distance, which was structured to be less than 18.47, considering four different independent variables (Laerd, 2018). The value of alpha (α) was set at .05 as a threshold for all statistical tests in this study with Bonferroni corrections applied when necessary to account for multiple comparisons.

Inferential statistics and moderation model analysis

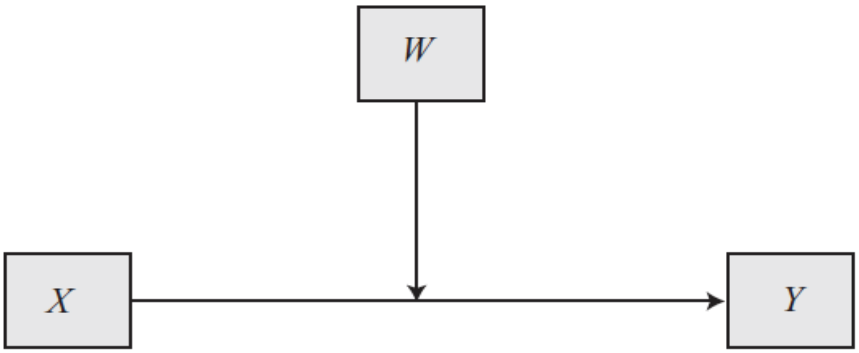
As a second step, inferential statistics was conducted using a 4-way multivariate analysis of variance (4-way MANOVA) to ascertain the level of statistical mean differences and effect size that COVID-19 lockdown groups, age, gender, and level of education have on the dependent variables of general memory comprehension, WM, anxiety, and depression. Furthermore, association between lockdown groups response and cognitive-emotional performances were determined through hierarchical multiple linear regression analysis. This analysis also provided the predicting effect of demographic variables of age, gender, and education levels on the association between the independent and the dependent variables of the study. The measurement levels for independent variable (COVID-19 lockdown group) and demographic variables (age, gender, and level of education) in this study were a mix of both continuous and categorical observations. This study therefore utilised hierarchical multiple linear regression analysis to depict the stepwise changes in

the effect of the prediction between the focal independent and demographic variables on the dependent variables (Baron & Kenny, 1986).

The concept of prediction in this study, which finds expression within the context of a moderation model, is an analytical strategy used to determine the influence of a certain variable on the size and direction of another variable through an external intervening variable. Thus said, a moderator is a variable that influences or affects the strength and direction of the association that exist between an independent variable and a dependent variable (Baron & Kenny, 1986; Hayes, 2018). The role of moderation in psychological and social science research is fundamental, as it is capacitated to investigate and guide the effect and explain 'when' the interactions between differing variables account for the differences in variances of another variable(s) of interest (Magill, 2011).

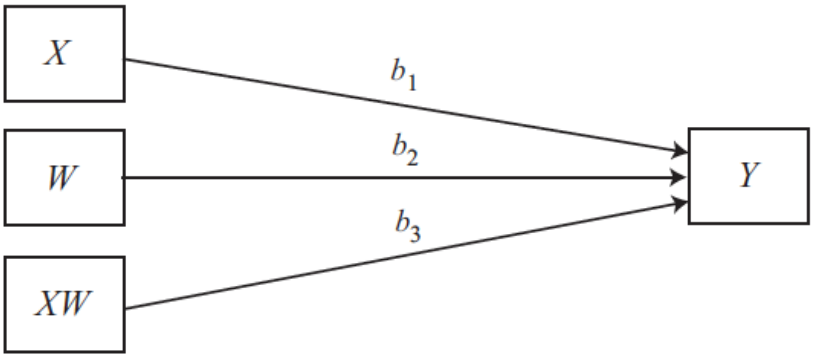
As a result of its robust strategy, moderation can be conducted using either correlational or experimental frameworks in determining the predicting influence it produces between study variables. It can also be represented as an estimation or interaction between a focal independent variable that produces the effect on the dependent variable(s) (Baron & Kenny, 1986; Frazier et al., 2004). In determining the size, direction, and strength of the predicting variables (age, gender, and level of education) on the association between COVID-19 lockdown group response and cognitive performance and emotional response, both conceptual and statistical models of Baron and Kenny (1986) as illustrated in Figures 2 and 3, were utilised to foreground the results and analyses of this study. The result of the study analyses were written and illustrated in the subsequent chapter, using a combination of tables and figures. This decision to use the figures was dependent upon the nature and outcome of the study results, which also incorporated (but not limited to) the use of bar charts and histogram in some cases.

Figure 2. Conceptual Diagram of Moderator Model



Note. A conceptual diagram of moderation model where *X* is the independent variable, *Y* is the dependent variable, and *W* represents the mediator variable.

Figure 3. Statistical Diagram of Moderator Model



Note. A statistical diagram of moderation model where path b_1 represent the effect *X* (independent variable) has on *Y* (dependent variable), b_2 represent the effect *W* (moderating variable) has on *Y* (dependent variable), and b_3 represent the interacting effect of *XW* (interacting variables) on *Y* (dependent variable)

Ethical Considerations

The larger international online survey study obtained ethical clearance from the Liverpool John Moores University Research Ethics Committee (approval code 20/NSP/035; see appendix G for ethics clearance certificate). The larger study utilised online methods to recruit participants, where participant information sheet (PIS) was made available and informed written consent form was acquired, detailing research purpose(s), duration of tests, and participant's right to withdraw at any time without negative impact or cost to them, as well as requesting permission for secondary analysis of data for student/degree purposes (see appendix H). Ethical clearance was further obtained from University of the Witwatersrand Human Research Ethics Committee (non-medical; protocol number: MASPR/21/08; see appendix I for ethics clearance certificate) to conduct secondary analysis of the pre-existing data for degree purposes.

No exposure to potential human risk was envisaged in this study, and as such, considered as a no risk study. In lieu of this, the study only made use of this pre-existing data, and did not collect any additional dataset, thereby justifying the level of no risk for conducting this study. Anonymity of the existing dataset was guaranteed and maintained throughout the study by assigning numerical codes to participants' results, making it untraceable to them, thus keeping data results confidential, while the dataset was also undisclosed to any other person except the supervisor and researcher. Data results and analyses were kept safely to further ensure participants' information confidentiality, and to provide safety of study outcome for future use when arises, while results and analyses were saved with password encryption on a designated digitised file as agreed by the supervisor and the researcher.

Chapter Four Results

Descriptive statistics and derived variables

This section was divided into three sub-sections as elucidated below. The aim was to elaborate the characteristics of different group of variables utilised in this study.

Demographic variables

A summary of the sample demographic variables used in this study are shown in Table 2.

Table 2. Demographic Characteristics of the Total Sample

Variables	n	%	*M*	*SD*	Range
Age	-	-	28.64	10.26	18 – 74
Geopolitical factors (SES)					
National coronavirus response factors (NCRF)	-	-	.22	.11	.02 – .48
Social security factors (SSF)	-	-	.47	.19	.07 – .80
Gender					
Female	747	45.7	-	-	-
Male	887	54.3	-	-	-
Level of education					
College/Matric and below	626	38.3	-	-	-
Undergraduate	647	39.6	-	-	-
Postgraduate	361	22.1	-	-	-
Continent grouping					
Europe	1308	80.2	-	-	-
North America	155	9.5	-	-	-
South America & the Caribbean	109	6.7	-	-	-
Africa & Middle East	46	2.8	-	-	-
Asia & Australasia	13	0.8	-	-	-

Note. Total *N* = 1634 for all variables except for geopolitical factors (*N* = 1538) and continental grouping (*N* = 1631); *M* = mean; *SD* = standard deviation; SES = socio economic status.

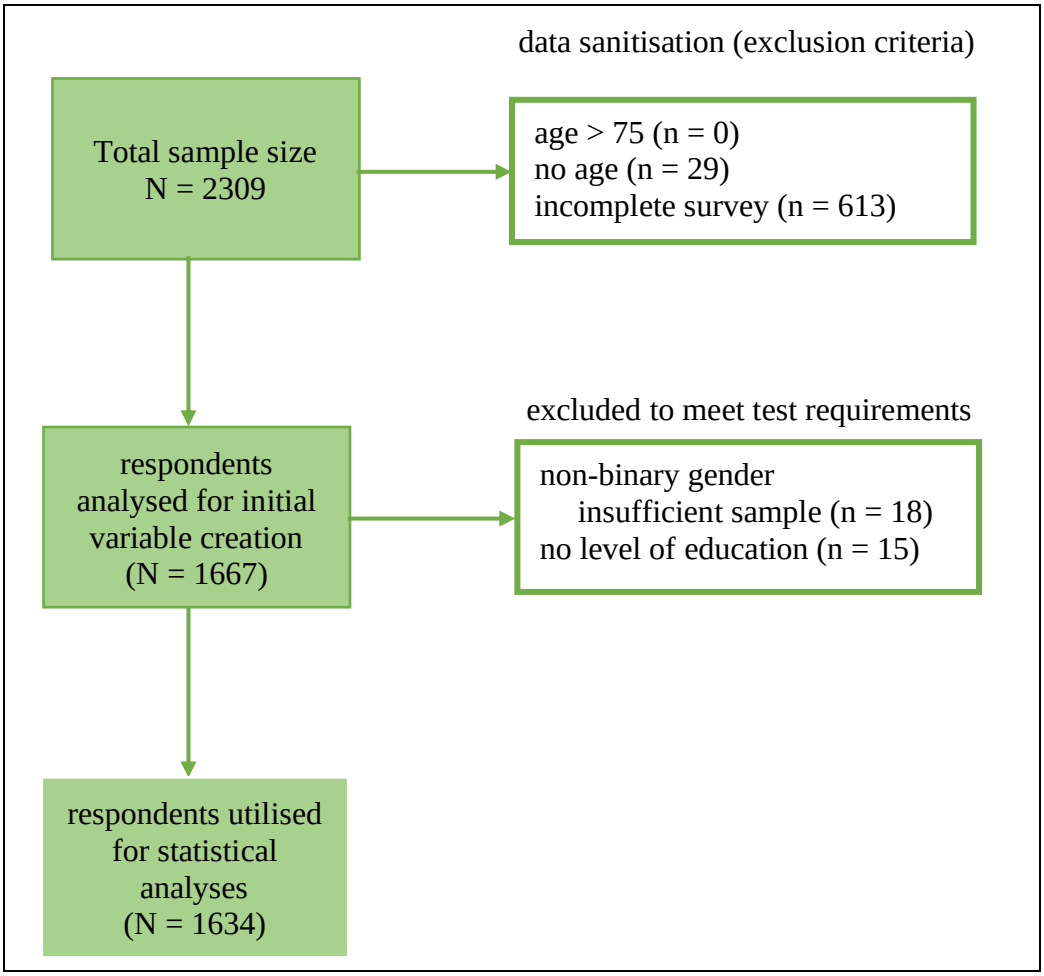
The entire raw dataset of the study comprised of 2309 respondents, out of which a total sample of 1634 participants was utilised in this study. Participants' data were removed primarily due to incomplete demographic data and incomplete survey. The flow chart represented in Figure 4 explained the process of data cleaning to reach the total sample size of 1634 respondents. The mean age of the total sample for this study (M = 28.64, SD = 10.26) is presented in Table 2. For the purpose of this study, age groups were dichotomised as ordinal variable to allow for better comparisons to be made in the analyses. With this in mind, the age group representing the 'younger adults' (18-25 years old) were slightly more represented (50.6%, n = 826), compared to the 'older adults' (26-75 years old) age group (49.4%, n = 807).

As shown in Table 2, the majority of participants were male (54.3%, n = 887). Level of education as an ordinal data was trichotomised to get a better spread and more applicable demography that better explained other statistical analyses of this study. The average number of 38.3% participants (n = 626) reported having college or matric certificates and below. The highest sample were those who have gone through undergraduate school level (39.6%, n = 647), while those who underwent any form of postgraduate level were least represented in the sample (22.1%, n = 361). In addition to participants' country representation as shown in Table 2 in the previous chapter, the grouping of participants with respect to their regional/continental standing reported Europe as having the highest participants representation in this study (80.0%, n = 1308). North America, South America, and the Caribbean reported about 16.2% of the total sample (n = 264), while Africa and the Middle East have representation of forty six (46) participants (2.8%), with Asia and Australasia constituting less than one percent of the study participants (0.8%, n = 13).

The participants reported a relatively higher stringent and strong government response (56.2%, n = 865) than low and weak government intervention (43.8%, n = 673) with respect to NCRF. However, human right protection and economic support provision (SSF) during the pandemic were reported to be higher (64.4%, n = 991) compared to lower or poor social security responses (35.6%, n = 547) [see appendix J for details]. In addition to this, the NCRF average scores (M = .22, SD = .11) suggested a generally weak stringent government responses across the

total sample, while the SSF score (*M* = .47, *SD* = .19) reflected a generally moderate socio-economic welfare responses by the government.

Figure 4. Data Cleaning Process of Study Participants

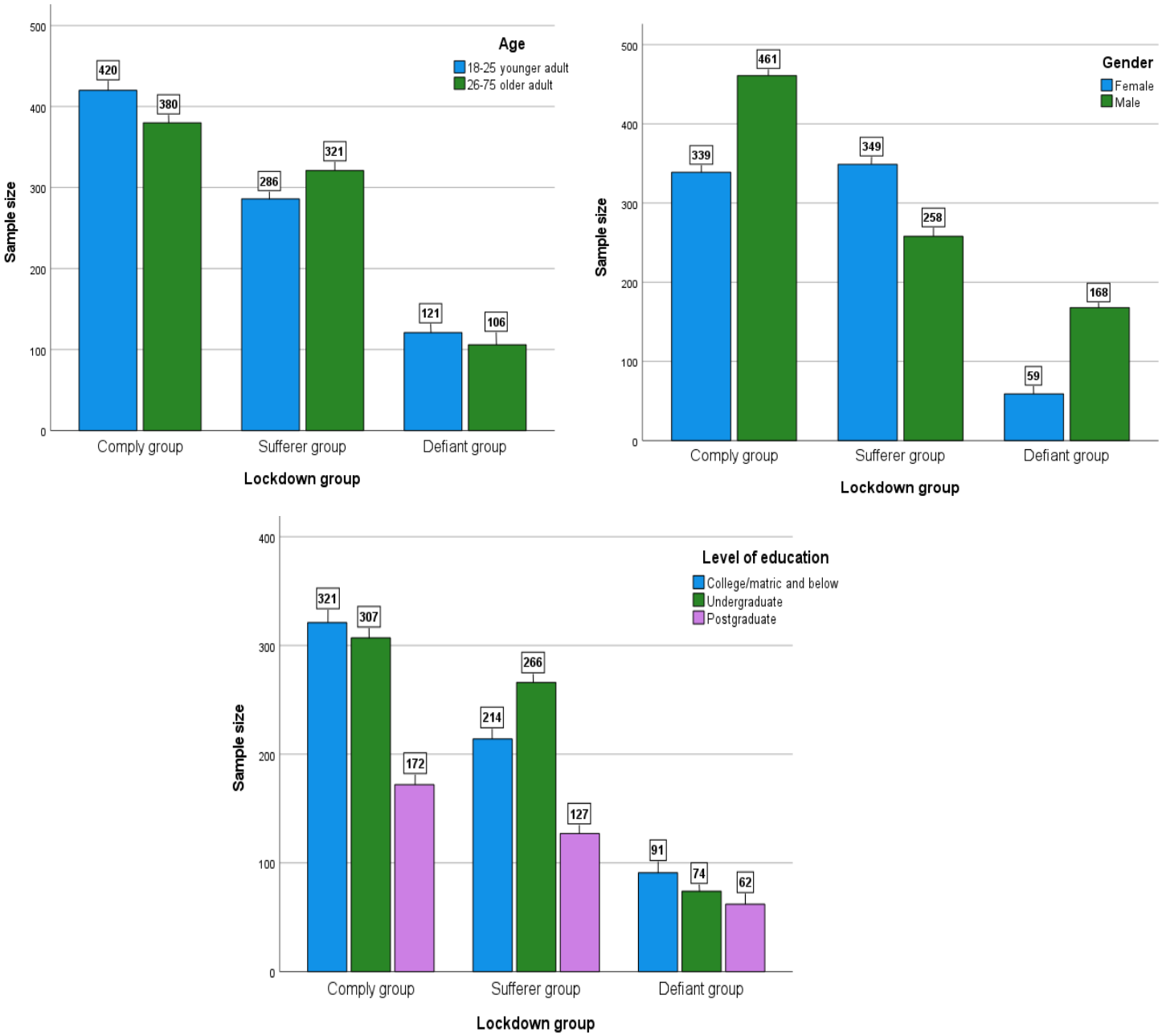


Lockdown groups

Consistent with the cluster analysis of the larger international survey study, the 'general population' in this study cluster was referred to as 'comply group' because of the similar characteristics of adherence to COVID-19 lockdown measures, as well as their assumed positive cognitive outlook and lower emotional reaction. The 'sufferers' in the larger study retained the same name as 'sufferer group' in this study, as they were considered to have a higher emotional response and burdened cognitive outlook compared to the comply group. The 'extreme responders' however was referred to as 'defiant group' as they hold conflicting views to government-imposed

lockdown measures, with often response in opposition to social norms and rules. Both Figure 5 and Appendix J shows the demographic distribution of the variables within the cluster composition of the sample size.

Figure 5. Demographic Variables Distribution by Lockdown Group



Note. Total *N* = 1634.

As shown in Figure 5, the demographic distribution across the lockdown group revealed that 'comply group' has the highest number of participants (n = 800, 49.0%), while the lowest participants were reflected within the 'defiant group' (n = 227, 13.9%). Comply group also recorded the highest number of respondents within each level of the demographic distribution, except for gender, where the sample respondents for females were slightly higher within the 'sufferer group' (n = 349, 46.7%), compared to comply group (n = 339, 45.4%) and 'defiant group' (n = 59, 7.9%). Additionally, females were approximately a third as likely as men to be represented in the defiant group, and generally less likely to be comply responder, and more likely than men to be sufferers. Consistent with the descriptive features of gender group, the lowest sample respondents within age demography was recorded amongst the defiant group (n = 227), especially with the older adults (n = 106), followed by younger adults within the same defiant group (n = 121). Furthermore, older adults (n = 321) were slightly higher than younger adults (n = 286) amongst the sufferer group, while the younger adults were approximately three and a half more represented in the comply group (n = 420) than in defiant group, and also more represented than in the sufferer (n = 286) group.

The descriptive statistics was also similar in the demographic variable of level of education whereby participants with college/matric qualifications and below were higher in comply group (n = 321) and defiant group (n = 321), but was relatively lower amongst sufferer group (n = 214) than the undergraduates (n = 226). Similarly, postgraduates (n = 127) were twice as likely to be represented in sufferer group than in defiant group (n = 62), while undergraduates were more likely than both postgraduates and college/matric level (n = 214) participants to be sufferers.

Cognitive–emotional variables

The general descriptive statistics of all the cognitive and emotional variables utilised in this study, and their distribution within the lockdown groups are represented in Tables 3.

Table 3. Descriptive Statistics of Cognitive – Emotional Variables across Lockdown Groups

Measures	Tasks	Comply group *M(SD)*	Sufferer group *M(SD)*	Defiant group *M(SD)*
General memory	Free recall task (max = 30)	8.51(6.38)	7.83(6.11)	5.69(6.69)
Working memory	Digit span forward task (max =36)	22.56(9.05)	21.41(9.13)	22.42(11.05)
HADS	Anxiety scale (max = 21)	7.29(4.02)	9.97(4.36)	9.78(3.22)
HADS	Depression scale (max = 21)	5.62(3.61)	7.41(3.80)	7.90(3.12)

Note. N = 1634. *M* = mean. *SD* = standard deviation. max = maximum. HADS = Hospital anxiety and depression scale (Zigmond, & Snaith,1983).

The cognitive measures for general memory across the lockdown group showed that comply group (*M* = 8.51, *SD* = 6.38) recorded the highest mean score compared to the sufferer and defiant group; however, the measure of dispersion in the defiant group (*M* = 5.69, *SD* = 6.69) was the highest across the lockdown group for general memory performance. The mean scores for working memory performance across the lockdown group response were relatively similar, but the defiant group (*M* = 22.42, *SD* = 11.05) recorded a higher variance than both comply and sufferer groups. Although the measurement range for these cognitive measures were not similar (free recall = 0-30, and digit span = 0-36), the measures of variance and dispersion between the lockdown groups for general memory were relatively similar compared to the measures for working memory as reflected in Table 3.

Similarly, both emotional measures of anxiety and depression subscales appeared to have relatively similar measures of variance and dispersion across the lockdown groups as shown in Table 3. The sufferer group (*M* = 9.97, *SD* = 4.36) however recorded the highest anxiety mean

scores compared to the comply and defiant groups. Most of the HADS anxiety and depression mean scores are within the mild range of probable manifestation of anxiety or depression. Only in the comply group (M = 5.62, SD = 3.61) did the borderline measurement was recorded, although the score was within the normal range of probable show of non-clinical depression. In summary, the emotional measures of anxiety across the lockdown group in this study had a slightly higher mean and standard deviation distribution compared to depression, although both possess similar measurement range values, with each maximum range as 21 (see appendix K).

Testing for normality and parametric assumptions

Prior to running parametric statistics, it is important to ascertain that the assumptions for this statistics are met. As a broad classification of statistical procedures, parametric tests are fundamentally based on the premise surrounding the population from which the sample of a study was drawn out (Pallant, 2011; Verma & Abdel-Salam, 2019). The assumptions of parametric test are estimated to follow a stringent path, and considered to have more power and robust technique to address type 1 error in statistical analyses (Pallant, 2011). Considering that the data for this study did satisfy a normally distributed observation as illustrated in appendix L and elaborated in the below normal distribution section, the following parametric assumptions were further examined with reference to particular criteria that needed to be satisfied before running parametric statistics in the study.

Interval scale of measurement

To fulfil parametric assumption, all dependent observations in a study must be considered as interval or ratio (continuous) in nature. This was consistent with all the dependent variables in this study, as they were determined using various psychological (online adapted) tests which were captured and recorded as interval or ratio data. In addition to this, all the independent variables in this study are either binary or trichotomy, which were acceptable exceptions with regards to the scales of measurement for independent variables (Pallant, 2011).

Random sampling

This assumption suggest that each element of the population should have equal chance of being included in the sample. This assumption is usually inferred in most social science and psychological studies because random sampling is a seldom possibility to enact in a real-world research scenario (Howell, 2014; Pallant, 2011). In this study, this assumption was not met because of the use of non-probabilistic sampling techniques, and as such, the assumption of random sampling was inferred, which was consistent with any social science and psychological research.

Independent sampling

The assumption postulate that each observation that makes up the data should be independent and not being influenced by other observations or measurements. This is one of the basic assumptions that are critical and seldomly violated by any study, especially when such study is considered as between-subject research (Stevens, 2009). For this present study, the assumption was met, as there was no reason to think that the observations were not independent. Further to this, each participants was assessed through the same standardised statistical procedures where the measurements of one participant was completely independent and did not influence the other participants.

Normal distribution

Normal distribution of a data is considered an essential parametric assumption for drawing reliable inferences about the underlying characteristics of the population from where the data was drawn (Verma & Abdel-Salam, 2019). Parametric test utilises various methods to indicate measures of approximate normality of the data, such as central limit theorem (CLT), skewness and kurtosis coefficients, Kolmogorov-Smirnov and Shapiro-Wilk test of normality, as well as histogram and normal PP plots. The CLT theoretically assumes that as the sample population increases, the shape of its distribution approximates normality (Howell, 2014). In accordance with this theorem, a sample size greater than thirty (30) participants can assume an approximate normal distribution, irrespective of the population skewed observation, which may look as violating the assumption

(Howell, 2014). In this study, the total sample size was 1633 participants, and each of the group consist of more than 100 respondents, so therefore, the study satisfied the assumption for normality on CLT premise.

Skewness and kurtosis are the values that give an idea of the distribution of scores in the data (Verma & Abdel-Salam, 2019). To classify a data distribution as normal, both skewness and kurtosis values need to fall within the range of -1 to +1, with the value of zero (0) indicating a perfect normal distribution (Field, 2009). In this study, both skewness and kurtosis values of the data were within the normal range of -1 and +1 (see appendix M). Consistent with the assumption of skewness and kurtosis value range, the data of this study was considered generally normally distributed. Details of other measures to ensure normal distribution of the sample data are described with reference to Kolmogorov-Smirnov and Shapiro-Wilk tests of normality (see appendix N).

Additional measure such as histogram plot of the variable distribution was employed to also test for normality. The frequency histogram plot of the data distribution as depicted in appendix L were used to determine the normal distribution of the data (Jambu, 1991). From these illustrations, it can be assumed that apart from the general memory data distribution (which can be viewed as positively-skewed and thus non-normal), the rest of the other variable data are normally distributed. This therefore further suggest that the data in this study was approximately normally distributed, hence parametric techniques are suitable for the study's statistical analyses.

Homogeneity of variance

This assumption postulate that the observations drawn from same population are poised to have equal variances (Howell, 2014). As a method for testing whether two or more multinominal variable distributions are equal, parametric assumption for normality are met when the test result for equal variances are non-significant (Pallant, 2011). In this study, assumption for homogeneity of variance was met for level of education (LoE) across all the response variables of free recall task [$F(2, 1630) = 0.94$, $p = .39$]; digit span forward [($F(2, 1630) = 1.34$, $p = .26$]; HADS anxiety [($F(2, 1630) = 1.62$, $p = .20$]; and HADS depression [($F(2, 1630) = 0.64$, $p = .53$]. Details of the assumptions being met as well as those that were violated are depicted (see appendix O) for all the

dependent variables across independent variable groups. Because of the robustness of some statistical techniques to this assumption including ANOVA and MANOVA (Ito, 1980) which were utilised in this study, as well as the majority of variable scores that fulfilled the criteria for equality of variance, the assumption for homogeneity of variance was considered met in this study, hence, parametric techniques were appropriate for the statistical analyses of this study.

Inferential statistical analyses

Evidence of significant findings on the two statistical analyses utilised in this study are reported below, with particular attention focused on areas of significant main effects, interaction effects, as well as the moderating effects of the sociodemographic factors between the observations.

Multivariate analysis with independent variables

In addition to the above fulfilled parametric assumptions, running a 4-way MANOVA test comes with added assumptions such as absence of multicollinearity, no univariate or multivariate outliers, equal population covariance matrices, homogeneity of variance, as well as multivariate normality residuals for all dependent variables (Finch, 2005; Laerd, 2018). In this study, the assumption of absence of multicollinearity was fulfilled as there was no higher correlation between any dependent variables that suggests 0.9 and above in the bivariate correlation analysis (see appendix P). In order to fulfil the assumptions for univariate and multivariate outliers, as well as multivariate normality, Mahalanobis test of multivariate normality was performed to determine if there was any extreme outlier(s) or influential points in the data. The Mahalanobis test showed that four (4) samples were above the critical value for four (4) independent variables ($\mathcal{X}_4^2 = 18.47$, $p < .001$), which may warrant the removal of such sample participants, and as a result, those samples were removed from the analyses in order to fulfil these assumptions (see appendix Q).

Other assumptions for running MANOVA were tested as detailed in the appendix (see appendices R and S). Although homogeneity of variance-covariance was violated, as well as part of Levene's test, research has shown that Box's M (see appendix S) can tend to be stricter and sensitive to equality of covariance when the sample size is large, and as such, violation of this

assumption are not unusual within social science research (Finch & French, 2013). Since these two assumptions were thus violated, and because of the robust method of MANOVA tests, interpretation of the statistical tests should be derived from Pillai's Trace results rather than Wilk's Lambda (Finch & French, 2013; Olson, 1976; Tabachnick & Fidell, 2013).

Reporting 4-way MANOVA results

The results of the 4-way MANOVA analysis reported multiples of statistical significant main effects, and an interaction effect in this study (see Table 4).

Table 4. Multivariate Significant Main Effects and Interaction Effect

Variable(s)	Test statistic (V)	*df1*	*df2*	*F* ratio	Sig.	η^2
Lockdown group	.081	8	3184	16.80	.000	.04
Age	.009	4	1591	3.77	.005	.01
Gender	.014	4	1591	5.56	.000	.01
Lkdn group*LoE	.020	16	6376	1.97	.012	.02

Notes. N = 1630. *df* = degree of freedom; Loe = level of education. V = Pillai's value. Sig. = significant.

Multivariate main and interaction effects

The main effect of the lockdown group was statistically significant on the combined dependent variables [$F(8, 3184) = 16.80$, $p < .001$, Pillai's V = .08, partial $\eta^2 = .040$]. Similarly, the analysis also reported a significant main effect of age groups [$F(4, 1591) = 3.77$, $p = .005$, Pillai's V = .01, partial $\eta^2 = .009$] on the combined dependent variables, while statistically significant main effect was also reported for gender [$F(4, 1591) = 5.56$, $p < .001$, Pillai's V = .01, partial $\eta^2 = .014$]. The analysis however reported a non-significant effect of level of education [$F(8, 3184) = 1.61$, $p = .117$, Pillai's V = .01, partial $\eta^2 = .004$]. In line with the significant differences found in this multivariate analysis, effect sizes were mostly small (Tabachnick & Fidell, 2013). Furthermore, the only statistical significant interaction reported in the analysis was between lockdown group and level of education on the combined dependent variables [$F(16, 6376) = 1.97$, $p = .012$, Pillai's V =

.02, partial η^2 = .005], while non-significant interaction effects were recorded for the remaining two, three, and four way interactions (all *p*'s > .05; see Appendix T).

The following analyses further explained the follow up of the significant main effects of the multivariate analysis of this study, using the separate univariate ANOVA of each independent variable on separate dependent variable of interest, as shown in Table 5.

Table 5. Univariate ANOVA of Significant Main Effects within Study Variables

Independent variable	Dependent variable(s)	*df1*	*df2*	*F* ratio	Sig.	η^2
Lockdown group	General memory	2	1594	6.67	.001*	.01
	Working memory	2	1594	2.32	.099	<.01
	Anxiety	2	1594	53.27	.000*	.06
	Depression	2	1594	41.64	.000*	.05
Age	General memory	1	1594	0.12	.727	<.01
	Working memory	1	1594	0.03	.855	<.01
	Anxiety	1	1594	12.28	.000*	.01
	Depression	1	1594	10.27	.001*	.01
Gender	General memory	1	1594	0.76	.385	<.01
	Working memory	1	1594	5.49	.019*	<.01
	Anxiety	1	1594	12.03	.001*	.01
	Depression	1	1594	0.20	.659	<.01
Lkdn*Loe	General memory	4	1594	2.50	.041	.01
	Working memory	4	1594	1.66	.156	<.01
	Anxiety	4	1594	2.15	.073	.01
	Depression	4	1594	2.81	.024	.01

Note. N = 1630. * = $p < .05$, except Lkdn*LoE where $p < .0125$ (applying Bonferroni adjustment to multiple variable comparisons)

Significant findings of lockdown group

Univariate ANOVA of the significant main effect of lockdown group

To follow up on the significant main effect of lockdown group, separate univariate ANOVA was run in this study to determine the effect of the lockdown group on each of the dependent variables (see Table 5 for details). The result of the univariate ANOVA showed a statistically significant effect for general memory [$F(2, 1594) = 6.67$, $p = .001$, partial $\eta^2 = .008$], anxiety [$F(2, 1594) = 53.27$, $p < .001$, partial $\eta^2 = .063$], and depression [$F(2, 1594) = 41.64$, $p < .001$, partial $\eta^2 = .050$]. However, no significant difference was found for working memory capacity [$F(2, 1594) = 2.32$, $p = .099$, partial $\eta^2 = .003$]. As a result of the significant effects of lockdown group on general memory, anxiety, and depression variables, further post-hoc analysis was conducted for each of the significant variables.

Post-hoc analysis of lockdown group significant main effect

A separate post-hoc analysis was conducted for each of the dependent variables that were statistically significantly associated with the independent variables of lockdown group. This post-hoc analysis looked at the effect of the possible pairwise comparisons of the lockdown group on the general memory score, anxiety score, as well as depression score (see Table 6). The results showed that the comply group ($M = 8.51$, $SD = 6.38$) performed better in general memory compared to the sufferer group ($M = 7.83$, $SD = 6.11$), but the effect was not statistically significant [$t(1594) = .59$, $p = .127$]. In comparison, the comply group ($M = 8.51$, $SD = 6.38$) performed significantly better in the general memory task compared to defiant group ($M = 5.69$, $SE = 6.69$; $t(1594) = 2.65$, $p < .001$). There was also a statistical significant difference in general memory performance [$t(1594) = 2.06$, $p = .006$], with the sufferer group ($M = 7.83$, $SD = 6.11$) performing significantly better in general memory compared to the defiant group ($M = 5.69$, $SE = 6.69$). These results therefore showed that the highest significant effect within the lockdown group with reference to better general memory performance was recorded amongst the comply group ($M = 8.51$, $SD = 6.38$).

Looking at the post-hoc analysis of the effect of lockdown group on anxiety score, sufferer group (M = 9.97, SD =4.36) reported significantly higher anxiety level compared to the comply group (M = 7.29, SD = 4.02; t(1594) = 2.43, p < .001). Similarly, the defiant group (M = 9.78, SD = 3.22) reported a significantly higher anxiety compared to the comply group [t(1594) = 2.18, p < .001]. The sufferer group although reported a higher level of anxiety compared to defiant lockdown group, however, the effect was non-significant [t(1594) = .25, p = .594]. In the light of the above analyses, the higher statistical significant effect within the lockdown group reference to increased level of anxiety was associated with the sufferer group (M = 9.97, SD = 4.36).

The post-hoc analysis of the lockdown group effect on depression score showed a significantly higher level of depression amongst sufferer group (M = 7.41, SD = 3.80) compared to the depression level within the comply group (M = 5.62, SD = 3.61; t(1594) = 1.87, p < .001). In the same manner, the results showed that the defiant group (M = 7.90, SD = 3.12) reported a higher depression level than the comply group, with a statistically significant effect [t(1594) =2.31, p < .001]. In contrast to the above outcomes, the result of higher depression level by defiant group (M = 7.90, SD = 3.12) compared to the sufferer group (M = 7.41, SD = 3.80) however reported a non-significant effect [t(1594) =.44, p = .304]. The results therefore showed that the defiant group reported significant higher depression level than other lockdown groups with reference to increased level of depression in the analysis.

Table 6. Post-Hoc Analysis for Lockdown Group

Dependent variable	Lockdown group comparison		Mean	Sig.	95% Confidence Interval	
	I	J	difference		LB	UB
General Memory	comply	sufferer	0.59	.127	-.168	1.347
	comply	defiant	2.652**	.000	1.203	4.101
	sufferer	defiant	2.062*	.006	.598	3.527
Anxiety	sufferer	comply	2.434**	.000	1.959	2.909
	defiant	comply	2.184**	.000	1.276	3.093
	sufferer	defiant	.249	.594	-.669	1.167
Depression	sufferer	comply	1.872**	.000	1.436	2.308
	defiant	comply	2.314**	.000	1.480	3.147
	defiant	sufferer	.442	.304	-.401	1.284

Note. N = 1630. Sig. = significance. ** = $p < .001$. * = $p < .05$

Significant findings of age group

Univariate ANOVA of the significant main effect of age group

The result of the univariate ANOVA for age reported statistically significant effect on anxiety [$F(1, 1594) = 12.28$, $p < .001$, partial $\eta^2 = .008$], and depression [$F(1, 1594) = 10.27$, $p = .001$, partial $\eta^2 = .006$], but not for general memory comprehension [$F(1, 1594) = .12$, $p = .727$, partial $\eta^2 < .001$], and WM capacity [$F(1, 1594) = .03$, $p = .855$, partial $\eta^2 < .001$]. The outcome of this result resulted into conducting post hoc analyses for both statistically significant dependent variables of anxiety and depression.

Post-hoc analysis of age group significant main effect

The post-hoc analysis reported the effect of possible pairwise comparison of the binary age-group on the anxiety score and depression score (see Table 7). The result showed that younger adults (M = 9.54, SD = .28) reported a higher level of anxiety compared to older adults (M = 8.38, SD = .17), with a statistical significant effect [$t(1594) = 1.16$, $p < .001$]. In the same manner, the

results showed that the younger adults (*M* =7.41, *SD*= .26) reported a significantly higher depression when compared to older adults (*M* = 6.44, *SD* = .16; t(1594) = .97, *p* = .001). Both of these analyses showed higher levels of anxiety and depression recorded amongst younger adult sample within this study.

Table 7. Post-Hoc Analysis for Age

Dependent variable	Age group		Mean difference	Sig.	95% Confidence Interval	
	I	J			LB	UB
Anxiety	Younger adults	Older adults	1.159**	.000	.510	1.807
Depression	Younger adults	Older adults	.973*	.001	.377	1.568

Note. *N* = 1630. Sig. = significance. ** = $p < .001$. * = $p < .05$

Significant findings of gender group

Univariate ANOVA of the significant main effect of gender group

In the same manner consistent with significant findings in lockdown group and age group, univariate ANOVA for statistically significant effect of gender were reported for WM capacity [$F(1, 1594) = 5.49$, $p = .019$, partial $\eta^2 = .003$], and anxiety [$F(1, 1594) = 12.03$, $p = .001$, partial $\eta^2 = .007$]. The result however showed non-significant effect on general memory comprehension [$F(1, 1594) = .76$, $p = .385$, partial $\eta^2 < .001$], and depression [$F(1,1594) = .20$, $p = .659$, partial $\eta^2 < .001$]. Follow up to the significant univariate ANOVAs for WM capacity and anxiety was the post hoc analyses to determine the significant mean effect between levels of gender with respect to the dependent variables of WM capacity and anxiety.

Post-hoc analysis of gender group significant main effect

This post-hoc analysis looked at the effect of possible pairwise comparison of gender differences on both WM performance and anxiety (see Table 8). The result showed statistically better WM performance for males (M = 22.91, SD = .40) compared to females (M = 21.07, SD = .68; $t(1594) = 1.84$, $p = .019$). However, the result showed that females (M = 9.53, SD = .29) reported a higher level of anxiety compared to males (M = 8.38, SD =.17) with a statistically significant effect [$t(1594) = 1.15$, $p = .001$]. The result of this post-hoc analysis therefore showed a higher WM performance response in males, while a higher level of anxiety was associated amongst the female sample respondents of this study.

Table 8. Post-Hoc Analysis for Gender

Dependent variable	Gender group	Mean	Mean difference	Sig.	95% Confidence Interval	
					LB	UB
WM capacity	Male	Female	1.841*	.019	.300	3.382
Anxiety	Female	Male	1.147*	.001	.498	1.796

Note. N = 1630. Sig. = significance. ** = $p < .001$. * = $p < .05$

Significant interaction findings of lockdown group and level of education

Univariate ANOVA of the interaction effect of lockdown group and level of education

Subsequent univariate ANOVA was also run for the statistically significant interaction effect between lockdown group and level of education on the combined dependent variables. Because of the involvement of multiple comparisons of observations in this analysis, a Bonferroni adjustment of statistical significance was applied to the interaction effect as a procedure to protect against inflated Type 1 error and reduced statistical power (Tabachnick & Fidell, 2013). As a result of this, a more stringent alpha level of significance was applied to the interaction effect by dividing the current significant level ($p < .05$) with the number of dependent observations in the analysis (4), which brings the significant level to $p < .0125$. Following up to this adjustment, the result of the

analysis reported statistically non-significant effect of the interaction variables (lockdown group*level of education) on all the dependent variables of the study. The non-significant effect was recorded for general memory comprehension [$F(4, 1594) = 2.50$, $p = .041$, partial $\eta^2 = .006$], as well as depression [$F(4, 1594) = 2.81$, $p = .024$, partial $\eta^2 = .007$]. In the same manner, non-significant effects were also reported for WM capacity [$F(4, 1594) = 1.66$, $p = .156$, partial $\eta^2 = .004$], and anxiety [$F(4, 1594) = 2.15$, $p = .073$, partial $\eta^2 = .005$]. These results therefore showed that although significant interaction was flagged in the multivariate analysis, the statistical result of between-subject effect analysis showed a further non-significant effect of the interaction on each of the separate dependent variables when a more stringent Bonferroni adjustment was applied.

Hierarchical multiple regression analyses

Following up to the main statistical analysis of the 4-way MANOVA, running the hierarchical regression analyses assisted in determining the significant amount of variances explained in each of the dependent variables with subsequent addition of an independent variable in the model (Jeong & Jung, 2016). The application of hierarchical regression in this study utilised the lockdown group responses and three socio-demographic variables of age, gender, and education level as the independent variables for this analysis. The same variables were sequentially entered into the regression analyses as two models. The first model entered into the analysis was the lockdown group, while the second model comprise age, gender, and education level which were considered as socio-demographic variables. This method of sequential model input was repeated for each of the dependent variables, totalling four hierarchical regression models performed for this study.

Prior to running these analyses, all the assumptions for conducting multiple regression were checked and ensured they were all met. Some of the earlier assumptions already met for the 4-way MANOVA, which were consistent with running multiple regression, were also considered. Additional assumptions of normal distribution of residual errors were performed and fulfilled for each dependent variables (see appendices U–X for details). Although the residual normality for

general memory (appendix U) was fairly positively skewed, it could however be assumed that majority of the observations in this variable are between -2 and +2, and as a result, normality of the variable's residual was assumed.

Reporting the hierarchical regression analyses

The detailed results from the four multiple regression analyses (see appendix Y-BB) were described, while the summary hierarchical multiple regression result was shown in Table 5. The full regression model of lockdown group and socio-demographic variables (see appendix Y) in predicting general memory was statistically significant [$F(6, 1623) = 6.63$, $p < .001$]. The adjusted R^2 value however indicated no significant change in the F – value when socio-demographic variables of age, gender, and level of education were added to the model, [adjusted $R^2 = .021$, $F(4, 1623) = 1.29$, $p = .273$]. To further determine which predictors are significant in the coefficient table, only lockdown group variables – sufferer group [$\beta = -.058$, $t(1623) = -2.22$, $p = .027$], and defiant group [$\beta = -.148$, $t(1623) = -5.72$, $p < .001$] were statistically significant, while age, gender, and level of education were statistically non-significant ($p > .05$), with the lowest non-significant value reported by level of education's college/matric & below [$\beta = -.041$, $t(1623) = -1.50$, $p = .135$]. This pattern of result therefore suggest that although the full model was significant, socio-demographic variables were not significant predictors of the association between lockdown group and general memory comprehension in this study.

The full model of the moderating effect of socio-demographic factors between lockdown group and working memory capacity (see appendix Z) was shown to be statistically significant [$R^2 = .014$, $F(6, 1623) = 3.75$, $p = .001$]. Although the outcome of the step 1 in the model was non-significant [$R^2 = .003$, $F(2, 1627) = 2.72$, $p = .066$], the addition of socio-demographic variables of age, gender, and level of education to the step 2 model resulted in a statistically significant F – statistic change, $R^2 = .014$, [$F(4, 1623) = 4.25$, $p = .002$]. The variables that contributed to the significant prediction model were gender [$\beta = .072$, $t(1623) = 2.85$, $p = .004$], and level of education [(postgraduate $\beta = .059$, $t(1623) = 2.10$, $p = .037$)], while age [$\beta = -.046$, $t(1623) = -1.78$,

p = .076], and college/matric & below [β = -.024, t(1623) = -0.89, p = .375] were statistically non-significant.

Furthermore, to determine whether age, gender, and level of education moderated the relationship between lockdown group and anxiety (see appendix AA), the result of the hierarchical regression showed a statistically significant model at both steps of the model analysis. The full model (step 2) showed a total variance of 13.7% explained by the model [R^2 = .140, F(6, 1623) = 44.18, p < .001]. While controlling for lockdown group in the full model, both age [β = -.152, t(1623) = -6.24, p < .001], and gender [β = -.178, t(1623) = -7.48, p < .001] recorded statistically significant moderating effects on anxiety, while level of education (college/matric & below [β = -.019, t(1623) = -.76, p = .449], and postgraduate [β = -.002, t(1623) = -.07, p = .947]) reported non-significant results.

The full model of lockdown group, age, gender, and level of education predicting depression (see appendix BB) also showed a statistical significant result across both steps [R^2 = .078, F(6, 1623) = 23.83, p < .001]. The adjusted R^2 value indicated a significant F – value when age, gender, and level of education were added to the model [adjusted R^2 = .068, F(4, 1623) = 5.60, p < .001]. Investigating the variables that contributed to this significant prediction while controlling for lockdown group in the analysis, age was the only significant predictor variable [β = -.092, t(1623) = -3.66, p < .001], while both gender and level of education reported non-significant results, with postgraduate [β = -.048, t(1623) = -1.79, p = .073] having the lowest non-significant p value.

In summary, the full models of the hierarchical multiple regression for all the variables in this study (see Table 5) showed that the highest variance explained by the model was reported on the dependent variable of anxiety, with the socio-demographic variables (except level of education) significantly moderated the relationship between lockdown group and anxiety variables. Further to this, only general memory recorded non-statistically significant effects with all the socio-demographic variables on its association with lockdown group, although the model was statistically significant, with no further prediction. In this hierarchical regression analyses, close to a quarter of

the total variances (23.5%) were explained on all dependent variables by the focal independent variable (lockdown group) and the socio-demographic variables.

Table 9. Summary of the Full Model of Hierarchical Multiple Regression for the Study

Independent variables	Model 1 General memory *B* (*SE)*	Model 2 Working memory *B* (*SE)*	Model 3 Anxiety *B* (*SE)*	Model 4 Depression *B* (*SE)*
Constant	9.01*** (0.38)	22.10*** (0.57)	8.85*** (0.24)	6.13*** (0.22)
Lkdn grp (ref: comply grp)				
Sufferer	-0.76* (0.34)	-0.91 (0.51)	2.48*** (0.22)	1.81*** (0.20)
Defiant	-2.72*** (0.48)	-0.46 (0.71)	2.71*** (0.30)	2.33*** (0.27)
Age	-0.25 (0.33)	-0.86 (0.49)	-1.29*** (0.21)	-0.69*** (0.19)
Gender	-0.41 (0.32)	1.36** (0.48)	-1.51*** (0.20)	-0.13 (0.18)
LoE (ref: undergraduate)				
College/matric & below	-0.53 (0.36)	-0.47 (0.53)	-0.17 (0.22)	-0.05 (0.20)
Postgraduate	0.13 (0.43)	1.32* (0.63)	0.02 (0.27)	-0.44 (0.24)
$F(6, 1623)$	6.631***	3.748**	44.184***	23.827***
R^2	0.024	0.014	0.140	0.081

Note. $N = 1630$. *SE* = standard error; Lkdn grp = lockdown group; LoE = level of education. ***$p < .001$. **$p < .01$. *$p < .05$. Models (1) to (4) represent four separate hierarchical multiple regressions with the name of the model describing the dependent variable of interest.

Chapter Five Discussion

The primary aim of this study was to explore whether responses to COVID-19 lockdown measures are associated with general memory, WM performance, and emotional responses of anxiety and depression. Further to this, the study also looked at the moderating effect of socio-demographic characteristics of age, gender, and level of education on the association between lockdown responses and cognitive-emotional variables. The nature of this study utilised an exploratory, non-experimental, and cross-sectional design to investigate the significant differences across the lockdown group responses and socio-demographic factors on the dependent observations. The study was nested within the larger international online survey study conducted between July and September 2020. The rationale of the current study however was to investigate and progress knowledge on how individual or group's cognitive capabilities (such as general memory and WM performances) and emotional characteristics of anxiety and depression, might possibly influence the varying compliance responses to COVID-19 lockdown restriction measures.

The results of the study produced three key findings. First, lockdown group response levels differ significantly on general memory comprehension, anxiety, and depression, but not on working memory, contrary to our original hypothesis. Second, the effect of socio-demographic variables resulted in significant change to the preliminary result (step 1) of the hierarchical regression analysis of WM performance, indicating that these variables – especially gender – have an effect on certain measures of participants' WM capacity over and above differing group responses to pandemic lockdown measures. Lastly, age and gender were significant predictors of the relationship between lockdown group responses and anxiety; however, none of the socio-demographic variables were significant predictors of the lockdown group responses and general memory comprehension relationship. In addition to this finding, specifically, level of education was not a significant predictor in the whole hierarchical regression analyses, with the exception of the relationship between lockdown group and WM performance. These core findings are discussed below.

Lockdown group response and cognitive performances

The significant difference of lockdown group responses on general memory showed that the comply group exhibited better memory comprehension than the sufferer group and defiant group. This means that the overall general memory performance of the comply group (people that easily adhere to group/social norms and COVID-19 lockdown rules) indicated positive recency effect on their delayed recall tasks, which tapped into a more stable long-term component of the storage mechanism of the free recall performance which was mainly affected by semantic coding (Baddeley, 2018; Glanzer & Cunitz, 1966). This component is unaffected by the rehearsal-preventing task of delayed recall, and as such, correct recalling of the texts from the beginning of the passage were more prevalent in the long-term storage component, compared to the short-term storage mechanism of single-trial free recall, which also reflects recency effect, but with immediate recall of the recently rehearsed texts from the end of the passage. It must be noted however that based on the online survey nature and context of this study, the assumption was that participants engaged the feature of recency effect of delayed recall with distinctively long pause (between 20-30 seconds) that preceded their recall response – a unique response time associated with free recall memory tasks (Rohrer & Wixted, 1994). In light of this, interpretation of this finding was considered in the context of this observation.

The significant difference across the lockdown group could be attributed to varying cognitive interpretation of individual/group variations as an indication of significant general memory performance difference. As earlier explained, the characteristics of the comply group in this study epitomised individuals who adhere easily to lockdown restrictions, with lowest score for poor mood, and features of positive cognitive outlook (Van Belle et al., 2021). The sufferer group however had slight variation compared to the comply group, especially with respect to having conflicting outlook to social restriction measures, which sometimes reflected burdened cognitive capacity on their memory performances. Furthermore, the defiant group was characterised with a more negative cognitive capacity with regards to lockdown restrictions, which often resulted into opposing responses towards dealing with the COVID-19 social isolation rules because of their low

cognitive outlook. In light of these cognitive variations, it was not unexpected why memory performance between the comply group and sufferer group indicated general memory equivalence, while both performances between comply and defiant groups, as well as the sufferer and defiant groups were found to show significant general memory performance differences.

Another possible reason for this significant difference can be attributed to the impact of recent life stress (such as COVID-19 pandemic) on the cognitive process of the participants. The outcome of this stress, reflected as either acute or chronic, was assumed to impair the retrieval process within the general memory capacity, and as a result, impinge on individual episodic memory content, which happens to be the seat of long-term storage mechanism of the free memory recall task (Shields et al., 2017). This therefore indicates that recent life stress has the potential to limit the capacity of long-term storage mechanism, especially when individuals or groups are faced with life-threatening psychological and mental challenges, thereby exerting differing substantial effect on memory retention and retrieval abilities within the context of their cognitive variations necessary for decision making responses (Gagnon & Wagner, 2016).

Age-related declining cognitive functioning could also be attributed to the significant effect of this study outcome. With the sample distribution of respondents in this study across different age-cohort, coupled with the positively skewed distribution of participants' general memory scores, it was not unusual to expect significant difference of age associated with cognitive performance of respondents across measures of lockdown groups in this study. This significant effect was prevalent especially with reference to reduced inefficient recall and retrieval performance of the episodic content of the long-term memory store (Spaniol et al., 2006). Although evidence-based results have lend support to this assumption (Lara et al., 2020; Thornton & Lukas, 2012), the experimental studies of Craik (1984) and Raymond (1971) foreground the assumption that the effectiveness of memory recall from long-term storage of episodic memory is affected with successive age-related increase, as well as the length and stimulus size of the recalled vocabulary or texts (Ward & Maylor, 2005). This therefore suggest that with the effect of age difference on episodic memory tasks such as delayed free recall, it is apparent that there may be certain differential mental

processing that are ineffective in older adults' cognitive functioning compared to the younger cohort, because of the resulting poor retrieval context and selective decline performance from the long-term storage mechanism of their episodic memory (Craik, 1994).

Despite limited but growing study on the relationship between WM performance and group responses to social isolation such as COVID-19 pandemic lockdown measures, findings have been somewhat unequivocal, especially because of variations in the social isolation measures (Evans et al., 2019), as well as different cognitive measures utilised to analyse the outcome and dimensionality of the assumed association (Bowden et al., 2012; Fiorenzato et al., 2021). The current study hypothesised that significant difference of WM performance would be found across the lockdown response levels of the comply, sufferer, and defiant groups; however, no significant group differences were found on digit span forward tasks that measured participants' working memory performance. This consequently resulted into inconsistent outcome with regards to previous studies and reviewed literature that suggested significant association between lockdown group responses and WM performances (Fiorenzato et al., 2021; Ingram et al., 2021; Kira et al., 2021).

It is however important to note that these previous studies predominantly focused on self-reported cognitive functioning, and/or broader executive functions including WM tasks (Fiorenzato et al., 2021; Ingram et al., 2021), but the current study looked specifically at visuospatial aspect of working memory performance (Baddeley, 2012). As a result, it is likely that differences would be evident in the outcome of this study, relative to the previously conducted research findings. In light of the present study therefore, it is plausible that various proposals could be responsible for non-significant difference across the lockdown group response on WM performance, assuming multiple explanations that concurrently affect the working memory capacity scores in this study.

Firstly, there was no baseline WM performance task data prior to the pandemic lockdown restriction period. This was mainly due to the sudden speed and prevalence of COVID-19 infection globally, which prevented most studies from obtaining the baseline data of participants cognitive functioning prior to the imposition of social isolation measures (Ingram et al., 2021). Because of the

absence of sufficient WM baseline scores before the pandemic (the reason for the exploratory nature of this study) with which to compare the propensity scores of participants' WM performance scores during the pandemic lockdown, it was assumed that this may account for test equivalence finding on the digit span forward task in this study. Secondly, the specific instrument used to measure participants' working memory performance in this study (i.e. digit span forward) is generally assumed to tap partly different psychological processes that is complementary to measuring certain cognitive performance of executive function, including working memory capacity (Gignac et al., 2018). This may have contributed to performance equivalence results across lockdown group responses.

This could be because digit span forward is theorised as tapping more into the storage and retrieval processes of measuring the short term memory (Luo et al., 2010), and as such, measuring the capacity of working memory might have been left out, resulting into a non-significant working memory performance equivalence in this study. Addition of the component of digit span backward (DSB) would have enhance the study's working memory performance results, as it was generally assumed that DSB taps more into the central executive processes over and above the visuospatial processing, and is reckoned as more involved in measuring working memory capacity in comparison to digit span forward (Bowden et al., 2012; Conway & Kovacs, 2013; Gignac et al., 2018).

Furthermore, the hypothesis and clinical perspective which postulate that with age-related increase in individuals, digit span forward measures tend to remain stable, whereas DSB measures decline, is consistent with the reason for WM performance equivalence in the current study (Lezak, 1995). The result of WM performance as measured by digit span forward in this study showed a stable and consistent pattern across the lockdown group responses, despite the fact that there were age-related variations in the sample, which resulted into non-significant WM performance across the lockdown group. This result therefore suggests that the measurement utilised to measure WM capacity in this study tapped into limited part of WM sub-component, and as such, the result of WM performance equivalence was recorded.

Based on the review of literature in this current study, it was hypothesised that significant differences will be found between participants' lockdown group response levels and the cognitive components of general memory comprehension and WM performance (e.g. Fiorenzato et al., 2021; Kira et al., 2021; Xie et al., 2020). One significant reason for this hypothesis was the assumed influence of COVID-19 lockdown measures on individual memory capabilities, which may alter individual cognitive outlook, and thus effect their responses to adherence and compliance of social restriction measures (Fiorenzato et al., 2021). In view of this, the results of this study therefore offer partial support to this body of knowledge, especially in favour of significant effect on general memory performance, while WM performance reported a non-significant difference across the lockdown group responses.

Lockdown group response and emotional reactions

The finding of the current study reported significant differences across lockdown group responses on both emotional content of anxiety and depression. The result showed that the sufferer group experienced higher anxiety symptoms than the defiant and comply groups; while on the other hand, the defiant group displayed higher depressive symptoms compared to the sufferer and comply groups. The outcome of the findings therefore suggest that both anxiety and depressive symptoms differ across the lockdown group responses, which are consistent with previous literatures and systematic reviews, most especially with those around COVID-19 behavioural and cognitive responses to social isolation measures (Bavel et al., 2020; Brooks et al., 2020; Choi et al., 2020; Fiorenzato et al., 2021). While depressive symptoms decreased across the lockdown response levels compared to heightened anxiety levels, the effect sizes of both anxiety and depression across group responses were relatively modest with 0.63 and 0.50 respectively. Nevertheless, the varying significant differences of emotional responses across the lockdown groups could be due to several reasons.

Firstly, the global lockdown as a result of the pandemic disrupted both personal, financial, and social lives of people, resulting into significant psychological and mental outcomes of their well-being. Moreover, the exacerbated extension of 'sit-at-home' lockdown restrictions due to

increasing COVID-19 infections and fatalities might have elevated individual emotional content, with probable worsened anxiety and depressive responses. This might have been more prevalent in the sufferer group because of their assumed financial difficulty and low optimism as a result of pandemic lockdown, which may aggravate their anxiety levels because of agitation and lower optimism in government's response to mitigate and control the disease spread. This explanation is consistent with recent literatures that postulate the exacerbated emotional levels of anxiety, stress, and depressive symptoms of people during COVID-19 pandemic social isolation measures, which consequently resulted into negative and maladaptive coping responses across differing individual and group outcomes (Gopal et al., 2020; Van Belle et al., 2021).

Secondly, evidence of significant difference of anxiety and depression across lockdown group may be attributed to individual differences that captures varying social and personable nature in response to COVID-19 lockdown compliance measures. Understanding the role of individual differences through the lens of personality traits shed more light on the impact of individual or group response towards upholding or violating the protective practices embedded in the lockdown restriction measures in order to combat COVID-19 infections (Abdelrahman, 2020). Neuroticism and conscientiousness, which are analogous to sufferer group in this current study, captured the context of people with high tendency to avoid risks of infection (thereby forced to adhere to compliance rules) because of growing negative concerns about the disease spread, despite their emotional disturbances to some social isolation rules (Zajenkowski et al., 2020).

In contrast, extraversion, which is similar to defiant group (especially within the context regarding social isolation rules) revealed an attitudinal response of impulsive risk taking because of intense difficulty in complying with social isolation rules, which sometimes result in compliance violation (Lucas & Diener, 2001); However, agreeableness, which is synonymous to comply group, reflect an explicit representation to concur with rules such as government policies regarding COVID-19 isolation measures without major emotional disturbances and negative impulsivity (Zajenkowski et al., 2020). In view of these characteristic reflections of the lockdown group responses relative to differing personality traits, it was plausible therefore to find differing levels of

anxiety and depressive symptoms across the group levels because of varying patterns of emotional behaviour as suggested by differing individual perceptions (Zajenkowski et al., 2020).

The role of mis-information arising from high social media exposure and usage, coupled with emerging conspiracy theories surrounding COVID-19 infections and treatments (Miller, 2020; Pereira et al., 2020), could also be attributed to significant differences of emotion across lockdown group responses. The findings on daily and frequent use of social media amongst the study sample, and lack of government's plan to respond adequately to changing scientific information (leading to misinformation), might have negatively influenced the emotional state of people towards inappropriate responses to the pandemic lockdown measures. For instance, defiant group, who were susceptible to high social media exposure and usage, were linked to higher depressive symptoms in this current study. This finding is consistent with recent studies which postulate that increasing misinformation, conspiracy theories, and fake news on COVID-19 infections and outcomes are significantly associated with heightened emotional and psychological responses (Chao et al., 2020; Sigdel et al., 2020; Wang et al., 2020). In light of the reviewed literature and hypothesis which stated that significant differences will be found between lockdown group responses to COVID-19 social restriction measures on participants' emotional content of anxiety and depression, the findings of this study therefore offer consistent support to the body of knowledge in favour of significant effect on emotional responses to COVID-19 lockdown measures.

Predicting effects of socio-demographic variables

With regards to the findings of the regression analyses of this study, socio-demographic variables were not significant predictors of the association between lockdown group responses and cognitive content of general memory comprehension. This finding contrasted with the hypothesis of this study, as well as previous study which postulate age, gender, and negative affect as predictors of association between responses to recent life stress (which could be viewed as analogous to COVID-19 pandemic) and poorer general memory performance, measured by immediate and delayed free memory recall (Shields et al., 2017). This therefore suggest that the association

between lockdown group responses and general memory are independent of either the buffering or exacerbating effect of age, gender and education level of participants.

In contrast to the above finding, both social demographic variables of gender and postgraduate level of education significantly predicted association between lockdown group and working memory performance. This result showed better working memory performance in males compared to females, which was shown to be consistent with recent study that postulate the effect of gender on the relationship between COVID-19 social isolation responses (leading to anxiety) and working memory (measures by *n*-back tasks) performance (Fellman et al., 2020). Additionally, the result of postgraduate level of educational as significant predictor of the association between the constructs was inconsistent with some of the previous studies, where level of education was reported as non-significant predictor of COVID-19 social distance compliance and working memory performance (Fellman et al., 2020; Xie et al., 2020). Although evidences of significant effect of the association between lockdown group responses and WM performance were reported in this study, it is noteworthy to ascertain that because of variations in the instrument utilised (digit span forward) in this study compared to other studies, it is possible that some other sub-components of WM capacity might not have been tapped by this measure, and as such, there may be possible inaccurate estimation of WM performance in this study. Due to this assumed variations, result of the WM assessment should be interpreted with caution.

Consistent with recent studies (Kira et al., 2021; Park et al., 2020), age as a socio-demographic variable significantly predicted association between lockdown group response and emotional response of anxiety and depression. The negative prediction of the result suggest that younger adults were more exposed to heightened levels of anxiety and depression than older adults. An explanation to this could be because older individuals have emotional capacity to contextualise a stressor such as COVID-19 lockdown measures outcome, which helps them to maintain stable emotional balance than the younger individuals (Bacon & Corr, 2020). In addition to this, older adults tends to have mature social disposition and better financial support-base such as better-paying jobs, which might reduce the context of emotional imbalance than for the younger adults.

Furthermore, gender was a significant predictor of group responses and anxiety relationship, but failed to significantly predict the relationship with depression. In comparison to males, females showed higher anxiety symptoms, which was consistent with reviewed literature and studies that primarily revealed evidence of significant increase in anxiety observed in females (Chinna et al., 2021; Kleitman et al., 2021; Volk et al., 2021). A potential explanation for this could be because of the assumptions that females bear more disproportionate domestic and caregiving responsibilities than men, especially during the pandemic period such as COVID-19 social isolation exercise, which result into contextually skewed gender division of labour in the society, especially within household set up (Almeida et al., 2020; Hazarika & Das, 2021). As a result of this suggested increase in responsibilities during the COVID-19 social lockdown measures, females could be considered more susceptible to increased anxiety and depressive symptoms.

Also, imposition of social isolation measures such as restriction of physical mobility during the pandemic could also increase females' exposure to domestic violence and hostile experiences. Influence of this could exacerbate their emotional disturbance levels, especially from areas where gender violence practices and narratives are prevalent such as the sub-Saharan Africa, and in particular, Southern Africa (Ahinkorah et al., 2021; Haider et al., 2020; Mittal & Singh, 2020). Level of education however was not significant predictor of the association between lockdown group and ER of anxiety and depression. This was also consistent with the view explicated in the reviewed literature that showed evidence of no effect of educational levels on the COVID-19 related social isolation measures and emotional contexts (Gopal et al., 2020; Xie et al., 2020). This therefore suggest that relationship between lockdown group responses, anxiety, and depression are independent of the levels and quality of acquired knowledge and intelligence of individuals. In view of the reviewed literature and hypothesis that epitomised socio-demographic variables as significant predictors of the association between lockdown group and cognitive-emotional capabilities, the general observation of the findings of this current study therefore offer partial support to the body of knowledge in this context.

Study limitations and future recommendations

Due to of the evolving viral and spatial dynamics of the COVID-19 pandemic and outcomes, research into understanding its impact on psychological health and well-being of people (Brooks et al., 2020; Chinna et al., 2021; Grover et al., 2020), as well as its influence on their cognitive profiles, decision-making, and behavioural responses to various pandemic lockdown measures (Bavel et al., 2020; Kira et al., 2021) have progressed. While this study provided new insights into how existing cognitive and emotional processes might influence the psychological responses of individuals and group levels toward COVID-19 lockdown measures, there are few limitations of the study that should be considered in light of interpretation of the findings of this study, as well as giving recommendations for future studies.

Firstly, the primary goal of this study was designed as exploratory in context, whereby statistical analyses were designed to explore the relationships among a range of variables of interest. On the other hand, the context of the study was also cross-sectional, and as a result of these study outlooks, its exploratory nature did not allow for precisely defined hypotheses to be ascertained, while its cross-sectional outlook limited the ability to draw causal conclusions on the findings of the study. Future studies should look at longitudinal design approach in order to enhance the definitive evaluation of cognitive-emotional performance and responses of the sample in relation to COVID-19 lockdown measures.

Another limitation of this study was the inability to collect baseline measurement data of participants' cognitive performance (specifically general memory and working memory) before the pandemic lockdown. This resulted into subjective WM performance results because there was no propensity scores to compare their pre-pandemic cognitive performance with the measures taken in this study, and as a result, limited the WM assessment scores for the study. In addition to this, the digit span forward (DSF) constrained the outcome of the WM performance results, as DSF is considered a cognitive assessment that is more involved in measuring the storage and retrieval processes of short-term memory. Inclusion of a more robust cognitive measurement such as *n*-back or digit span backward (DSB) tasks, which are known to be highly effective tasks that measures the

ability to continuously monitor and update information in the WM sub-component processes (Conway & Kovacs, 2013; Fellman et al., 2020), would enhance the WM performance results in future studies.

Despite this limitation, this study was however unique in investigating both general and working memory performances simultaneously, while many previous studies predominantly looked at singular cognitive (especially working memory) performance of adults (Fellman et al., 2020; Xie et al., 2020). This current study explored both the general memory performance (which looked at the process and storage mechanisms of the short-term and long-term memory components), and the visuospatial storage mechanism within the central executive processing and visuospatial sketchpad of the working memory capacity of the study sample (Baddeley, 2007; 2012). This assisted in gaining robust understanding of the broader construct of the memory capacity of participants, and how such an important cognitive system influences individual and group responses to pandemic and social isolation measures.

In addition, general findings of this study provided informative data linking COVID-19 lockdown responses and cognitive-emotional performances, which helps to improve our understanding of public perceptions that consequently inform their responses to social isolation measures in the face of a severe viral pandemic. In lieu of this, this study was able to add to our understanding of cognitive-emotional processes that are involved in people's behavioural and decision-making responses in the course of prolonged lockdown and restriction measures during the pandemic. Therefore, these findings may prove to be useful to inform strategies for improving and maintaining individual and group behavioural responses to future COVID-19 waves or pandemics.

Moreover, all data collection procedures for this study was performed online, and as a result, the possibility of participants being distracted while completing the assessment could not be ruled out. This could possibly lead to bias in the mode of collection of such data. Similarly, it might be possible that some participants could have written down the free memory recall test instead of recalling them from their initial memory recollection. This could further result into measurement error and bias of the data. It is noteworthy to mention though that such was unlikely in this study,

taken into consideration the observed memory recall scores. In fact, only 1.2% (20 individuals) got between 28-30 correct score on free memory recall test. Also, participation in the study was advertised and recruited online, which restricted participation to only those with access to the internet, thereby leading to sampling bias where those who lacked access to online devices and platforms were disadvantaged from participating in this study. Furthermore, because of the use of self-reported measures to collect data in the study, the debate on participants' honesty in responding accurately could have engendered the limitation of self-judgement bias, which is generally common with most self-reported questionnaires or measures (Chinna et aal., 2021).

However, in comparison (especially in terms of methodological rigour), the strength of this study was its use of *k*-means cluster analysis to classify the lockdown groups based on similarity responses on compliance to lockdown rules (Duffy & Allington, 2020; Van Belle et al., 2021). Apart from using this cluster analysis to maintain a meaningful population size within each cluster to enhance statistical analysis and findings of the study, the use of *k*-means also assisted in grouping individuals with similar characteristics in order to correctly analyse and describe valuable information and patterns that are specific and representative of each of the group characteristics within the cluster analysis (Wu, 2012).

Limited scope of what constitute the construct of socio-economic status (SES) of participants was another constraint of this study. Although different levels of education were captured to reflect part of socio-economic metrics, no other socio-economic measures were recorded in the study tasks. Because of the role of SES on psychological and mental health behaviours among people, coupled with emerging results of the association between SES and COVID-19 lockdown and infections (Clouston et al., 2021; Kleitman et al., 2020), it becomes necessary to investigate differing economic and social conditions that are considered sensitive enough to implicate differing population responses in the face of progressive COVID-19 pandemic. Factors such as the living standard of people, their income levels, occupational, as well as marital statuses, should be considered as part of the metrics of SES of the sample participants in future studies. A further limitation from this study was that despite the large sample size, the total sample

of this study could not be determined as representative of all the nationalities represented. Specifically, there were significant variations of sample representation across the continental regions, with Europe having the dominant sample size, while Africa, Asia, and Australasia were sparsely represented. In respect of this, caution should be exercised, as generalisability of the findings in this study would be limited.

In spite of the above generalisability and SES limitations, the study showed a unique merit of a large sample size drawn from across different nations of the world. Similar to other large scale COVID-19 survey-based studies (see Chinna et al., 2020; Gollwitzer et al., 2020), the current study added to our understanding of patterns of individuals cognitive-emotional responses to lockdown restriction measures from differing socio-cultural contexts and perspectives. In addition to this, it could be argued that the use of online survey methods increased the number and spread of the sample and allowed for more effective data management, as opposed to the more traditional face-to-face and paper-pen data collection process. However, the use of online methods also may restrict certain age and socio-economic population groups, which limits the representativeness of the sample (see Heen et al., 2020, for a more extensive reviews). Futhermore, the use of standardised measures that are employed in diverse settings, such as the Hospital anxiety and depression scale (HADS) also added to the merit of this study, especially the quality of data collected, and the results of the study. In particular, the HADS, which measured the prevalence of anxiety and depression, is recognised as effective psychometric properties that is widely used for general clinical and non-clinical practices in multiple countries (Fiorenzato et al., 2021; Zigmond & Snaith, 1983).

Conclusion

The global influence of the COVID-19 pandemic has impacted not only the physiological and psychological conditions of people, but also their way and quality of life, resulting in collective social disruptions and potential social abnormality (Brooks et al., 2020; Kira et al., 2021; Kira et al., 2021). Additionally, the imposition of pandemic lockdown measures have generated differing behavioural and psychological responses, which in turn elicited potential influence on people's existing cognitive performances and emotional reactions. Therefore, there is a need to understand

association between these differing responses to COVID-19 lockdown measures and related cognitive capacity and emotional response. This report showed varying participants' cognitive performance and emotional responses towards lockdown restrictions, while being obligated to physical and social lifestyle restrictions during COVID-19 pandemic (Fiorenzato et al., 2020). The results of the study suggest that both cognitive (especially general memory and working memory) and emotional profiles of individuals may be susceptible to the burden and effect of prolonged social restriction measures, which may further implicate their responses toward compliance or violation of such social distancing rules.

Taken together, this study provided an important snapshot of the effect of cognitive performance and emotional responses of group structures on pandemic lockdown responses. The results of this study suggest that cognitive-emotional processes may underly pandemic lockdown responses, and potentially inform future interventions for further lockdown measures in the COVID-19 or future pandemics. The result of these findings could be utilised to inform the development of policies and interventions aimed at larger societal structures. This could be achieved by educational measures used to enhance cognitive appraisal and behavioural approaches in order to limit the spread and negative outcomes of the COVID-19 or possible future pandemic lockdown measures.

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Appendices

Appendix A: COVID-19 Lockdown Questionnaire

Questions about how you feel about the COVID lockdown

I followed the COVID lockdown rules

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I supported lockdown measures

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I am adhering to social distancing rules

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I wash hands more often for at least 20 seconds

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I cover my mouth when coughing

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I avoid close contact with someone who is infected

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I have been avoiding places where many people are most likely to gather (e.g. parks, beaches, other outdoor spaces)

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**

- ○ **None of the time**

I have been taking homeopathic remedies too help overcome the coronavirus

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I have been taking herbal remedies to help overcome the coronavirus

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I have been avoiding eating meat to help overcome the coronavirus

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I have been drinking ginger tea to help overcome the coronavirus

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**

- **Hardly ever**
- **None of the time**

I have been using antibiotics to help overcome the coronavirus

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

During the COVID lockdown I met up with friends or family outside the home

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

During the COVID lockdown I had friends or family visit me at home

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I have been outside when having coronavirus-like symptoms

- **Completely**
- **Nearly all the time**

- **Some of the time**
- **Hardly ever**
- **None of the time**

I have had a confirmed case of coronavirus

- **Yes**
- **No**

I have NOT had a confirmed case of coronavirus, but I think I might have had it

- **Yes**
- **No**

I have been in contact with a counselling or support service

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I support police powers during the COVID crisis

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I agree with the following statement: "Too much fuss is being made about the risk of coronavirus":

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I agree with the following statement: "The coronavirus was probably created in a laboratory":

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I agree with the following statement: "Most people in the UK have already had coronavirus without realising it":

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I agree with the following statement: "Pets can transmit coronavirus":

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**

- **Hardly ever**
- **None of the time**

I agree with the following statement: "Coronavirus can last on some surfaces for up to 7 days":

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I agree with the following statement: "Sanitising hand gels are more effective at protecting you from coronavirus than washing your hands with soap and water":

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I agree with the following statement: "The NHS recommends that you should wear a face mask when you are out, even if you do not have coronavirus":

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I agree with the following statement: "There will be a quick resolution to the coronavirus crisis and lockdown measures will end soon":

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I am closely following official guidance/recommendations on how to protect myself and others

- ○ **All recommendations**
- ○ **Most recommendations**
- ○ **Some recommendations**
- ○ **Hardly any recommendations**
- ○ **I am not following any of the recommendations**

I have lost sleep over coronavirus

- ○ **Completely**
- ○ **Worse than usual**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

My eating patterns have changed during the coronavirus lockdown:

- ○ **Eating more than usual**
- ○ **Eating less than usual**
- ○ **Eating more or less the same as usual**

I am eating much more HEALTHY food (e.g. vegetarian, low-fat, salads, vegetables, fruits, etc) since the coronavirus outbreak:

- ○ **Definitely**
- ○ **Somewhat**
- ○ **Unsure**
- ○ **Not really**
- ○ **Definitely not**

I am eating much more UNHEALTHY food (e.g. vegetarian, low-fat, salads, vegetables, fruits, etc) since the coronavirus outbreak:

- ○ **Definitely**
- ○ **Somewhat**
- ○ **Unsure**
- ○ **Not really**
- ○ **Definitely not**

I am drinking much more alcohol since the coronavirus outbreak

- ○ **Definitely**
- ○ **Somewhat**
- ○ **Unsure**
- ○ **Not really**
- ○ **Definitely not**

I am using non-prescription drugs (e.g. painkillers, other over-the-counter remedies) much more since the coronavirus outbreak

- ○ **Definitely**
- ○ **Somewhat**

- **Unsure**
- **Not really**
- **Definitely not**

I am finding the coronavirus outbreak and/or the lockdown measures extremely difficult to cope with

- **Definitely**
- **Somewhat**
- **Unsure**
- **Not really**
- **Definitely not**

I have been spending time thinking about the coronavirus

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I have argued more with family/people in the home during the COVID lockdown

- **Completely**
- **Nearly all the time**
- **Some of the time**
- **Hardly ever**
- **None of the time**

I feel more anxious since the lockdown measures were introduced

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I feel more depressed since the lockdown measures were introduced

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I feel helpless as a result of coronavirus

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

I will lose my job as a result of coronavirus and/or the lockdown

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

I will experience financial difficulties as a result of coronavirus and/or the lockdown

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

Life will return to normal soon

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

During the COVID lockdown I had friends or family visit me at home

- ○ **Completely**
- ○ **Nearly all the time**
- ○ **Some of the time**
- ○ **Hardly ever**
- ○ **None of the time**

The economy will start to grow again soon

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

We will be able to vaccinate the population against coronavirus soon

- **Certain**
- **Likely**
- **Unsure**
- **Unlikely**
- **Definitely not**

School will stay closed in the future

- **Certain**
- **Likely**
- **Unsure**
- **Unlikely**
- **Definitely not**

Older people and those with underlying health issues will continue to be asked to remain home

- **Certain**
- **Likely**
- **Unsure**
- **Unlikely**
- **Definitely not**

My country's government has handled the crisis

- **Consistently and organised**
- **Somewhat consistent and organised**
- **Unsure**
- **Somewhat inconsistent and confused**
- **Inconsistently and confused**

I would describe my trust in my country's government to control the spread of coronavirus as:

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

I would describe my trust in the coronavirus information my country's government provide as:

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

My belief that the government acted too slowly to control the spread of coronavirus is:

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

My belief that the government communication provided helpful advice:

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

My belief that the government plan responded well to the changing scientific information and situation:

- ○ **Certain**
- ○ **Likely**
- ○ **Unsure**
- ○ **Unlikely**
- ○ **Definitely not**

I check social media for information or updates about coronavirus

- ○ **Daily or more frequently**
- ○ **Once a day**
- ○ **Once every few days**
- ○ **Once a week**
- ○ **Less than once a week**

Appendix B: Demographic questionnaire

1. What is your age (please write a number in the box below)?

2. What gender do you currently identify with?
    a. Male
    b. Female
    c. Prefer not to be identified by gender
    d. Other

3. Please write which country (including the region) you are from in the box below:

4. On which side of the political divide do you tend to identify?
    a. Far left
    b. Left
    c. Central Right
    d. Far right
    e. No political interest

5. In terms of British Politics - in the recent Brexit referendum and voting how might you have voted?
    a. For Brexit (to leave the European Union)
    b. For Remain (to stay in the European Union)
    c. Undecided
    d. Not interested
    e. Other

6. What is your highest level of education? Please write in the box below (e.g. School-level exams, Undergraduate degree, Master's degree, PhD):

Appendix C: General memory assessment: Free memory recall test (FMRT)

Please read the following free recall passage carefully. You can take as long as you want to read it. Once you have read it, click for the next page, where you will be asked to recall as many **bold words** from the passage as you can. You will NOT gain points for recalling common words that are not in bold.

FREE RECALL PASSAGE:

Who can use the term "gone **viral**" now without **shuddering** a little? Who can look at anything anymore— a **door** handle, a cardboard **carton**, a **bag** of **vegetables** — without **imagining** it **swarming** with those **unseeable**, **undead**, **unliving** blobs dotted with **suction** pads waiting to fasten themselves on to our **lungs**?

Who can think of **kissing** a stranger, **jumping** on to a **bus** or sending their child to school without feeling real **fear**? Who can think of **ordinary** pleasure and not assess its **risk**? Who among us is not a **quack** epidemiologist, virologist, statistician and **prophet**?

Which **scientist** or doctor is not **secretly** praying for a miracle? Which **priest** is not — secretly, at least — **submitting** to science? And even while the virus **proliferates**, who could not be **thrilled** by the swell of **birdsong** in cities, peacocks **dancing** at traffic crossings and the **silence** in the skies?

There were 30 words in bold in the previous passage - try to write as many as you can remember below (either in a list, or separated by commas). Don't worry if you can't remember them all - most people can only remember some!

Appendix D: Working memory assessment: Digit span forwards (DSF)

The following questions aim to test your memory. Please DON'T write down the letters, but try to memorise them (you can take as long as you like, BUT, try to be as quick as possible). Please check the box below to state how you feel about memory tests!

- ◯ Like
- ◯ Dislike

Write a YES in the box below when you have memorised the following digits:

B- R - N

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

Q-R-T-S

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

H-W-D-N-P

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

Y-P-K-D-F-C

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

M-F-S-G-B-R-K

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

P-M-J-H-S-W-C-N

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

K-N-P-F-G-Q-S-L-P

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Write a YES in the box below when you have memorised the following digits:

P-K-M-H-L-G-D-W-Z-Q

Try to write the letters you just memorised in the correct order below (if you can't remember, write what you can):

Appendix E: Hospital anxiety and depression scale (HADS)

Questions about your feelings

I feel tense or wound up

- **Most of the time**
- **A lot of the time**
- **Occasionally**
- **Not at all**

I feel as if I am slowed down

- **Nearly all of the time**
- **Very often**
- **Sometimes**
- **Not at all**

I still enjoy the things I used to enjoy

- **Definitely as much**
- **Not quite as much**
- **Only a little**
- **Hardly at all**

I get a sort of frightened feeling like 'butterflies' in the stomach

- **Not at all**
- **Occasionally**
- **Quite often**
- **Very often**

I get a sort of frightened feeling as if something awful is about to happen

- **Quite badly**
- **Not too badly**
- **A little**
- **Not at all**

I have lost interest in my appearance

- **Definitely**
- **I don't take as much care as I should**
- **I may not take quite as much care**
- **I take just as much care as ever**

I can laugh and see the funny side of things

- **As much as I always could**
- **Not quite so much now**
- **Definitely not so much now**
- **Not at all**

I feel restless as I have to be on the move

- **Very much indeed**
- **Quite a lot**
- **Not very much**
- **Not at all**

Worrying thoughts go through my mind

- **A great deal of the time**
- **A lot of the time**
- **From time to time**
- **Only occasionally**

I look forward with enjoyment to things

- **As much as I ever did**
- **Rather less than I used to**
- **Definitely less than I used to**
- **Hardly at all**

I feel cheerful

- **Not at all**
- **Not often**
- **Sometimes**
- **A lot**

I can sit at ease and feel relaxed

- **Definitely**
- **Usually**
- **Not often**
- **Not at all**

I get sudden feelings of panic

- **Very often**
- **Sometimes**
- **Not often**
- **Not at all**

I can enjoy good book or programme

- **Often**
- **Sometimes**
- **Nott often**
- **Very seldom**

Appendix F: Amazon voucher and Debrief sheet

End of Survey and debrief

Thank you for taking part in this survey, we very much appreciate your contribution. If you would like to be entered into the prize draw for the chance to win a **£l00 Amazon voucher**, please write your email address in the box below.

Please be assured that this information will not be saved with all your other answers, we will save all email addresses in a separate database for the purposes of the prize draw and to disseminate group findings and summary data.

If you have experienced any discomfort during the completion of this survey (e.g. if it has raised some uncomfortable thoughts and feelings) please consider either contacting Dr Samantha Brooks for further guidance on support networks to contact or consider contacting online organisations such as those listed on the UK's NHS website:

https://www.nhs.uk/conditions/stress-anxiety- depression/mental-health-helplines/

You can also gain further information about the UK government's response to the COVID pandemic here:

https://www.gov.uk/coronavirus

Remember also if after completing the survey you change your mind and do not want your answers to be included in the study please email Dr Samantha Brooks with the date and time that you completed the survey and your answers will not be included.

Once again thank you for taking part! Stay safe, stay well.

Dr Samantha Brooks and colleagues at Liverpool John Moores University, UK.

drsamanthabrooks@gmail.com

Appendix G: Ethics approval

From: UREC minimal Risk Registration
Sent: 27 July 2020 14:44
To: UREC minimal Risk Registration; Brooks, Samantha
Cc: Ashworth, Emma
Subject: UREC Minimal risk registration number - Brooks - 20/NSP/035

Dear Samantha

Thank you for registering your study as minimal risk.

PI: Samantha Brooks

Title of study: Three types of COVID lockdown response: Links to neural processes of affect regulation

Minimal Risk UREC approval reference number: 20/NSP/035

Approval is given on the understanding that:

· The study is conducted in accordance with the Minimal Ethical Risk Guiding Principles<https://www.ljmu.ac.uk/ris/research-ethics-and-governance/research-ethics/university-research-ethics-committee-urec>

· Any adverse reactions/events which take place during the course of the project are reported to the Committee immediately by emailing researchethics@ljmu.ac.uk<mailto:researchethics@ljmu.ac.uk>;

· Any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately emailing researchethics@ljmu.ac.uk<mailto:researchethics@ljmu.ac.uk>;

· The LJMU logo is used for all documentation relating to participant recruitment and participation e.g. poster, information sheets, consent forms, questionnaires. The study consent forms, data, information etc. will be accessible on request to a student's supervisory team and/or to responsible members of Liverpool John Moores University for monitoring, auditing and data authenticity purposes.

· Where any substantive amendments<https://www.ljmu.ac.uk/ris/research-ethics-and-governance/research-ethics/university-research-ethics-committee-urec/amendments> are proposed to the protocol or study procedures that change the associated risk from minimal to low risk (use the decision tool to establish the associated risk), the investigators must complete an ethics application form describing all aspects of the study and submit for ethical review and approval as required.

· Where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

Please note that approval is given for a period of five years from 27/07/2020 and therefore the expiry date for this project will be 5 years from the approval date. An application for extension of approval must be submitted if the project continues after this date.

Best wishes

UREC

Appendix H: Participant information sheet and consent form

Title of Study:

COVID Lockdown: thoughts, feelings, and dreams.

You are being asked to participate in a research study conducted by:

Dr. Samantha Brooks, a cognitive neuroscientist researcher and lecturer at the School of Psychology, Liverpool John Moores University, Liverpool, UK.

You can contact Dr. Samantha Brooks about this study at:

s.j.brooks@ljmu.ac.uk or drsamanthabrooks@gmail.com

What is the purpose of the study?

Research shows that the dream images we produce when we dream tell us something about how we wish things to be in our everyday lives. Currently our everyday lives have seen unprecedented changes due to the coronavirus outbreak in early 2020 and the subsequent lockdowns across the world to try to prevent the spread of the virus. Some of us are accepting the lockdown while others are struggling to accept it or are resisting it. The amount of resistance our minds experience in response to external events has an impact on how we think and feel. And this resistance can have an impact on the dream images we produce which can tell us something about our 'true' feelings and cognitive coping mechanisms. Often psychologists ask participants to 'self-report' how they think and feel for example by using questionnaires. This approach tells us something but not all about cognitive and emotional processes in the brain. Instead, psychologists can use other methods that tap into unconscious processes such as with subliminal stimulation or by interpreting a person's dreams which avoid deliberate responses that are often shaped by our need to be perceived favourably.

This online study aims to understand the cognitive coping processes that are associated with COVID lockdown and how these cognitive processes are linked to emotions (in the form of questionnaires and dream-image themes).

Why have I been invited to participate?

This study is an online ‘self-selection' study – which means that anyone is eligible to take part if interested. We have tried to ensure that the study aims are explicit so that each potential participant fully understands what is being measured. We would like to ask as many people as possible from around the world – but only those who are currently in – or have previously experienced – lockdown in their country in an attempt by their government to control the coronavirus outbreak.

Do I have to take part?

You do not have to take part in this study. Your participation in this online study is entirely voluntary and you can choose to withdraw at any time without any adverse consequences.

Participants completing the whole survey and who provide their email address at the end (which will be listed in a separate database to the survey details to maintain anonymity) will be entered into a random prize draw for the chance to win a £l00 Amazon voucher advertised during October 2020.

What will happen to me if I take part?

You will first need to consent to taking part by checking the consent statement after reading this information.

After that you will be asked a series of questions including:

1. Demographics:
    a. Age
    b. Gender
    c. Highest level of educational attainment
    d. General political views (if any)
2. Validated questionnaire/self−report and cognitive measures:
    a. Questions about feelings: (HADS; Zigmond & Snaith, l983)
    b. Questions about self-regulation thoughts (SRQ, Brown et al., 1999)

c. Questions about obsessive-compulsive thoughts (Foa et al., 2002)

d. Digit-span working memory task (forward) (Cambridge Brain Sciences)

e. Free Recall test (written by author)

3. Other questions:

a. Coping with COVID lockdown (Based on a MORI survey conducted by Duffy & Allington, 2020).

b. An open question about a dream or dreams that were most recently remembered (max l,000 words)

How long will all this take?

In the first section the demographics questions should take no more than 5 minutes to complete. The second section questionnaires and digit span test will take a bit longer (and can be completed over a number of days, up to one week). The questions about feelings should take approximately 10 minutes; the questions about self-regulation should take approximately 15 minutes; the questions about obsessive-compulsive thoughts should take approximately 10 minutes. All questionnaires require you to tick one box out of maximum 5 alternative answers – you will not be able to move forward until all questions are answered. Finally, the ‘game-like' digit- span task should take approximately 20 minutes to complete and requires you to remember a series of digits. The other questions about coping with the COVID lockdown and describing dreams should take about 30 minutes to complete. Again, these can be completed on different days. The COVID lockdown questions again require you to choose one answer from a short list of possible answers (max 5 items).

The dream question asks you to think carefully about the last vivid dream or dreams you had and write as much detail about them as possible (while avoiding the inclusion of personal information about other people or places). The total survey should take a maximum of h hours to complete with the dream diary – but could take less time – and completion can be spread over a week - you can save it and return to it later (but the survey will close one week after first opening it).

What are the possible disadvantages and risks of taking part?

There are no dangers in taking part. However, it might be tiring to answer so many questions. It might also feel uncomfortable to write about a private dream – but you must remember that these details will always remain totally confidential and will not be traceable to you. You can provide your email address to be entered into the prize draw, but you are not obliged to do so. If you do your email address will immediately be removed from the survey database and placed into a separate database for the prize draw and for sharing of the final group data. If it gets tiring answering all the questions you can take a break at any time and you can stop completing the survey if you want to.

What are the possible benefits of taking part?

Despite the possible disadvantages it may also be interesting to reflect on your thoughts and feelings relating to the COVID lockdown and it might be fun to think about a previous dream you have had. And you will be helping cognitive neuroscientists and psychologists to understand how people react (cognitively and emotionally) to a pandemic lockdown. Findings from this study may help to advise future government policy and reactions to potential future pandemics – so that future lockdown experiences might be more pleasant.

What will happen to the data provided and how will my taking part in this project be kept confidential?

The information you provide as part of the study is the research study data. Any research study data from which you can be identified (e.g., from identifiers such as your name date of birth audio recording etc.) is known as personal data. Personal data does not include data that cannot be identified to an individual (e.g., data collected anonymously or where identifiers have been removed). We will use a unique ID code (e.g., 0l0203etc.) for the data we collect about you and will only use your age gender and highest education level (e.g., we will not record your date of birth or any other identifying information). We ask you to provide your email address for entry into the prize draw and to send you a summary of the group findings when the study is completed. Your email address however will be removed from the survey data output and stored in a separate data

base soon after completion. Anonymous data might be used for additional or subsequent research studies, and we might share anonymous data with other UK investigators (e.g., in online databases). There will be no personal information that could identify you when shared with other researchers or when results are made public.

Limits to confidentiality

The investigator will work with the participant in an attempt to minimize and manage the potential for indirect identification of participants.

The Investigator will keep confidential anything they learn or observe related to illegal activity unless related to the abuse of children or vulnerable adult's money laundering or acts of terrorism.

The investigator has a professional obligation to inform relevant agencies if they learn about…

In certain exceptional circumstances where you or others may be at significant risk of harm the investigator may need to report this to an appropriate authority. This would usually be discussed with you first.

Examples of those exceptional circumstances when confidential information may have to be disclosed are:

1. The investigator believes you are at serious risk of harm either from yourself or others
2. The investigator suspects a child may be at risk of harm
3. You pose a serious risk of harm to or threaten or abuse others
4. As a statutory requirement e.g., reporting certain infectious diseases
5. Under a court order requiring the University to divulge information
6. We are passed information relating to an act of terrorism

What will happen to the results of the research project?

The investigator intends to enable students complete a dissertation to satisfy their degree programme (additional ethical approval for a named student to work on this study will be acquired) and to publish the results in a journal article.

Who is organising and funding/commissioning the study?

This study is organised by Liverpool John Moores University, but external funding is currently not necessary for this project.

Who has reviewed this study?

This study has been reviewed by and received ethics clearance through the Liverpool John Moores University Research Ethics Committee.

What if something goes wrong?

If you have a concern about any aspect of this study, please contact the relevant investigator who will do their best to answer your query. The researcher should acknowledge your concern within l0 working days and give you an indication of how they intend to deal with it. If you wish to make a complaint, please contact the chair of the Liverpool John Moores University Research Ethics Committee (researchethics@ljmu.ac.uk) and your communication will be re-directed to an independent person as appropriate.

If you are harmed by taking part in this research project, there are no special compensation arrangements. If you are harmed due to someone's negligence, then you may have grounds for legal action.

Data Protection Notice

The data controller for this study will be Liverpool John Moores University (LJMU). The LJMU Data Protection Office provides oversight of LJMU activities involving the processing of personal data and can be contacted at secretariat@ljmu.ac.uk. This means that we are responsible for looking after your information and using it properly. LJMU's Data Protection Officer can also be contacted at secretariat@ljmu.ac.uk. The University will process your personal data for the purpose of research. Research is a task that we perform in the public interest.

Your rights to access change or move your information are limited as we need to manage your information in specific ways in order for the research to be reliable accurate and anonymous. If you withdraw from the study, we will keep the information about you that we have already

obtained.

You can find out more about how we use your information by contacting secretariat@ljmu.ac.uk.

If you are concerned about how your personal data is being processed please contact LJMU in the first instance at secretariat@ljmu.ac.uk. If you remain unsatisfied you may wish to contact the Information Commissioner's Office (ICO). Contact details and details of data subject rights are available on the ICO website at:

https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

Contact for further information:

If you have any questions or queries, please do not hesitate to contact:

Dr Samantha Brooks: drsamanthabrooks@gmail.com / s.j.brooks@ljmu.ac.uk

Liverpool John Moores University Ethics Chair: researchethics@ljmu.ac.uk

Thank you for reading this information sheet and for considering taking part in this study.

Please now read and check the box below to continue:

CONSENT:

I confirm that I have read and understand the information provided for the above study.

I have had the opportunity to consider the information, ask questions, and have had

these answered satisfactorily ☐

Appendix I: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE:	**PROTOCOL NUMBER: MASPR/21/08**
PROJECT TITLE:	Exploring the pandemic: COVID-19 lockdown response levels as predictor of working memory performance and associated emotional response.
INVESTIGATOR	Oyejide Aderemi (1022005)
SCHOOL/DEPARTMENT OF INVESTIGATOR	SHCD/Psychology
DATE CONSIDERED	10 June 2021
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	No Risk
EXPIRY DATE	31 December 2023

ISSUE DATE OF CERTIFICATE 28 July 2021 **CHAIRPERSON** ____ (Dr Sahba Besharati)

cc: Dr Sahba Besharati and Prof. Samantha Brooks (Supervisor)

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

Signature **Date** 28 / 07 / 2021

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix J: Demographic Distribution across the Lockdown Variables

		Comply group		Sufferer group		Defiant group	
Variables		n(%)	*M*(*SD*)	n(%)	*M*(*SD*)	n(%)	*M*(*SD*)
Age		**800(49.0)**	**28.60(10.92)**	**607(37.1)**	**29.19(9.98)**	**227(13.9)**	**27.32(8.36)**
Younger adults		420(50.8)	-	286(34.6)	-	121(14.6)	-
Older adults		380(47.1)	-	321(39.8)	-	106(13.1)	-
Gender		**800(49.0)**	-	**607(37.1)**	-	**227(13.9)**	-
Female		339(45.4)	-	349(46.7)	-	59(7.9)	-
Male		461(52.0)	-	258(29.1)	-	168(18.9)	-
Level of education		**800(49.0)**	-	**607(37.1)**	-	**227(13.9)**	-
College/matric & below		321(51.3)	-	214(34.2)	-	91(14.5)	-
Undergraduate		307(47.4)	-	266(41.1)	-	74(11.4)	-
Postgraduate		172(47.6)	-	127(35.2)	-	62(17.2)	-
Geopolitical indices							
National coronavirus response factors		**767(49.9)**	**.22(.11)**	**559(36.3)**	**.24(.10)**	**212(13.8)**	**.19(.12)**
NCRF	0.2 and below	364(23.7)	-	192(12.5)	-	117(7.6)	-
	0.21 and above	403(26.2)	-	367(23.8)	-	95(6.2)	-
Social security factors		**767(49.9)**	**.47(.18)**	**559(36.3)**	**.51(.19)**	**212(13.8)**	**.37(.17)**
SSF	0.39 and below	250(16.3)	-	159(10.3)	-	138(9.0)	-
	0.40 and above	517(33.6)	-	400(26.0)	-	74(4.8)	-

Note. Total *N* = 1634 for all variables except Geopolitical indices (*N* = 1538). NCRF = National coronavirus response factors. SSF = Social security factors. Scores of 0.2 and below represent a weak/low government response to COVID-19, while 0.21 and above represent a strong/high government response to COVID-19 pandemic. Scores of 0.39 and below represent poor social security provision by the government, while 0.40 and above represent high social security provision by the government during COVID-19 pandemic.

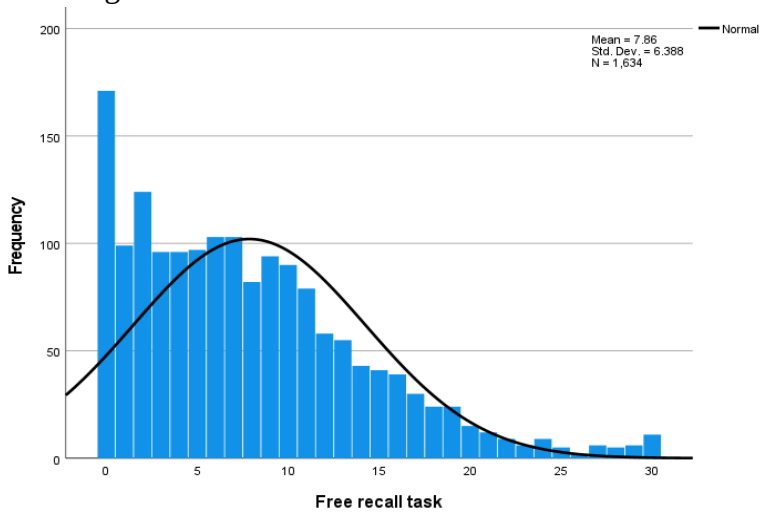
Appendix K: Descriptive Statistics for Cognitive – Emotional Variables

Measures	Tasks	*M*	*SD*	Range
General memory	Free recall task (max = 30)	7.86	6.39	0 – 30
Working memory	Digit span forward task (max = 36)	22.11	9.38	0 – 36
HADS Anxiety	Anxiety scale (max = 21)	8.63	4.26	0 – 21
HADS Depression	Depression scale (max = 21)	6.60	3.74	0 – 21

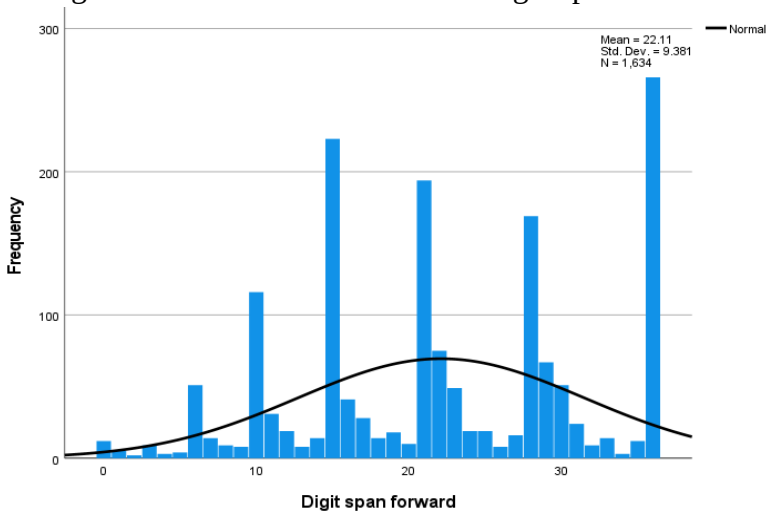
Note. N = 1634. M = mean. SD = standard deviation. max = maximum. HADS = Hospital anxiety and depression scale (Zigmond, & Snaith,1983).

Appendix L: Histogram of Data Distributions for Dependent Variables

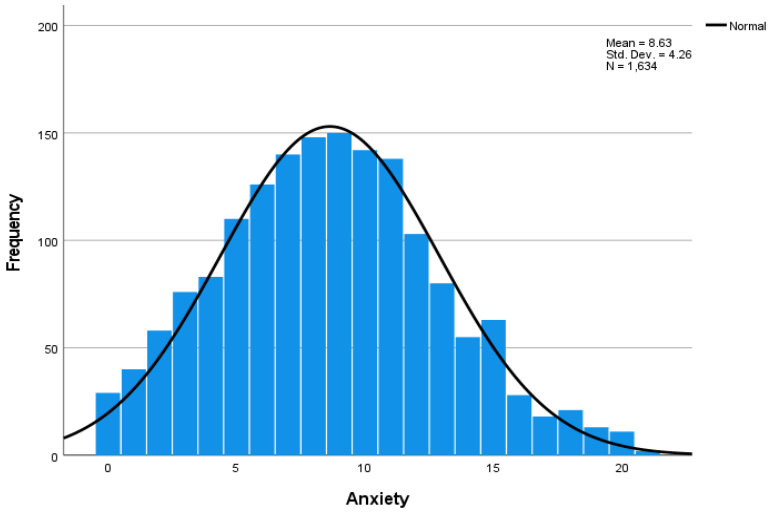
Histogram of Data Distribution from Free Recall Task



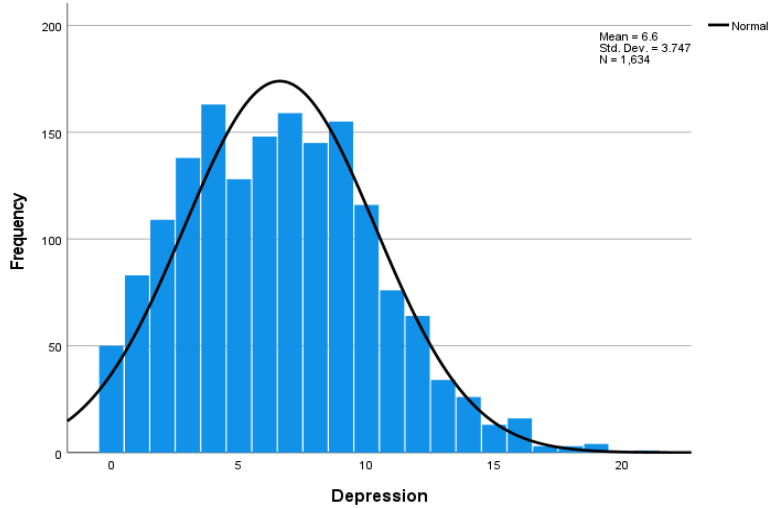
Histogram of Data Distribution from Digit Span Forward Task



Histogram of Data Distribution from Anxiety Scale



Histogram of Data Distribution from Depression Scale



Appendix M: Skewness and Kurtosis Tests of Normality

Variable	Measurement	Skewness	Kurtosis
General memory	Free recall task	.98	.85
Working memory capacity	Digit span forward	-.08	-.94
Anxiety	HADS anxiety scale	-.22	-.28
Depression	HADS depression scale	.38	-.17

Appendix N: Kolmogorov-Sminorv and Shapiro Wilk Tests of Normality

Measurement	Kolmogorov–Smirnov test		Shapiro–Wilk test	
	Statistics	Significance	Statistics	Significance
Free recall task	.109	.000	.923	.000
Digit span forward	.111	.000	.950	.000
HADS anxiety	.055	.000	.988	.000
HADS depression	.089	.000	.977	.000

Note. .000 = $p < .05$

Appendix O: Levene's Test for Homogeneity of Variance

Dependent variables	Independent variables (in group) statistics			
	Lockdown group	Age	Gender	Level of education
Free recall	2.02	5.98*	15.08*	0.94
Digit span	14.87*	0.06	0.02	1.34
Anxiety	13.48*	0.00	12.00*	1.62
Depression	5.71*	3.18	4.04	0.64

Note. *p < .05

Appendix P: Correlation Statistics for Multicollinearity Assumption

Variable	Measurement	Free recall task	Digit span task	Anxiety	Depression
General memory	Free recall task	1	.24**	-.07**	-.11**
Working memory	Digit span task	.24**	1	-.07**	-.07**
Anxiety	Anxiety	-.07**	-.07**	1	.58**
Depression	Depression	-.11**	-.07**	-.58**	1

Note. N = 1630, ** = correlation significance at $p < .01$

Appendix Q: Mahalanobis Test for Multivariate Normality and Outliers

	Case number	Statistic
Mahalanobis 1	980	25.71
Mahalanobis 2	84	20.77
Mahalanobis 3	1053	19.20
Mahalanobis 4	348	18.84
Mahalanobis 5	1239	16.85
Mahalanobis 6	1585	16.57

Note. N = 1634. Mahalanobis value = 18.47

Appendix R: Levene's Test of Equality of Error Variances

Measurement	Statistic	df1	df2	Sig
Free recall task	2.507	34	1594	.000*
Digit span task	1.404	34	1594	.062
HADS Anxiety	1.876	34	1594	.002*
HADS Depression	1.419	34	1594	.056

Note. N = 1630. Sig. = significant. * = $p < .05$

Appendix S: Box's M Test of Equality of Covariance Matrices

Box's M	509.752
F	1.402
df1	340
df2	61278.050
Sig.	.000

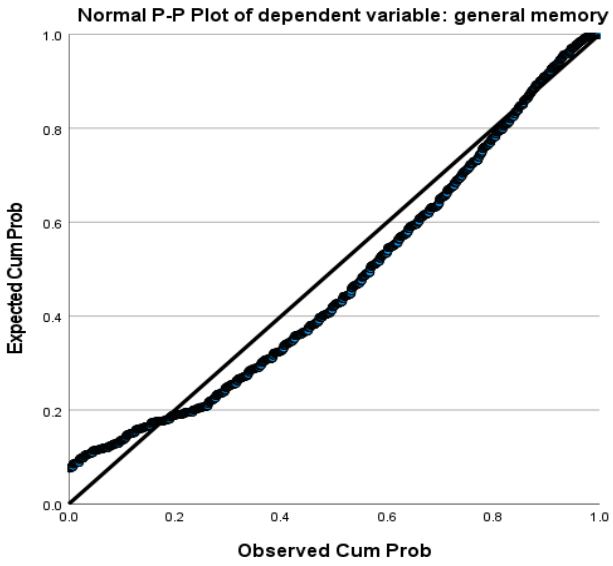
Note. $N = 1630$. Sig. = significant. $p < .001$

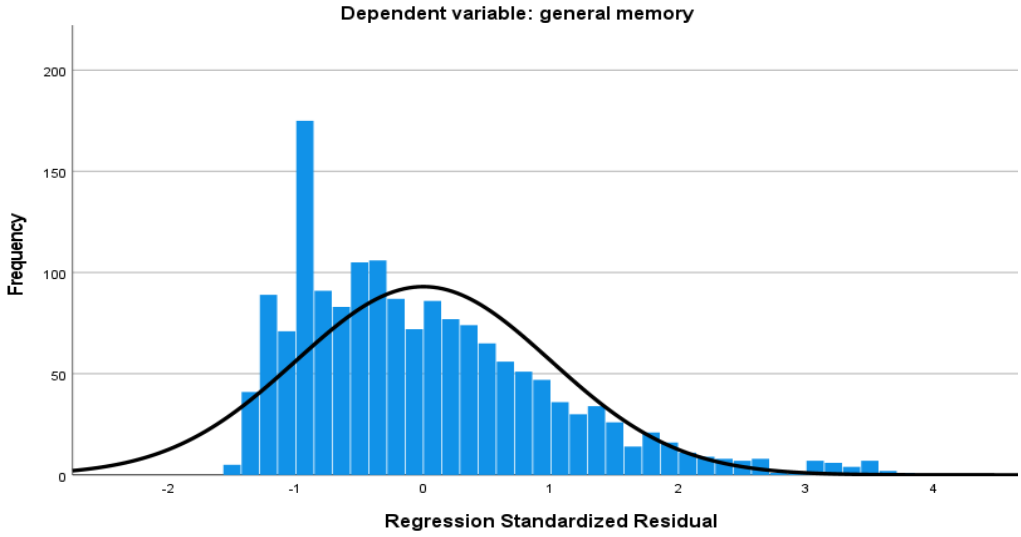
Appendix T: Multivariate Non-Significant Main Effect And Interaction Effects

Variable(s)	Test statistic (V)	*df1*	*df2*	*F* ratio	Sig.
LoE	.008	8	3184	1.608	.117
Lkdn group*Age	.008	8	3184	1.553	.134
Lkdn group*Gender	.008	8	3184	1.571	.128
Age*Gender	.003	4	1591	1.341	.252
Age*LoE	.003	8	3184	0.622	.760
Gender*LoE	.004	8	3184	0.849	.559
Lkdn group*Age*Gender	.007	8	3184	1.361	.209
Lkdn group*Age*LoE	.009	16	6376	0.863	.625
Lkdn group*Gender*LoE	.007	16	6376	0.680	.817
Age*Gender*LoE	.004	8	3184	0.645	.563
Lkdn group*Age*Gender*LoE	.012	16	6376	1.186	.271

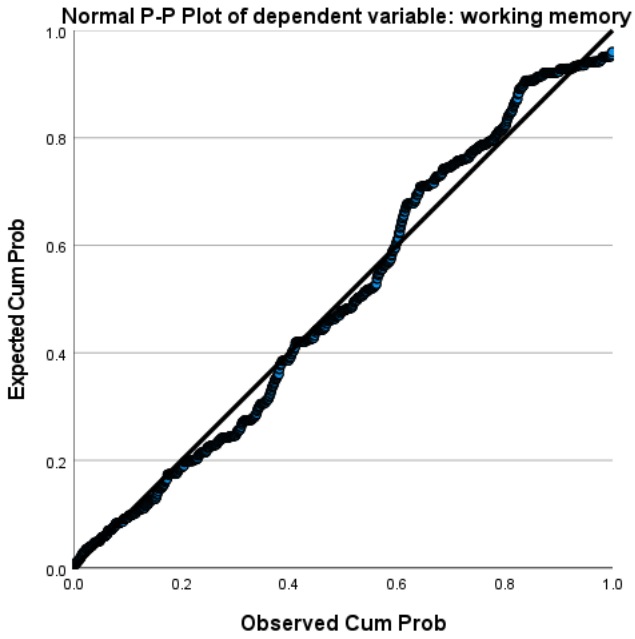
Notes. $N = 1630$. Lkdn = lockdown; *df* = degree of freedom; Loe = level of education. V = Pillai's value. Sig. = significant.

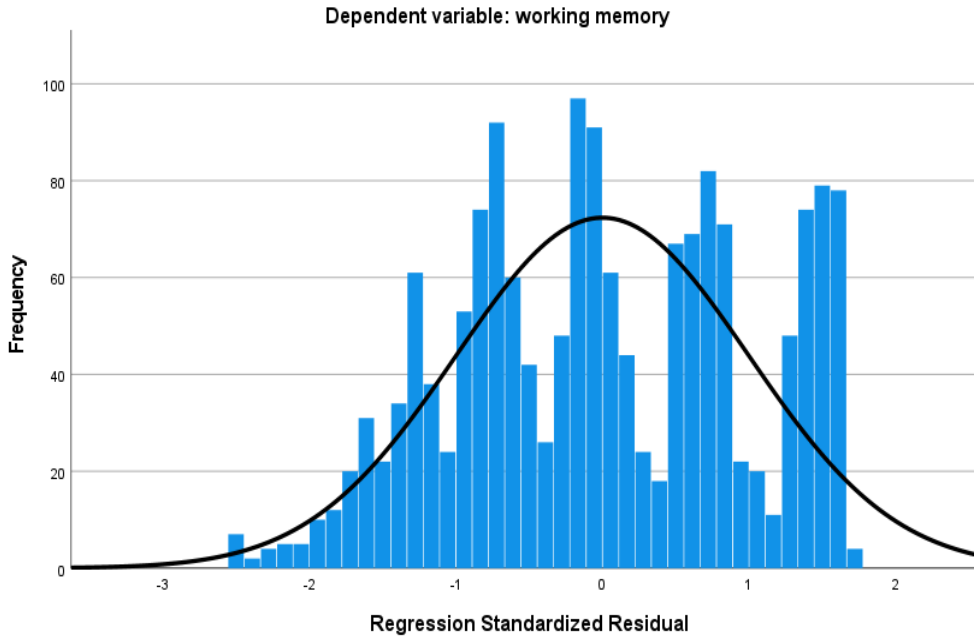
Appendix U: Linearity Plots and Normality of Residuals for General Memory



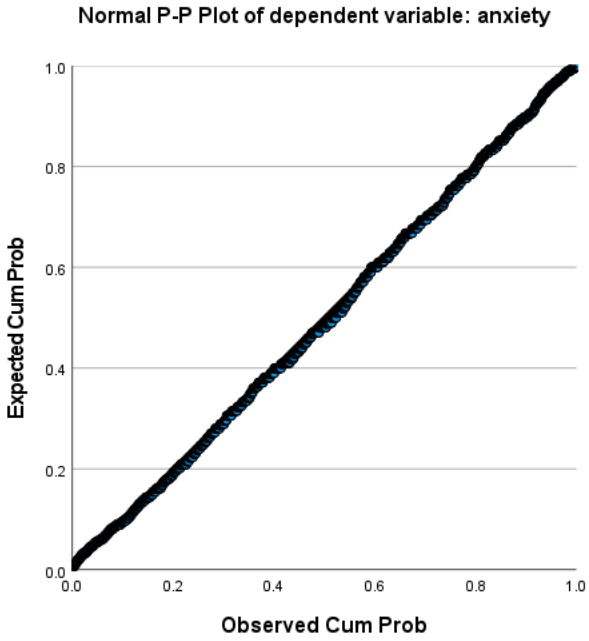


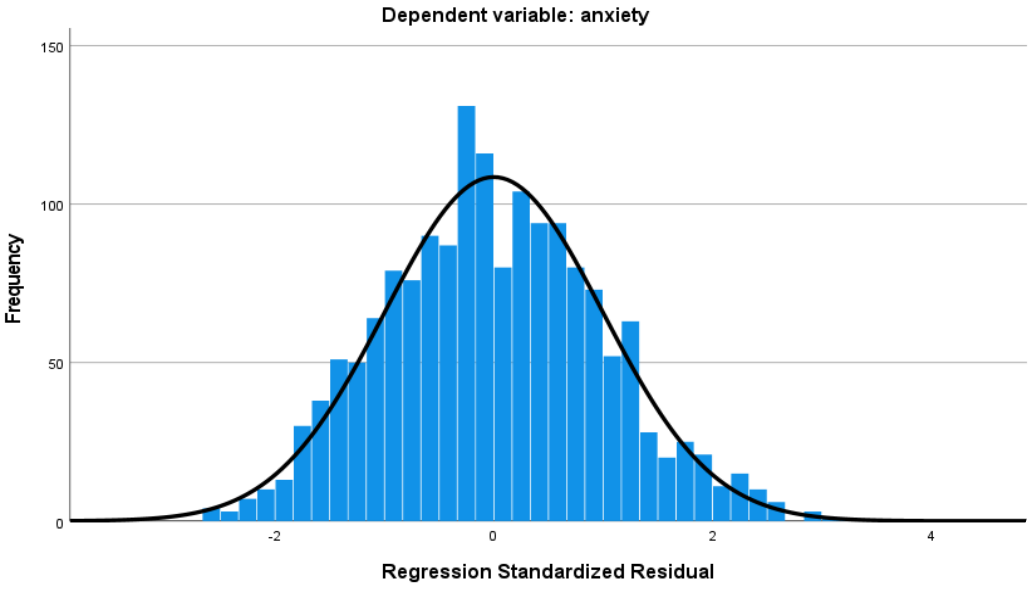
Appendix V: Linearity Plots and Normality of Residuals for Working Memory



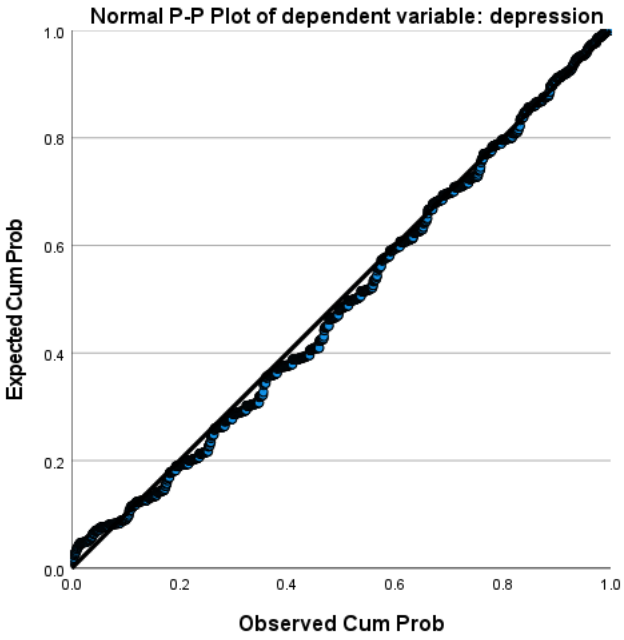


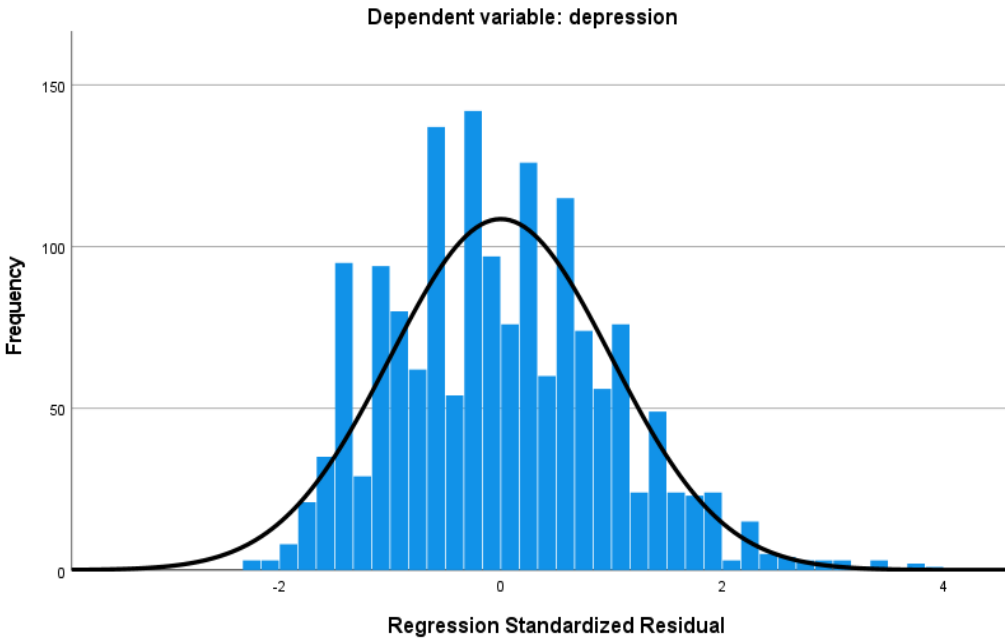
Appendix W: Linearity Plots and Normality of Residuals for Anxiety





Appendix X: Linearity Plots and Normality of Residuals for Depression





Appendix Y: Hierarchical Multiple Regression Predicting General Memory from Lockdown Group, Age, Gender, and Level of Education

	General memory					
	Step 1			*Step 2*		
Variable	*B*	*SE*	*β*	*B*	*SE*	*β*
Constant	8.47**	0.22		9.01**	0.34	
Lkdn group (ref: comply group)						
Sufferer group	-0.69*	0.34	-0.05	-0.76*	0.34	-0.06
Defiant group	-2.78**	0.47	-0.15	-2.72**	0.48	-0.15
Age				-0.25	0.33	-0.02
Gender				-0.41	0.32	-0.03
LoE (ref: undergraduate)						
College/matric & below				-0.53	0.36	-0.04
Postgraduate				0.13	0.43	0.01
R^2	0.021			0.024		
ΔR^2	0.021			0.003		
F	17.309**			6.631**		
ΔF	17.309**			1.287		

Note. N = 1630. *SE* = standard error; Lkdn = lockdown; LoE = level of education. **p < .001. *p < .05

Appendix Z: Hierarchical Multiple Regression Predicting Working Memory from Lockdown Group, Age, Gender, and Level of Education

	Working memory					
	Step 1			*Step 2*		
Variable	*B*	*SE*	*β*	*B*	*SE*	*β*
Constant	22.57***	0.33		22.10***	0.57	
Lkdn group (ref: comply group)						
Sufferer group	-1.15*	0.50	-0.06	-0.91	0.51	-0.05
Defiant group	-0.15	0.70	-0.01	-0.46	0.71	-0.02
Age				-0.86	0.49	-0.05
Gender				1.36**	0.48	0.07
LoE (ref: undergraduate)						
College/matric & below				-0.47	0.53	-0.02
Postgraduate				1.32*	0.63	0.06
R^2	0.003			0.014		
ΔR^2	0.003			0.010		
F	2.723			3.748**		
ΔF	2.723			4.249**		

Note. N = 1630. SE = standard error; Lkdn = lockdown; LoE = level of education. ***p < .001. **p < .01. *p < .05

Appendix AA: Hierarchical Multiple Regression Predicting Anxiety from Lockdown Group, Age, Gender, and Level of Education

	Anxiety					
	Step 1			*Step 2*		
Variable	*B*	*SE*	*β*	*B*	*SE*	*β*
Constant	7.30**	0.14		8.85**	0.22	
Lkdn group (ref: comply group)						
Sufferer group	2.64**	0.22	0.30	2.48**	0.22	0.28
Defiant group	2.48**	0.30	0.20	2.71**	0.30	0.22
Age				-1.29**	0.21	-0.15
Gender				-1.51**	0.20	-0.18
LoE (ref: undergraduate)						
College/matric & below				-0.17	0.22	-0.02
Postgraduate				-0.02	0.27	0.00
R^2	0.094			0.140		
ΔR^2	0.094			0.047		
F	84.117**			44.184**		
Δ*F*	84.117**			22.043**		

Note. $N = 1630$. SE = standard error; Lkdn = lockdown; LoE = level of education. $^{**}p < .001$.

Appendix BB: Hierarchical Multiple Regression Predicting Depression from Lockdown Group, Age, Gender, And Level of Education

	Depression					
	Step 1			*Step 2*		
Variable	*B*	*SE*	*β*	*B*	*SE*	*β*
Constant	5.61**	0.13		6.13**	0.22	
Lkdn group (ref: comply group)						
Sufferer group	1.80**	0.20	0.23	1.81**	0.20	0.23
Defiant group	2.29**	0.27	0.21	2.33**	0.27	0.22
Age				-0.69**	0.19	-0.09
Gender				-0.13	0.18	-0.02
LoE (ref: undergraduate)						
College/matric & below				-0.06	0.20	-0.01
Postgraduate				-0.44	0.24	-0.05
R^2	0.068			0.078		
ΔR^2	0.068			0.013		
F	59.610**			23.827**		
ΔF	59.610**			5.598**		

Note. N = 1630. SE = standard error; Lkdn = lockdown; LoE = level of education. **p < .001.